THE INFLUENCE OF FOREST EDGE, ELEVATION, ASPECT, SITE INDEX, AND ROADS ON DEER USE OF LOGGED AND MATURE FOREST, NORTHERN VANCOUVER ISLAND

by

WALTER DAVID WILLMS
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ABSTRACT

This study was proposed by the B. C. Fish and Wildlife Branch to evaluate the effect of forestry practices and forest characteristics on deer use of logged and mature forests. The specific factors studied were "time since burning", "elevation", "site index", "aspect", "forest edge", "roads" and "vegetation". The effect of elevation and aspect on deer use was studied for both the mature and logged forest while the other factors were considered only for recently logged areas.

The location of this study was the Nimpkish Valley, northern Vancouver Island in British Columbia. This area was selected primarily because it had a large population of Columbian black-tailed deer (<u>Odocoileus</u> <u>hemionus</u> <u>columbianus</u> Richardson), active logging, and variable terrain.

The deer response to "time since burning","elevation", and "site index" was generally determined by plant quality and climate. The importance of vegetative quality to deer is reduced when the climatic conditions become favorable for the animals. Therefore, during a mild winter the deer are less dependent upon the greater plant production found on areas with later seral stages, lower elevation, and higher site index, than they are during a severe winter. Similarly, on an annual basis, high plant production is less important on the warm south aspect than it is on the colder north aspect.

Two types of forest edges were studied, the upper which is parallel to the elevation contours and the adjacent which is perpendicular to the elevation contours. The upper edge influences deer use of areas, both inside and outside the forest, by maximizing use near the edge. Deer use declines with increasing distance from the edge. The only apparent effect of the adjacent edge on deer use of recently logged areas was to depress use at the edge. This also occurred at the upper edge.

Roads affect deer use of recently logged forests by increasing use adjacent to the road but decreasing use on the road and the road edge. It appears that deer use the road only for travel.

Deer exhibit preference for a variety of plant species. The use with increasing cover of an individual species is generally parabolic while the use with increasing cover for all species combined is generally linear. Furthermore, maximum use occurs on those areas where the number of species present is greater than 1.

The response of deer to increasing elevation, in the mature forest, is positive on the south aspect and zero, or nearly so, on the north aspect. This relationship is similar to that which occurred on recently logged areas following a mild winter.

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INTRODUCTION

This study was initiated by Mr. D. Blood, former Regional Biologist, Nanaimo, B.C. It was located in the Nimpkish Valley which is in the northern half of Vancouver Island. This area is occupied by the Columbian black-tailed deer (Odocoileus hemionus columbianus Richardson).

The primary objective of this study was to evaluate the influence of various environmental factors on deer use of logged and forested land. These factors were forest edge, elevation, aspect, site index, and roads. Also investigated was the use of various plant communities by deer.

Logging usually results in an increase in deer numbers. The seral vegetation which follows after a few years, consists of luxuriant herbaceous vegetation. This food provides the basis upon which the deer populations can increase. The mature forest may simultaneously provide shelter from adverse weather and predators and, in its undercover serve as an important source of winter food. Theoretically, therefore, an interspersion of newly logged areas in a mature forest will provide an ideal habitat for deer.

1. Literature Review

Autogenic succession of both plants and animals following logging of the forests of Northwest Pacific coastal areas has been partially documented by Krajina (1965), Gates (1968) and Spilsbury and Smith (1947). The early seres display vigorous development of herbs and shrubs to create a large source of food for herbivores. The incresed food, together with the shelter provided by adjacent mature forests, greatly increase the carrying capacity for deer (Robinson, 1950; Brown, 1961). Cowan (1945), for example, estimated the population of black-tailed deer (*Odocoileus hemionus columbianus* Richardson), in a mature forest of the Pacific Northwest, to be one deer per square mile, whereas a logged habitat, in a similar geographical area, may support one hundred deer per square mile (Brown, 1961).

Deer are animals of the forest edge. They require the mature forest for protection from weather and predators as well as a source of emergency food in winter. Areas recently logged and slash burned are a major source of food for deer and may provide on occasion sunny areas for warming during the winter.

1.1 Shelter Requirements

Shelter adjacent to adequate forage is essential for deer survival in severe winters (Julander, 1966). Deer mortality is high where shelter is sparse, and where deep snow inhibits mobility and covers the food suply. Cover serves not only in modifying snow depth and texture but also in providing protection from wind and cold weather (Robinson, 1960). Robinson (1960) found that white-tailed deer (Odocoileus virginianus Bailey), sought bedding sites, during winter, on a south exposure under dense conifers. This combination provided optimum protection from wind and was the warmest site available.

1.1.1 Protection from Snow

Deep snow is perhaps the single most important factor responsible for deer mortality in the winter. It inhibits their mobility and foraging opportunities (Verme, 1965). White-tailed deer will avoid deep snow (10 to 14 inches or greater) in forest openings by moving into dense conifer stands Tefler, 1970; and Tefler, 1970b). The response of mule deer (Odocoileus hemionus hemionus Rafinesque), to snow is similar. Gilbert et al., (1970) note that uniform snow cover 18 inches deep very severely inhibits the mule deer movement in a n area.

The foraging opportunities for deer are severely restricted by uniform snow. Coblentz (1970) found a strong relationship between the amount of herbaceous material ingested and the depth of snow. With no snow cover the diet of white-tailed deer consisted of about 63 percent herbaceous material; with a 3 inch snow cover the herbaceous material no longer formed a part of the diet. Woody browse, though less preferred, replaced the herbaceous material in the diet.

1.1.2 Protection from Temperature Extremes

In both winter and summer, deer use of an area is strongly influenced by temperature. Deer actively seek an area of certain temperature range or an area closely approximating their temperature preference. Miller (1970) observed that black-tailed deer in Oregon seek cover when summer temperatures exceed 60 F. This substantiates the suggestion by Taber and Dasmann (1958) that the optimum temperature for black-tailed deer in California is between 55 to 65 F. In cold weather deer will seek sites which provide them with the greatest comfort (Ozoga, 1968). For instance, in northern Michigan white-tailed deer prefer to rest under the mature conifers which have the narrowest thermal range but frequent south slopes and open areas when these are sunny (Verme, 1965).

1.1.3 Shelter Quality Provided by Conifers

Conifers provide the best shelter from snow and cold weather (Ozoga, 1968). Dense forest stands with a high proportion of softwoods intercept falling snow and decrease the depth of accumulation on the ground (Weitzman and Bay, 1958; Verme 1965; in Tefler, 1970a). A dense coniferous forest provides protection not only from wind and snow but also from cold weather. The warmest average temperature during the coldest weather was found under swamp conifers. The heat, obtained under these conditions, is radiated from the conifers (Moen, 1968a) and soil beneath them.

1;2 Food Requirements

Suitable shelter is an essential requirement of deer. The quality of available shelter is reflected in the health of the deer population, particularly in winter. The importance of shelter cannot be denied; however, an even greater requirement, one which forms the basis of the population size, is herbage and browse. The primary effect on deer population is related to plant productivity and quality (nutrient, species, palatability, species diversity).

1.2.1 Factors Affecting Plant Growth

Numerous works have been written about environmental influences on plant growth. Although information on this topic is fairly common it has been reviewed in the following section to complete the review of literature.

Vegetation and soil quality are a function of geological material, relief, organisms, time, and climate (Dokuchaev, 1898; Jenny, 1941; Major, 1951; in Krajina, 1965). Fire can qualify as climatic (lightning), geologic (volcano), or organic (man) (Krajina, 1965). In this thesis only the effect of climate and fire on vegetation shall be considered. Soils are not discussed since their influence on vegetation is most important in determining the extent and location of vegetation types (Klein, 1965).

Seed germination, plant growth, and flowering are influenced mainly by light and temperature. Free water is essential for germination which therefore will not occur below 32 F. Germination occurs at an optimum temperature which is approximately half-way between the maximum and minimum temperatures at which germination may occur (Meyer et al., 1960).

Net growth rate of plants is dependent upon the rate of photosynthesis and the rate of respiration occurring over a period of time. If the rate of growth is positive then photosynthesis exceeds respiration; the point at which the two are equal is the compensation point.

1.2.1.1 Light

The relationship between light and photosynthesis is nearly a linear one until about 1000 ft. candles(Hoover *et al.*, 1953 in Klein, 1965; Meyer *et al.*, 1960). Photosynthesis increase above 1000 ft. candles is less rapid. Plants in the temperate region require a relatively high light intensity to proceed at an optimum rate (Withrow, 1951, in Klein, 1965).

A forest canopy changes the intensity and quality of light. Direct sunlight may have an intensity of between 8,000 to 10,000 ft. candles (Meyer *et al.*, 1969); whereas light intensity under a forest canopy is frequently less than 100 ft. candles (Klein, 1965; Spurr, 1964). Shade tolerant plants have adapted to light shortage to the extent of having a lower compensation point (50 - 100 ft. candles) than heliophilic plants (100 - 200 ft. candles) (Meyer *et al.*, 1960). A further adaptation of shade tolerant plants is their ability to utilize sun flecks (Spurr, 1964). Strong light is harmful to plants since it brings about a disintegration of the chlorophylls (Meyer *et al.*, 1960) and a decrease in photosynthesis (Spurr, 1964; Odum, 1959).

Light intensity and light quality (utilizable wave-length of light) are both severely limited under the forest canopy. The colours of the spectrum which stimulate photo-synthesis to the greatest extent are red (760mu) and blue (540mu) (Meyer *et al.*, 1960). These are readily absorbed by the forest canopy so that the light is proportionately richer in green. This filtering effect further reduces the rate of photosynthesis in plants (S purr, 1964).

1.2.1.2 Temperature

Photosynthesis is primarily affected by light, whereas respiration is primarily affected by temperature. Respiration increases with temperature to a modal value then decreases until the plant dies (Surr, 1964; Meyer *et al.*, 1960).

Photosynthesis and vegetative growth respond to temperature in much the same way as respiration in that they increase with higher temperatures until a modal value is reached at approximately 77 to 86 F., thereafter a decrease occurs (Meyer *et al.*, 1960). In the temperate region, growth rates of plants and hence photosynthesis bates decrease greatly with any drop in temperature below $70^{\circ}F$. (Popp 1926 and Hicks, 1934 in Kelin, 1965). Most plant species do not grow appreciably below $41^{\circ}F$. Meyer et al, 1960).

1.2.1.3 Effect of Temperature and Light on Flowering

The flowering of plants is strongly affected by temperature and light. The interactions are complex and therefore only a few generalities will be made. While the photoperiod of plants varies from one species to another many plants in the temperate regions require a long photoperiod. The effect of temperature on flowering is to either reinforce the effect of the photoperiod or to act in opposition to it. (Meyer et al, 1960). Since light duration and quality, as well as temperature, determine flowering in most plants, the removal, or development, of a canopy will determine to a great extent whether flowering of the understory plants will occur.

1.2.2 Factors Affecting Plant Quality

1.2.2.1 Plant Maturity

A very important factor governing the quality of forage on the summer range is the stage of maturity of these plants (Klein, 1965). The young parts of the plant are usually the most nutritious, particularly in protein. Nutrients in the older leaves become redistributed to areas of growth such as the new leaves and later in the season, to the reproductive parts of the plant. Furthermore, as the plant matures it becomes less palatable as its fibers increase and its cells become lignified.

1.2.2.2 Fire

Forest fires and slashburning initiate a secondary succession. This involves many changes in the habitat which include, release of nutrients to the soil and atmosphere, removal of organic accumulation on the forest floor and removal of the forest canopy. These changes are reflected in the nutrient quality of vegetation, species diversity, species number, and productivity of vegetation.

1.2.2.2.1 Browse Variety

Species numbers and diversity increase during the initial stages of autogenic succession, but decrease in later stages (Odum, 1966). In the Pacific Coast Forest species are present in the greatest numbers 5 to 10 years after burning (Gates, 1968), whereas after 18 years their numbers decline to half the maximum. Of the plant forms in Gates area, forbs and shrubs were represented by the greatest number of species.

Diversity of browse species is both desirable and necessary for deer nutrition. Verme (1965) observed that deer prefer variety in browse even though only the most nutritious species are eaten in any great quantity. Low value browse, it was noted, consumed in liberal amounts would maintain deer throughout the winter. Only one species was found which alone would support deer.

1.2.2.2.2 Browse Nutrition

Fire temporarily improves the fertility of soil. Nutrients are released in the ash, the decaying roots of burn-killed plants produce a green manuring effect, and the nutrification rates increase with the absence of shade (Daubenmire, 1968). Lay (1957) and Shepherd (1953) observed that burning usually results in a high protein and phosphorous level in the invading vegetation. The duration of this effect was, however, only for one or two years (Lay, 1957).

1.3 Effect of Forest Succession on Deer

The influence of forest succession on deer in the Pacific Coastal Forest has been described by various authors (Gates, 1968; Robinson, 1958; Brown, 1961). Dasmann (1964) found that deer use of a forest was at a maximum 8 to 10 years after burning while Gates (1968) found maximum use 4 years after burning. Robinson (1958) observed that deer raised on newly logged land exhibited rapid rates of growth. He attributed this to a combination of soil fertility, new plants, species in their initial growth phases, increased insulation, and differential growth and maturation periods of herbs and grasses.

Deer use declined on an area which was burned more than 10 years ago (Dasmann, 1964); after about 20 years, in his area, when shrubs were tall and the tree canopy was well formed, the deer population is reduced to levels similar to those in old growth forest (Dasmann, 1964).

1.4 Factors Contributing to Population Decline

This decline is attributed to several factors: tree canopy grows out of the reach of deer, thereby eliminating a source of winter food, food quality is reduced (Robinson, 1958), and production of grasses, forbs, and browse is reduced (Blair, 1969).

Plant productivity in the understory is generally related to the understory density (Blair, 1969; S purr, 1964). Hence, less food is available for herbivores as sta nd density increases. Under dense young conifer stands light transmission may be less than 5 percent of full sun; a condition which leads to the disappearance of understory vegetation (Shirley, 1945, in Blair, 1969). Light under some mature forest canopies is only 1/2 percent of full sun (Spurr, 1964). This explains the scarcity of vegetation in such forests and the reduction of the deer population from possibly 100 deer per square mile in a logged environment as recorded by Brown (1961) to 1 deer per square mile in a mature forest as recorded by Cowan (1945).

1.5 Other Factors Affecting Deer Movement

1.5.1 S ite Index

Other factors which influence deer movement (either directly or indirectly in regard to food and cover) are site index, elevation, and aspect. Site index is essentially an estimate of productivity and would, therefore, usually be reflected in nutrient quality of most plants. Since vegetation with high protein content is preferred by deer (Brown, 1961; Crouch, 1966; Einarsen, 1946), those plants on a high productivity site will be utilized more than those of a lower productivity site (this would be particularly true during the growing season before the nutrients are redistributed to the seeds). The extent to which a "high" and "low" site are useful to deer varies with the age of the autogenic succession. A "high" site on a recently logged forest enhances deer use, however, its' usefulness to deer declines more rapidly than that of a "low" site. This is caused by a faster rate of growth on the "higher" sites which shorten the time of succession.

1.5.2 Aspect

Aspect affects deer by altering the climate, which in turn is important to the comfort of the animal and to the growth of vegetation.

In the North Temperate Zone the south and southwest aspects receive more of the sun's energy than other aspects and the north aspect receives the least (Spurr, 1964). This effect is particularly pronounced when the sun is low over the horizon. The effect of aspect on plants, therefore, is usually in the modification of the potential energy (light and heat) received. On this basis the growing season would begin earlier and plant productivity and quality would be higher on southern slopes than on northern.

Besides being influenced by vegetation, deer are also directly affected by temperature and will select the aspect which best meets their requirements. Taber and Dasmann (1958) noted that the Columbian black-tailed deer in California move around from hour to hour and from season to season to find the most comfortable air temperature. In winter the deer spend most of their time on the warmer southern facing slopes. In summer these slopes become too warm for the deer and the northern facing slopes are occupied during the day but are usually deserted at night in favour of southern facing slopes. Similar observations have been made with mule deer by Loveless (1964) in Moen, (1968b) and Julander (1966).

1.5.3 Elevation

The influence of elevation on deer movement is primarily through the temperature gradient associated with it. In the maritime climate of California the temperature decreases between 1 to 1.5 F. with each 1,000 foot rise in elevation (Spurr, 1964). These values are considered comparable to the Pacific Northwest situation. The effect is to stimulate earlier plant growth at lower altitudes which provides an important early source of food.

Cooler temperatures at higher altitudes ensure earlier snowfall, later snow melt in the spring, and greatest accumulation of snow than at the lower elevations. This is the primary reason, in most cases, for deer migration to lower altitudes in winter (Dasmann and Taber, 1956).

These cooler conditions also postpone the growing season in the spring. This effect provides a gradient of plants at various stages of maturity - the oldest at the bottom and the yougest at the top. Since young plant material is more nutritious and palatable than older material, conceivably, youthful forage could provide an incentive for deer to migrate up to their summer range (Hebert, 1971). Other investigators consider migration patterns to be innate (Dasmann and Taber, 1956).

1.5.4 Logging Patterns

Logging patterns and size of area logged contribute significantly to the quality of deer habitat. These factors have been studied subjectively and there is much speculation on the matter (Robinson, 1958; Brown, 1961; McGinnes, 1969; Tefler, 1970a; Verme, 1965; Krefting and Phillips, 1970).

Krefting and Phillips (1970) found that deer use was highest in patterns where clearcut strips were cut 75 feet by 400 feet with narrow strips of mature forest alternating. Such patterns provided more attractive habitat to deer than clearcut blocks (0.4 acres) or forests cut on the diameter-limit, shelterwood, or selection basis. Tefler (1970a) concluded that the best deer habitat in eastern Canada consisted of logged strips which were less than 200 feet wide. This is consistent with Reynold's (1966b in McGinnes, 1969) findings that openings larger than 20 acres (in Arizona) were little used by deer. However, deer use increased as the size of the logged patches decreased. Apparently deer did not ordinarily move much more than 1,200 feet from the forest edge.

Since logged-over land is attractive to deer, conifer regeneration often becomes difficult because the seedlings are browsed. To provide both food for deer and adequate conifer regeneration, Verme (1965) suggested cutting larger patches than those described above. He proposed patches which were 40 to 60 acres in size.

1.5.5 Snow Accumulation

1.5.5.1 As Affected by Aspect

The nature of the snow packs are important in the life of deer in the Pacific Northwest. Of particular interest are the effects of aspect, elevation and forest edge on snow deposition and melt. Meiman (1968) observed that the effect of aspect appears to be predominantly a melt influence although there are strong indications that accumulation, irrespective of melt, is related to aspect. Melt would of course be most rapid on slopes receiving the most energy from the sun - viz. those with a southern aspect.

1.5.5.2 As Affected by Elevation

Elevation imposes a significant effect upon snow accumulation. In general, accumulation increases with elevation at rates which vary from one place to another (Meiman, 1968). A study, in California, showed that depth increase ranged from 1 to 2.5 inches per 100 feet increase in elevation (U.S.Army, 1956, see Stanton, 1966). Furthermore, since temperatures are normally warmer at lower altitudes melt occurs first there.

1.5.5.3 As Affected by Forests

1.5.5.3.1 Forest Canopy

Forest clearings and their edge exhibit a marked influence on both snow deposition and melt. More snow accumulates in forest openings (up to 10 acres in size (Goodell, 1971)) than beneath forest canopies (Jeffrey, 1968; Stanton, 1966; and Rothacher, 1965). This may be largely due to a redistribution of snow attendant upon reduction of wind velocity in the openings (Jeffrey, 1968). Snow accumulation rate, at least in some situations, beneath the forest canopy is inversely related to canopy density (Goodwell, 1959; Molchanov, 1963 in Jeffrey, 1968).

1.5.5.3.2 Forest Clearing

Snow deposition within the forest opening shows a relationship with the forest edge. Hoover (1962, in Jeffrey,

1968) and Stanton (1966) note that snow-drifts generally form at the forest edge adjacent to open areas. Anderson et al (1958, in Rothacher, 1965) found that heaviest snow accumulation tends to occur at the bottom edge of a clearcut area regardless of aspect. Snow accumulation occurs not only at the edge but also in the center of relatively small clear-cut areas. For example, snow builds up toward the center (after a depression near the forest edge) in clearings of 10 to 16 acres (Stanton, 1966), and in others that are 60 feet in diameter where the surrounding trees average 80 feet tall (Goodell, 1964 in Stanton, 1966).

1.5.6 Snow Melt

A relationship of snow accumulation and melt with aspect and forest edge was noted by Rothacher (1965) on the west slopes of the Oregon Cascades. On clearcut strips, 132 feet wide, in an east-west direction and located on south to southwest aspects, snow depth decreased with distance from the south edge of the forest. This was true during both snow accumulation and melt. Snow melted first, in Rothachers study, on the upper, north edge where solar radiation is least interrupted by tree crowns.

Although snow accumulates more rapidly in clear-cut areas, it also melts faster since more heat is available (Miller, 1955; and Anderson, 1956 in Jeffrey, 1968). Again, numerous other influences tend to reinforce or negate this generalization. For instance, Rothacher's study demonstrates the relation of snow accumulation and melt with aspect and forest edge. Complicating the melting rates is the combination of convecting heat (from adjacent forests), with solar and longwave radiation, and sensible heat all of which vary in melting influence from open to mature forests. The following example is a generalization of the interactions: Small openings receive convected heat from adjacent forests, as well as more sensible heat and longwave radiation, but less direct beam radiation than large open snow fields; therefore their melt rates are less than those in large open areas but are greater than in closed forest (Goodell, 1959; Molchanov, 1967; Jeffrey, 19

1.6 Pellet Group Counts as a Census Technique

The pellet group count has become an acceptable technique for both censusing deer (Gates, 1968; Dasmann, 1964) and giving their relative distributions (Brown, 1961; Krefting and Phillips, 1970; McGinnes, 1969). This technique is based on an assumed defecation rate by deer and the assumption that pellet group counts are in proportion to the amount of time deer spend in each location.

Various sources of error are inherent in this method; included are: defecation and pellet decomposition rates vary with food palatability and therefore the season in which the food was eaten; defecation rates vary with deer activity; pellet decomposition rates vary with climate and hence cover; and all errors involved in sampling techniques.

Neff (1968) made a complete review of the pellet group count technique. He includes topics on size and slope of sample plot, distribution of sample units, sampling intensity, defecation rate, observer bias, other sources of error, and an experimental evaluation of pellet group counts.

2. Study Site Description

2.1 Physiography (Bunce, 1960; Canadian Forest Products Ltd. (Canfor) information; and Contour Maps Produced by Surveys and Mapping Branch, Ottawa).

The Nimpkish Valley lies within the mountain mass of the northern part of Vancouver Island. The mountains range from 5,000 to 6,000 feet above sea level (Hoadley, 1953). The valley floor drops in altitude from about 950 feet at its southeastern end to sea level at Beaver Cove. The altitudes of lakes, adjacent to the study area in the Valley, are: Schoen Lake, 1320 feet; Woss Lake, 491 feet; Vernon Lake, 675 feet; and Nimpkish Lake, between 0 - 100 feet. Schoen Lake is offset several miles from the Nimpkish Valley.

The main valley trends northwest-southwest and has the typical U-shaped glacial form. It is from half to three miles wide and 57 miles long (Bunce, 1960). Figure 1 presents a view of a portion of the valley.

2.2 Geology (Bunce, 1960; Canfor information; and Geology Map - 1028A)

The bedrock stratigraphy structure of the Nimpkish

Figure 1 A south-east facing view of a portion of the Nimpkish Valley with Woss Camp in the background.

area were developed over several geological periods, especially the Triassic, Jurassic, and Cretaceous. The stratigraphy has two primary components; the coast granitic intrusions and the "Vancouver group"; rocks of this latter group are assigned to the Triassic period, and are further subdivided into three subgroups: the rocks of the Karmutsen group, the Quatsino formation, and the Bonanza group (Hoadley, 1953).

Rocks of the Karmutsen group consist predominately of basaltic and andesitic lavas, agglomerates, breccias, and tuffs (Map 1028A). The lavas are generally basic and contain only small amounts of acidic types such as dacite and rhyolite (Bunce, 1960). This group occupies the greatest proportion of the Nimpkish area.

The Quatsino formation consists primarily of crystalline limestone associated with minor volcano rocks (Map 1028A). The limestone varies in depth from 500 to 3,500 feet but contributes only 5 percent of the valley's surface (Bunce, 1961). It occurs both south and east of the Nimpkish Lake.

The Bonanza group consists of both sedimentary and volcanic rocks with the latter lying above the former. The lower layer is about 400 to 500 feet thick and is composed of tuffaceous argillite, impure limestone, and quartzite at the base. The upper layer is thicker than the lower layer and consist of andisitic lavas, agglomerates, tuffs, breccias, and lavas which are a mix of basalt, trachyte, and dacite. Of the three groups, this one is represented by the smallest area (1.6%) of the valley (Bunce, 1960). It is generally found on the edges of the valleys north of Nimpkish Camp.

The Coastal intrusion occurred during Jurassic and /or Cretaceous time. It is formed of holocrystalline, igneous, rocks which are from basic to acidic. The intrusion extends beyond Woss Lake in the southeast to beyond Nimpkish Lake in the northwest, a distance of about fifty miles (Bunce,1960).

During the Pleistocene period, glaciation was responsible for depositing glacial drift over extensive areas throughout the Valley. These deposits are not deep and the bedrock frequently crops up even in the valley bottom.

2.3 Soils (Bunce, 1960)

The last glaciation was recent and the soils are immature. Parent materials range in fertility from the poorer tuffs and acidic lavas to the base-rich basalts and the fertile soils derived from the granodiorities of the major intrusive bodies. These granodiorites have provided the greater part of high productivity site soils. Glacial drift has its own characteristics besides those inherited from the bedrock; it gives rise to gleys and ground-water podzols over slightly elevated ground, and podzols where the bedrock emerges through the drift. Soil may be many feet deep in the valley bottom and lower slopes but may become very shallow, with out-croppings of bedrock, only 100 feet above the valley floor.

2.4 Site (Bunce, 1960)

The term, site index, as used in this report is defined as the average height of the dominant and co-dominant Douglas-fir trees at 100 years of age. It expresses the summation of all interactions of climatic, biotic, topographic, and edaphic factors.

The site index classed by Canfor, and their midpoints, are as follows: Class I, 200; Class II, 170; Class III, 140; Class IV, 110; and Class V, 80. The percent of the total area, which each class occupies in the Nimpkish Valley, is, Class I, 1%, Class II, 21%, Class III, 46%, Class IV, 22%, and Class V, 10%.

2.5 Climate (Canfor Information; Bunce, 1960)

The Nimpkish Valley experiences a moderate temperature range but extremes in precipitation. Mean annual precipitation values for Woss Camp, a few hundred feet above sea level, ranged from 71 to 116 inches over a 15 year period; the average is 90 inches. The six months between April and September account for only 23 percent of the total annual precipitation (See Appendix Ia for summary). Precipitation at Nimpkish Camp, also a valley bottom station, which is about 20 miles northwest of Woss, has a very similar record (Bunce, 1960) however, farther south the precipitation range becomes greater. This may be the result of a more variable terrain.

Snow falls every year in the Nimpkish Valley at elevations above 1,000 feet; snowfall may begin as early as November above 1,500 feet and accumulates to varying depths until late spring. With the exceptions of steep north slopes, the snow line, by the end of April, has usually retreated to about 3,000 feet. On the north slopes the snow will remain until midsummer. The average annual snowfall at Woss Camp is 40 inches (See Appendix 1b).

Temperature extremes at Woss Camp vary from a maximum of 99°F to a minimum of -4° (See Appendix 1c and d). No month has an average temperature which is below freezing.

2.6 Biota (Bunce, 1960)

Several forest types occur in the Nimpkish Valley. The two major types are Douglas-fir (*Pseudotsuga menziesii* (Mirb. Franco) and Douglas-fir-western hemlock (*Tsuga heterophylla* Raf. Sarg.). These are present over nearly all well drained valley bottoms and on hillsides to the 2,000 feet contour.

Six other types are represented in the Valley, viz. Western red cedar (*Thuja plicata* (Donn.)); lodgepole pine (*Pinus contorta* (Dougl.)); Sitka spruce (*Picea sitchensis* (Bong. Carr)) - western hemlock; Pacific silver fir (*Abies amabalis* (Dougl.)); yellow cedar (*Chamaecyparis nootka-tensis* D. Don. Spach.); mountain hemlock (*Tsuga mertensiana* (Bong.)); subalpine fir (*Abies lasiocarpa* (Hook)). The Western red cedar type occurs on land with poor drainage and swampy ground. It is replaced by the lodgepole pine type where peat formation is pronounced. The latter type also exists on low rocky hills where the water supply is low in dry weather. In the northern end of the valley a more maritime climate in summer accounts for the replacement of the Douglas fir with the sitka spruce-western hemlock type.

The next three types are found at higher altitudes: Pacific silver fir (may be outnumbered by balsam, western hemlock, and mountain hemlock); yellow cedar; and mountain hemlock-subalpine fir. The latter occurs at elevations in excess of 4,000 feet.

2.7 Fire History (Bunce, 1960; and Fire History Maps, Canfor)

Uncontrolled fires have occurred throughout the Nimpkish Valley with a frequency of about one every 100 years (Bunce, 1960). Appendix 2 summarizes the fire history by showing the approximate times of fire, the age of present stands produced, the size of areas burned, and general location.

The effect of fire has been to create large blocks of even-aged timber consisting predominantly of Douglas-fir. Nearly all the area of the Valley below 2,000 feet has been burned at one time or another during the last 1,000 years, with the exception of the ten miles of the Valley closest to the sea.

2.8 Logging History (Bunce, 1960; and Canfor Logging History Maps)

Logging in the Nimpkish Valley first began in 1915 at Englewood and around Beaver Cove. Logging continued inland, preceded by the railroad, and reached the north end of Nimpkish Lake by 1923. By 1943 logging operations had extended to the south end of Nimpkish Lake and after 1945 was proceeding up the Valley at an average rate of 2,000 acres per year. Logging around Woss Camp started in 1947 and around Vernon Camp in 1953.

Canadian Forest Products Ltd. has three logging camps in the Valley situated at the southeast of Nimpkish Lake and spaced about 20 miles apart. They are, beginning from Nimpkish Lake, a) Nimpkish Camp, b) Woss Camp, and c) Vernon Camp. The latter was established in 1955 to salvage 6,400 acres of timber damaged by fire.

The total effect of the logging operations has been to remove the heavy timber of the fir-hemlock type in valley bottoms and leave less accessible sidehill timber of hemlock-balsam stands (Bunce, 1960). Initially the logging settings were contiguous and near the valley bottom. At present sidehills are being logged and the settings are separated by mature timber.

2.8 History of Deer Populations (Bunce, 1960; Canfor Information)

Until 1961, the response of deer populations to logging were not what was expected. In 1958, about 15 years after logging started, the deer population was estimated by the Game Branch, (now Fish and Wildlife Branch, B. C. Dept. of Recreation and Conservation) to be only 1.8 deer per square mile while for the same year Canfor estimated the population to be about 2.4 deer per square mile. The estimates were based on hunting returns and pellet group counts respectively. Since 1958 the population increased gradually until 1961 when it "exploded" and reached an estimated 65 deer per square mile in 1964. Although no data is available for the interval until 1969, the opinions expressed by residents of the Valley are that the population continued expanding until 1968 when a great number of deer died during the winter of 1968-69. The die-off began with the exceptionally heavy snowfall during that winter. The following year the population was estimated by myself to be approximately 51 deer per square mile. Current observations indicate a rapidly expanding population. This is indicated by the large number of yearling deer seen during the summer, in comparison to adults. The available data on deer population increase is depicted graphically in Figure 2 and in tabular form in Appendix 3.

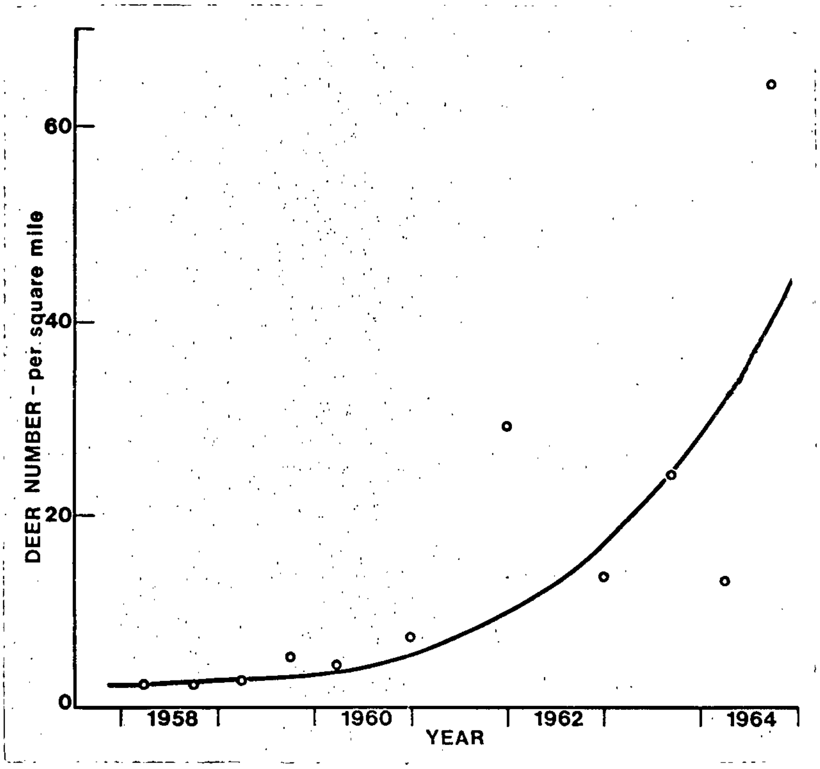

Figure 2 An estimate of the increase of deer populations in the Nimpkish Valley.

3. Methods and Materials

3.1 Selection of Study Area

The Nimpkish Valley was selected as the most suitable area for reasons given as follows. The Valley contains a large deer population; good access; logging on a variety of aspects and altitudes; and available living accomodations. The significance of a large deer population lies in the increased sampling accuracy with increased populations (Neff, 1968). Variable terrain and logging permits the study of aspect and elevation on deer usage of mature and logged forests.

3.2 Project Divisions

The objectives of this study were approached by means of three independent sub-projects. The field work for them was completed in two summers of 1969 and 1970.

(a) During the first summer fifty "permanent" pellet group plots were established throughout the Nimpkish Valley, on recently logged forests. The purpose of these plots was to provide information on the effect of site index, elevation, aspect, and time since slash burning on deer use of logged areas. These plots also provided an estimate of population size. They were resampled at the beginning of the second summer.

(b) Another major sub-project was begun and completed during the second summer. The influence of forest edge on deer use of mature and recently logged forests was studied on five sites where transects of temporary subplots were established to sample pellet group density. Additional information was obtained from these plots on roads and vegetation as they influenced deer use.

(c) A third sub-project was begun and completed at the end of the second summer. This project was intended to give information on deer use of mature forests and the effect of aspect and elevation through study of temporary pellet group subplots.

3.3. Pellet Group Counts

All pellet group subplots in this study were circular with a radius of 5.64 feet (this gave each an area of 100 square feet). The use of small plots (e.g. 50 $ft.^2$) may permit a sampling accuracy equal to that of fewer larger plots yet still reduce the total area sampled (Pechanec and Stewart, 1940; in Neff, 1968). However, the small plots also require greater effort to establish and sample and will often increase border errors. Furthermore, larger plots will show less variability when the deer population is low (Smith, 1964, in Neff, 1968). With increasing plot size the possibility of overlooking pellet groups increases as also does the difficulty of delineating the plot boundary. The plot size chosen provided the best compromise with the above advantages and disadvantages.

Subplot boundaries were determined with a stick which was 5.64 feet long. The center of the subplot was first established, then one end of the stick was placed on the center while the other end marked the boundary.

The number of pellets required to be counted as one group varied from one situation to another. One isolated pellet was never considered to be a group unless there was evidence of other pellets from a disturbed group. A pellet group was counted only if its center was within or on the plot boundary.

Sampling intensity varied with each project. A compromise between sampling efficiency and available time were primarily responsible for variation in intensity.

3.4 Vegetation Survey

All three sub-projects contributed to the survey of the Valley vegetation. A survey of vegetation was made with 3 sub-projects. In the ecotone and mature forest sub-projects (b and c) the subplots used to sample the vegetation were the same as those used to sample the pellet group density. Vegetation on the permanent plots was sampled with ten sub-plots on each plot, established in a systematic-selective manner. Vegetation on each sample was recorded by species, growth habit (herb and shrub etc.), vegetative cover as a percent of the ground area, and relative contribution of each species to this percentage.

Where pellet groups and vegetation were sampled simultaneously a correlation of deer use with vegetation was undertaken. On the permanent plots, where this was not the case, the vegetation was tabulated for reference.

3.5 Permanent Plots (Sub-project a)

3.5.1 Plot Location

Several criteria were used to select areas on which to locate plots. In view of the very great variability in vegetation and terrain it was essential first to personally select areas which were suitable for study but reasonably homogeneous topographically and floristically; sampling (stratification) with this restriction, made establishment and relocation easier. This consideration was important for reducing the variation among samples on the plot as well as permitting easier establishment and relocation of permanent subplots. Other criteria were: selection of areas logged and burned within the last 10 years; selection to give plot locations over a suitable range of altitudes; and selection of areas to display a variety of aspects. Eventually 50 permanent plots were established on logged areas where all but four were on slashburn. Where slashburning had not been carried out, the age of the new succession was considered from the time of logging. The number of plots representing each successional age are shown in Table 1. Similar Tables (2 and 3) have been constructed to show the number of plots representing each site and elevation class. A description of each plot is given in Appendix 4.

Table 1

Number of Plots Representing each Successional Age

Successional Age	Year Slashburned*	Number of Plots
1	1968	1
2	1967	8
3	1966	10
4	1965	12
5	1964	4
6	1963	7
7	1962	3
8	1961	3
9	1960	2

*Year slashburned provided by George Muir of Canfor.

Table 2

Number of Plots Representing Each Site Class

Site Class*	Number of Plots
100	1
110	3
120	12
130	14
140	13
150	6
160	1

*Site Classes provided by George Muir of Canfor.

Table 3

Number of Plots Representing Each Elevation Class

Elevation Class* (X100)	Number of Plots	Elevation Class (X100)	Number of Plots
8	3	20	3
9	6	21	1
10	5	22	
11	3	23	3
12	3	24	
13	1	25	3
14	2	26	1
15	8	27	
16	1	28	1
17	1	29	
18	2	30	1
19	1	31	1

*Elevation obtained from topography maps printed by B. C. Dept. of Lands and Forests - 3rd edition.

3.5.2 Plot Layout

Each plot consisted of 40 subplots (samples) established systematically along eight transects radiating from a center. This arrangement allows five subplots per transect. The subplots were spaced 50 feet apart, from their centers, along the transect. The transects were established by compass with one in each of the following directions: north, northeast, east, southeast, south, southwest, west, northwest. A 200 foot chain was used to space the subplots on the transect.

The plot and subplot centers were marked with a stake and plastic ribbon. In the former, the stakes were about five feet tall with a long ribbon while in the latter the stakes were only about six inches tall and with a short ribbon.

Other information obtained for each plot was the percent slope of the terrain with a Sunto clinometer, the site index from George Muir of Canfor, the altitude from topographic maps, and year burned, also from George Muir of Canfor. The slope of the land was not considered in any calculations since it was moderate (30 - 40%) in most cases and is not considered to affect deer movement significantly (Julander, 1966).

An initial pellet group count was made on all subplots. After being counted the pellet groups were removed from the plots.

3.5.3 Plot Relocation and Estimating Deer Populations

During May of the following year the plots, with the exception of one, were resampled for pellet groups on each subplot. This information could be used for correlating deer use of logged areas with site index, elevation, and number of years since slashburning as well as for estimating deer populations. The deer population can be estimated with the following formula:

$$\text{Deer per square mile} = \frac{\text{Deer-day}}{\text{13 groups}} \times \frac{\text{No. group}}{\text{Plot}} \times \frac{\text{Plot}}{\text{Sq. feet}} \times \frac{\text{Square feet}}{\text{Square mile}} \times \frac{1}{\text{Days since last sample}}$$

Explanation:

$\frac{\text{Deer-day}}{\text{13 groups}}$	An assumption is made that deer defecate 13 times per day.
$\frac{\text{No. groups}}{\text{Plot}}$	The number of groups are those counted during the second year.
$\frac{\text{Plot}}{\text{Square feet}}$	This value is the inverse of the total area sampled per plot.
$\frac{\text{Square feet}}{\text{Square Mile}}$	Number of square feet in one square mile.
$\frac{1}{\text{Days since last sample}}$	The inverse number of days between the two sampling periods.

The value obtained could be fitted with confidence limits.

3.6 Ecotone Study (Sub-project 6)

3.6.1 Location of Plots

Five plots were established, within the Nimpkish Valley, primarily to evaluate the relationship of deer use of recently logged and mature forests and the effect of the forest edge. To study this relationship it became essential to select areas with a recently logged and slashburned site adjacent to a mature forest, and where the ecotone was distinct and regular. This last characteristic facilitated measuring of the edge and interpreting the interactions.

Other conditions which had to be considered when selecting an area were aspect and time since slashburning. Both of these parameters determine to a large extent the deer usage of an area. Although desired combinations of these parameters were limited, four study areas were eventually selected, with two on the north aspect and two on the south aspect. The north aspect was represented by an area burned in 1961 and another in 1967 while the south aspect was represented by a 1961 and a 1966 burn. The area burned in 1966 was large enough to permit the location of two plots. The plots are described more fully in Appendix 5.

3.6.2 Plot Layout

The logging pattern in the Valley was instrumental in determining the plot layout. In all cases the plots were on a slope with a forest edge situated on the upper side and, with the exception of two plots, open on three sides. In the two exceptions the plots were situated in a corner bounded by two forest edges and open on the other two.

Another feature associated with all plots, except one, are fireguards situated between the mature and logged forests (See Fig. 3a, 3b, and 3c). On steep slopes where the

Figure 3a   Forest edge with fire-guard on plot 4, burned in 1961.

Figure 3b   Forest edge with fire-guard on plots 2 and 3, burned in 1966.

Figure 3c Forest edge without fire-guard on plot 1, burned in 1961.

fireguards followed the contours, they tended to form banks on both their upper as well as their lower edges. Furthermore, the fireguards are associated with an accumulation of slash at their edges, and also, since they are often dug to the parent material, plant growth on them is limited.

The subplots for sampling pellet groups and vegetation were arranged systematically in transects. These transects were parallel one to another and, with the exception of one plot, dissected the upper forest edge perpendicularly. The forest edge in Plot 4 curves from S 25 E to S 25 W. In this case the transects continued to be parallel but were in a direction to minimize any deviation from perpendicular to the forest edge.

The transects were established in a similar manner on each plot. Three to four rows of stakes, parallel to the forest edge, provided adequate reference points with which to align the transects and the subplots. The stakes were 200 feet apart in each row while the rows were 300 feet apart. A 300 foot chain and a Silva compass were used to locate each stake. Each stake, in a row, had a counterpart in every other row, which was opposite to it and in the same direction as the transects. Since the stakes in a row were 200 feet apart, and the transects only 25 feet, nine transects could be fitted from one stake to the other.

Subplots on each transect were spaced about 40 feet apart. A poke stick was used to space the subplots but since this measurement is subject to variation, the more exact location was estimated with reference to the stakes. Since the stakes along each transect are 300 feet apart, this will accommodate 7½ subplots. Any variation in the number of subplots is corrected when recording the distance of each from the forest edge by either increasing or decreasing the distance between them.

In all plots, except the first, four rows of reference stakes were used; one on the forest edge and the last 900 feet from it. In the first plot no stakes were used on the forest edge and the first row from it was only (approximately) 300 feet away. Two other rows were established parallel to the first and away from the edge. The exact distance of the stakes from the forest edge was measured with a range finder.

Transects greater than 900 feet from the forest edge, and those into the forest, could not be adjusted with reference stakes. In this case the transect's alignment was based solely on the compass while the subplot location on the transect, in relation to the forest edge, was based on the average spacing of the subplots on the transect where reference stakes were available.

3.6.3 Sample Size

The sampling intensity used was about 10 percent of the plot's area. However, the plot's area was subject to variation. All but one plot had 40 transects each; plot 5 had only 27, being limited by a short upper forest edge. The greatest variation in plot size occurred as a result of differences in transect lengths. This was the result of several factors including differences in the size of the logged area, topographical limitation, and limitation of time. An attempt was made to extend the transects 900 feet into the logged area. This distance was surpassed in some plots (1 and 2) and was short of it in one (4). The transects were cut short in the corner of plot 4 by a major logging road. On plot 1 the transects were extended up to 1,200 feet from the forest edge.

Transects into the forest varied in length, depending upon the pellet group density and available time. On south aspects the transect length alternated between 320 and 1500 feet. Lack of time prevented the extending all transects to 1500 feet. The shorter transects were considered long enough to encompass the main influences of the forest edge.

On north aspects the transects were extended an arbitrary 320 feet into the forest. Here the pellet group density dropped off sharply within a short distance of the forest edge.

3.6.4 Road Effect

The effect of roads on deer use of logged areas could be evaluated with the same plots that were used in the ecotone study. This was possible on plots 1, 2, and 3 where abandoned logging roads dissected the plots. The location of these roads on each transect was noted while sampling the subplots. The relationship of pellet-group density with distance from the road could then be calculated.

3.7 Mature Forest (Sub-project c)

A minor study was made at the end of the second summer to obtain an indication of the effect of aspect and slope on deer use of mature forests. This required plots on both north and south aspects and at various altitudes. Eventually ten plots on each aspect were chosen.

3.7.1 Plot Location

This study required two slopes with one facing or nearly so, in a north, and the other in a south direction. Their altitudes should range from the valley floor to about 3,000 feet. Such conditions, however, were not available since all accessible slopes were either logged at various intervals or did not have the necessary altitudinal range. This situation was rectified by establishing plots at various altitudes but on different slopes.

An equal number of plots on both north and south aspects were sampled. They were located at various altitudes and frequently off roads which extended for a considerable distance into the mature forest. In a few cases the plots were located by walking into the forest from a road or logged area. The altitude of each plot was obtained with the aid of an anemometer. The readings obtained were checked with a contour map and adjusted if necessary. Appendix 6 provides a description of each plot.

3.7.2 Plot Layout

Each plot consisted of 30 subplots laid out in a systematic-selective manner. They were spaced about 50 feet apart from one another. Both vegetation and pellet groups were sampled from them.

4. Observations

The observations of this thesis are represented primarily by figures in the form of graphs. This is particularly true for the observations of the ecotone study (sub-project b).

4.1 Permanent Plots (Sub-project a)

The pellet groups on the permanent plots were counted on two different occasions, first, when the plots were established in 1969, and again in the following summer. Since the pellet groups were removed after the initial sample, an estimate of deer population could be made using the assumption that deer defecate 13 times per day. The population estimates for each plot are shown in Table 4. Estimates of sampling accuracy for the first and second samples are given in Appendix 7.

The total pellet group count per plot (an estimate of deer use) was used in multiple regression analysis with the following independent variables: "time of burning", "elevation", and "site index". A separate analysis of each sample permitted an estimation of the effect of the independent variables on deer use for two different periods. These periods were (1) the time before the summer of 1969 and in particular the first year preceding it, and (2) the time interval between the summer of 1969 and 1970. The information

TABLE 4

Estimates Of Deer On Permanent Plots

Plot No.	Sample Period (days)	Number of Pellet Groups - per plot	Estimated Deer per Sq. Mile*	Plot No.	Sample Period (days)	Number of Pellet Groups - per plot	Estimated Deer per Sq. Mile*
1	361	29	43.1	26	310	37	64.0
2	359	53	79.1	27	309	24	41.7
3	357	31	46.5	28	308	20	34.8
4	356	41	61.8	29	307	46	80.3
5	355	41	61.9	30	311	28	48.3
6	Not available			31	310	21	36.3
7	339	23	36.3	32	310	48	83.0
8	353	26	39.7	33	308	37	64.4
9	342	34	53.3	34	305	48	84.4
10	341	60	94.4	35	304	27	47.6
11	340	18	28.4	36	304	42	74.1
12	340	22	34.7	37	303	48	84.9
13	339	34	53.8	38	302	32	56.8
14	338	48	76.1	39	301	32	57.0
15	337	18	28.6	40	303	17	30.1
16	336	22	35.1	41	288	14	26.1
17	330	42	68.1	42	280	15	28.7
18	329	36	58.7	43	293	23	42.1
19	327	16	26.2	44	292	13	23.9
20	320	4	6.7	45	295	5	9.1
21	318	52	87.7	46	294	21	38.3
22	317	48	81.2	47	292	17	31.2
23	319	53	89.1	48	284	35	66.1
24	318	10	16.8	49	283	31	58.7
25	312	20	33.4	50	285	21	39.5

*Equation used shown in Section 3.5.3.

from the multiple and simple regression analysis is presented in tabular form in Appendix 8 and the simple regression in graphic form in figures 4 to 9. The regression analysis was made on plots unstratified for aspect. The regressions of the stratified data were not tested to establish whether the regressions were significantly different.

The data for the regressions of the variables "time since burning", "elevation", and "site index" was derived from the same plots. Independent analysis of each variable should be avoided and, instead, analysis of covariance used. In this study, though, analysis of covariance was not used because in most instances the plot distribution was a prohibitive factor.

4.1.1 Sampling Period

The pellet group counts of the first sampling period were, in general, correlated very significantly to the independent variables ("time since burning", "elevation", and "site index"). The null hypothesis that the slopes of the regression did not differ significantly from zero was rejected at the 1 percent level. Analysis of the stratified data on "north slope" for "elevation", and on "south slope" for"time since burning" did not reveal statistically significant regressions at P .01. In both of these cases the significance of the regression was reduced to P .05.

A test for linearity of all the simple regressions was made. The null hypothesis stated that the regression was linear. The hypthesis was not rejected for all regressions except those where "time since burning" was the independent variable both for unstratified plots and stratified for north and south aspect. In the first instance the level of significance was P .05 but in the latter two it was P .01.

4.1.1.1 Time Since Burning (Autogenic Succession)

The relationship between "pellet group counts" (hereafter referred to as "deer use") and "time since burning" is significantly non-linear. The best fit line for both the unstratified and stratified data was drawn by computer at U.B.C. using the model for a fourth degree polynomial as the underlying regression model. The results are are shown in Figure 4a and 4b South. The line for Figure 4b North was drawn free-hand t o illustrate the relationship expressed by the data.

The graphs depict a trend which suggests that deer use is maximum on those areas which were burned 8 or 9 years previously. This appears to be trûe for both the north and south aspects. The difference in the use by deer of burns is initially slow for the first few years after fire and then it is more rapid. A "plateau of use" is reached after about 7 years. On south slopes deer soon use on those plots reaches a first peak and then after a lag of 2 or 3 years deer use again increases until it reaches a major second peak at (or near) 8 years from the time the forest was first logged and burned.

4.1.1.2 Elevation

During the first period of sampling, but not during the second, the response of deer use to elevational change,

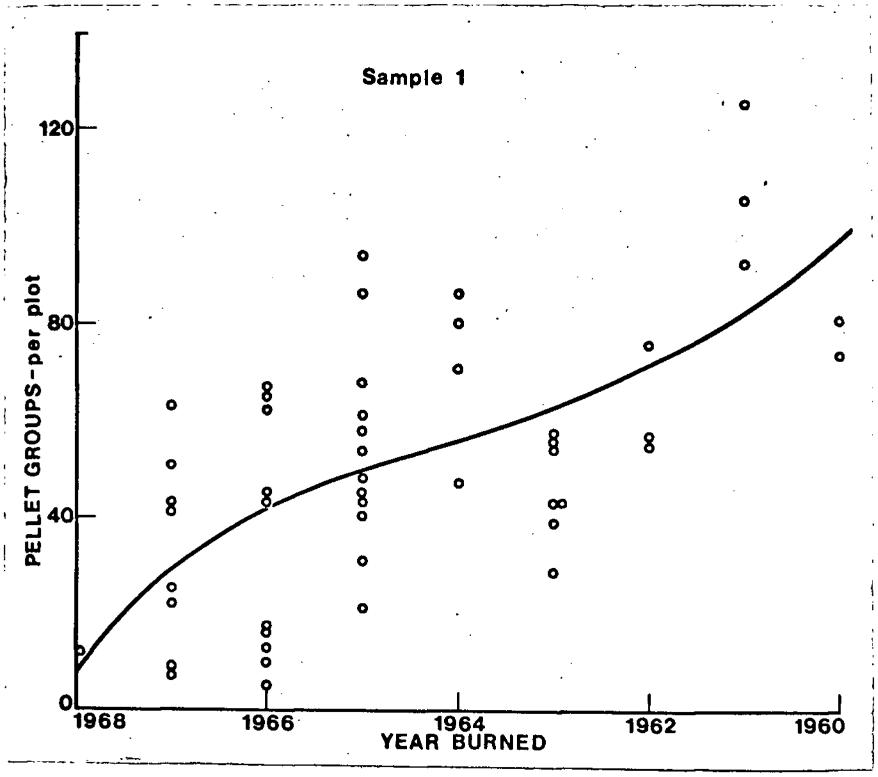

Figure 4a Response of deer to age of burn. Observations for first sampling and for plots on all aspects.

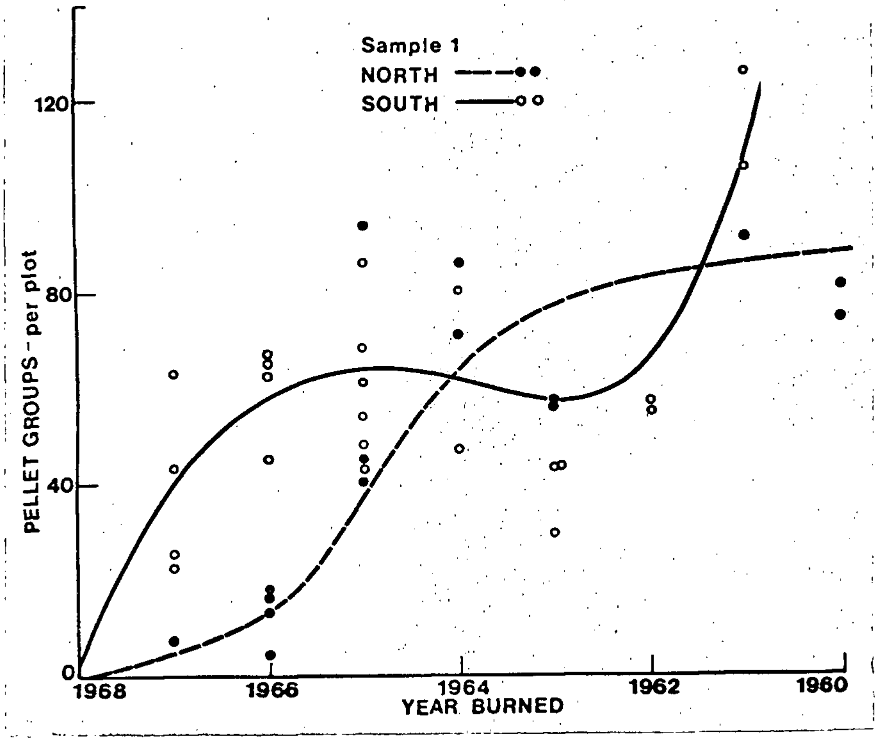

Figure 4 b Response of deer to age of burn. Observations for first sampling and stratified for north and south aspects.

from 800 to 3200 feet, was negative (Figures 5a and 5b). The response was similar on both the north and south aspects with the exeption that the decline in use was more rapid on the north slope. Deer use at every elevation, within the range studied, was less on the north slope than on the south.

4.1.1.3 Site Index

The "response of deer" to "site index" is partially masked by the negative correlation of site index to elevation. This is evident by the correlation coefficients shown in Table 5.

Table 5

Correlation Of Elevation And Site Index In The Nimpkish Valley.

Aspect	Correlation Coefficient	Coefficient of Determination
North	-0.8803	0.7749
South	-0.7965	0.6344
All	-0.7501	0.5626

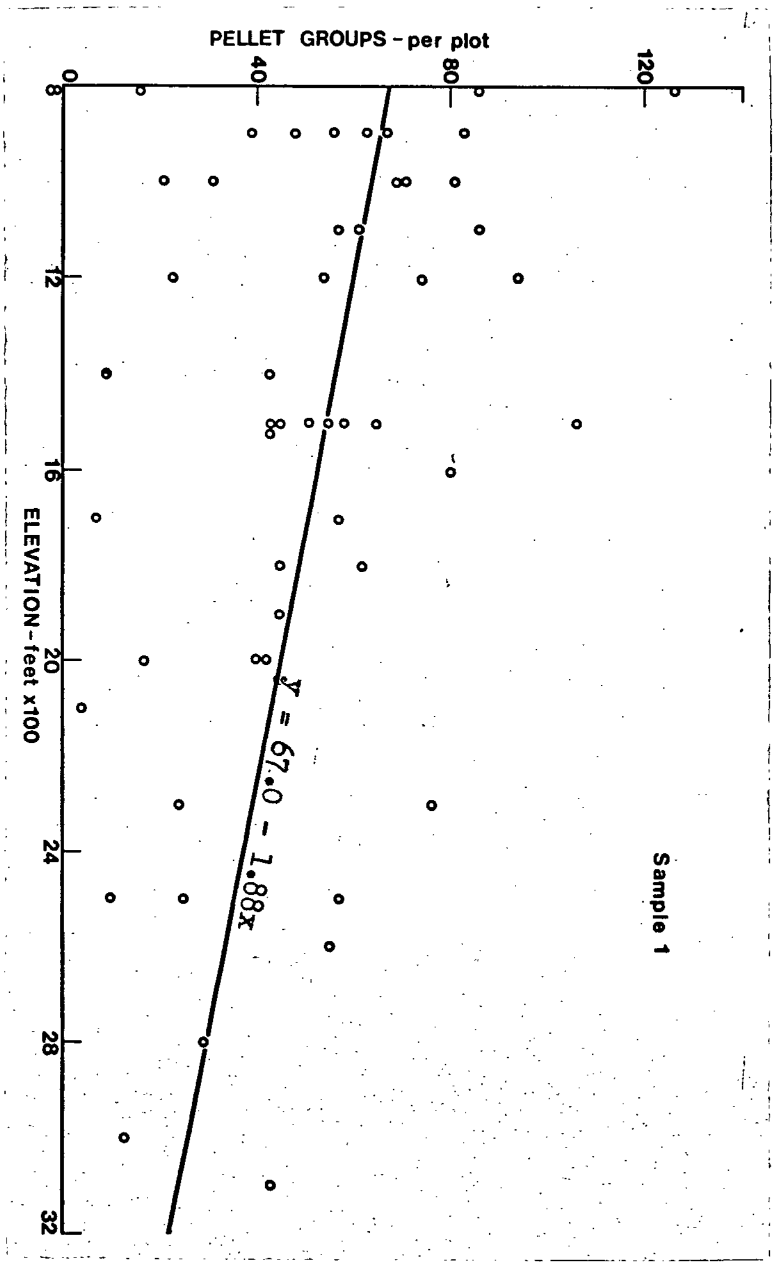

Figure 5a Response of deer to elevation on logged areas. Observations for first sampling and for plots on all aspects.

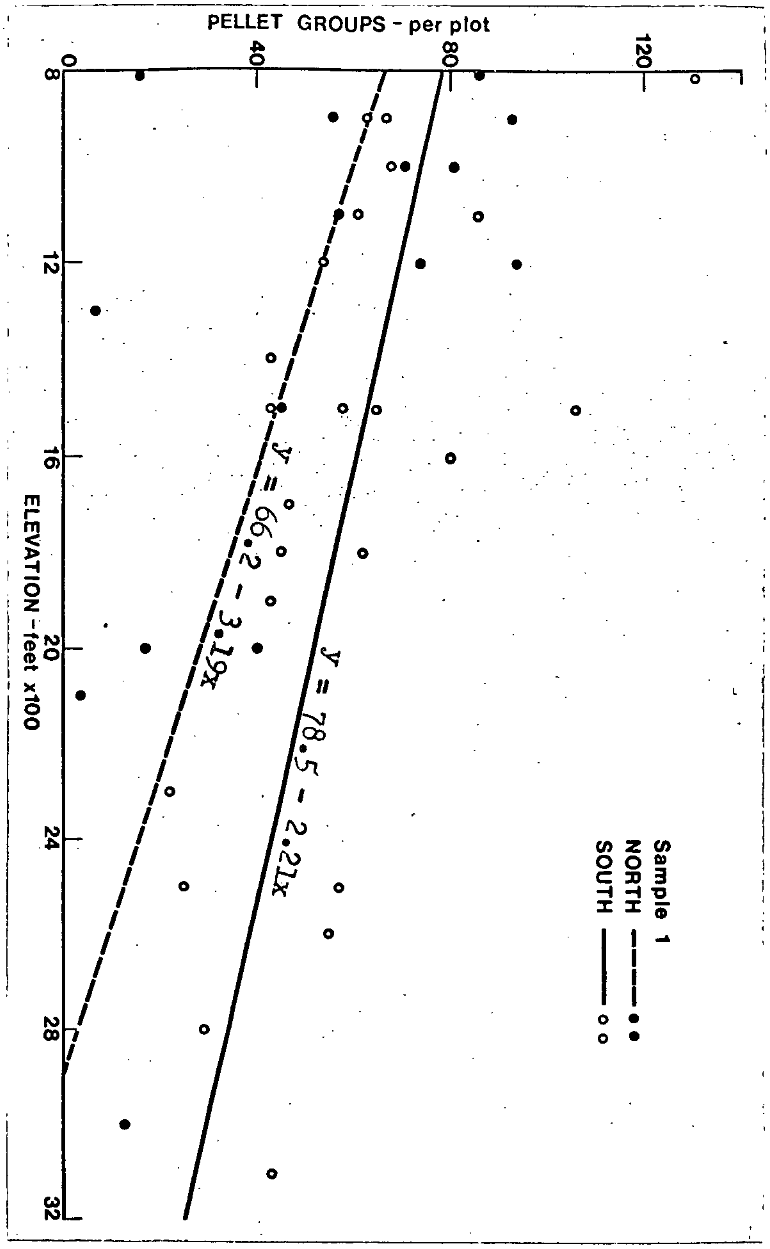

Figure 5b Response of deer to elevation on logged areas. Observations for first sampling and stratified for north and south aspects.

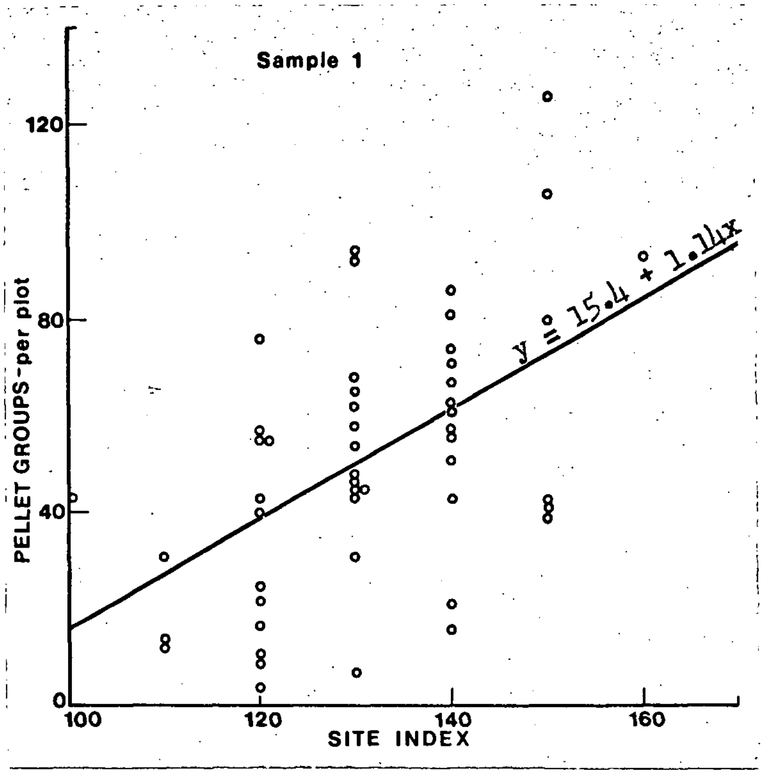

Figure 6a Response of deer to site index on logged areas. Observations for first sampling on all aspects.

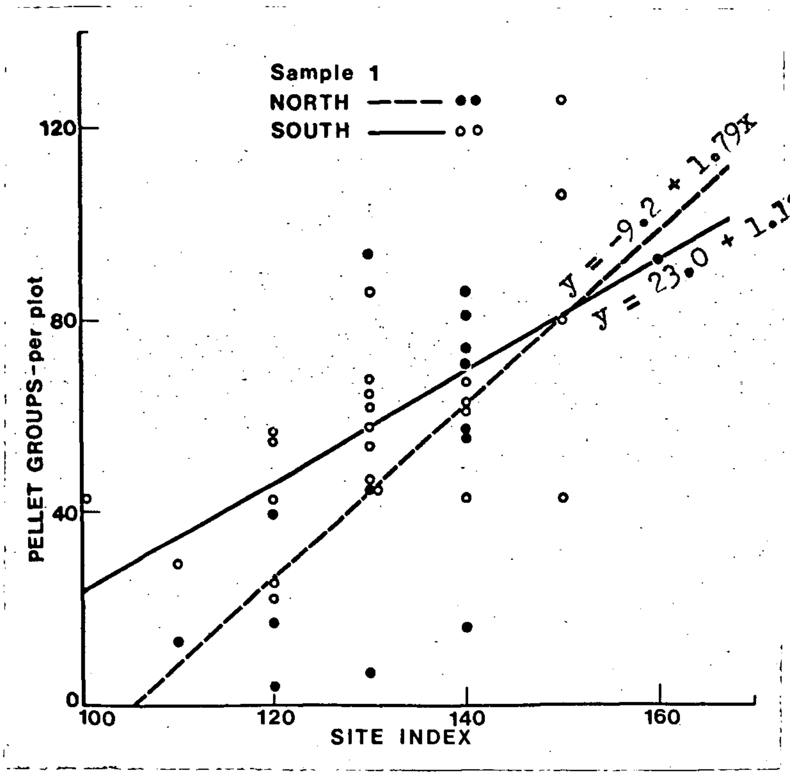

Figure 6b Response of deer to site index on logged areas. Observations for first sampling and stratified for north and south aspects.

When analyzed with simple regression, however, shows a significant linear relationship with deer use. This relationship can be seen in Figure 6a and 6b. Deer use on a north aspect shows a greater response to an increased site index than it does on a south aspect. This may be a true relationship of "deer use" with "site index" but also it could be the result of the correlation of site index with elevation.

4.1.2 Second Sampling Period

The behaviour of deer as indicated by pellet group counts in relation to autogenic succession, changing elevation, and changing site index, was different in the two periods. In general, the correlation of deer use with the independent variables was not significant at the P .05 level during the second sampling period. Only the time since burning showed a correlation at that level of significance.

A test for linearity was made, for all simple regressions. In all cases the null hypothesis as stated in Section 4.1.1., was not rejected at the P .05 level of significance.

4.1.2.1 Time Since Burning (Autogenic Succession)

The relationship of "deer use" to "autogenic succession" in this sample is significant at the P .05 level for the plots unstratified for aspect and for the north aspect of unstratified plots (Figures 7a and 7b). This relationship was

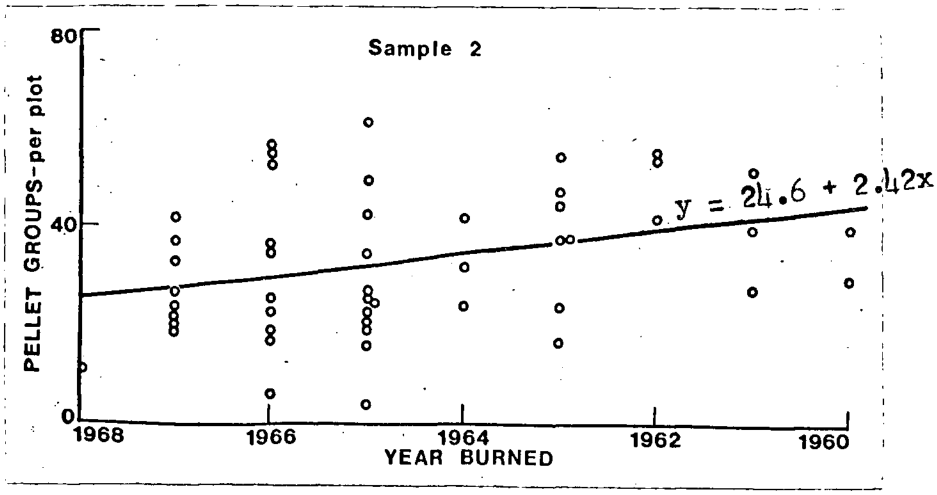

Figure 7a Response of deer to age of burn. Observations for second sampling and for plots on all aspects.

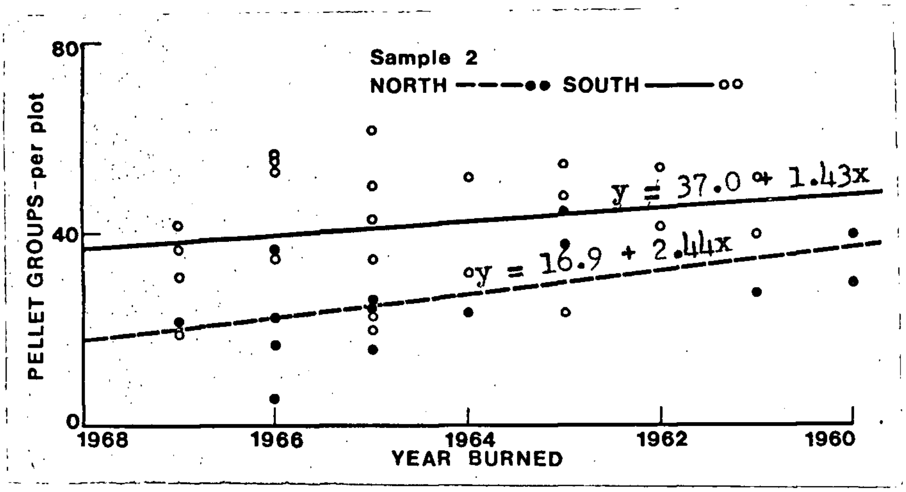

Figure 7b Response of deer to age of burn. Observations for second sampling and stratified for north and south aspects.

not significant for "the south aspect".

Regression analyses of data, stratified by aspect (north and south), indicates that deer use is lower on the north aspect than on the south (Figure 7b). This response is similar to that found in the first sampling but differs in that the regression is statistically less significant.

4.1.2.2 Elevation

In the second sampling period the "response of deer" to "elevation" was somewhat different from that of the first sampling period. Although the regression is not significant at the P=.05 level the regression coefficient is now generally positive with increasing elevation. This is true for the data, unstratified for aspect and for the data stratified for the south aspect. The data for the north aspect deviates from the general with a negative regression coefficient (Figures 8a and 8b).

Although the relationships of deer use to elevation are fairly weak, in this sample, several generalities can be made. For the period that this sampling represents, the deer use with elevation differed on the north and south aspects. On the south aspect deer utilized the upper elevations (up to 3200 feet) more than the lower but on the north aspect deer utilized the lower elevations more than the upper.

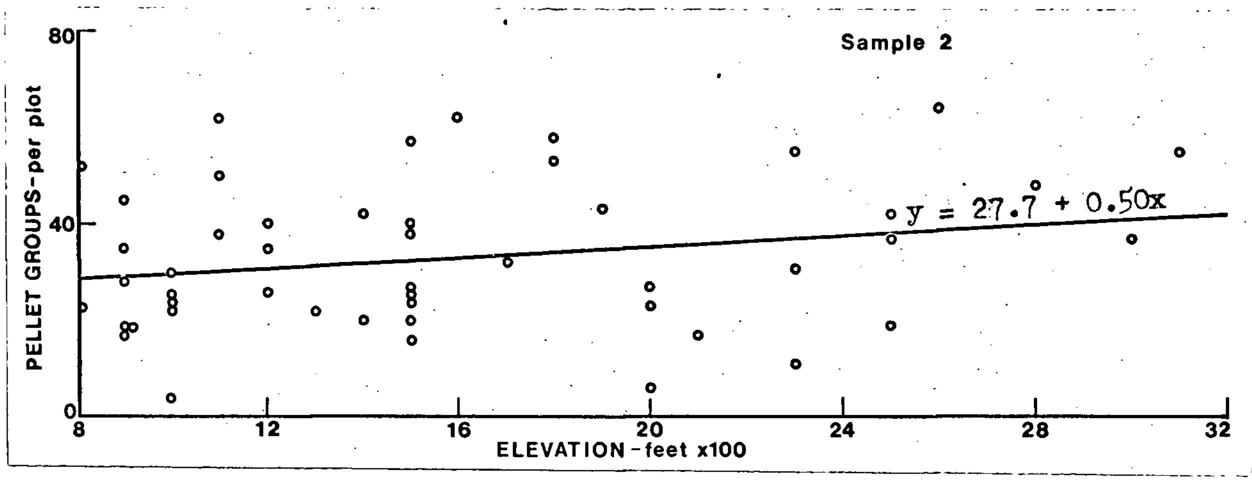

Figure 8a Response of deer to elevation on logged areas. Observations for second sampling and for plots on all aspects.

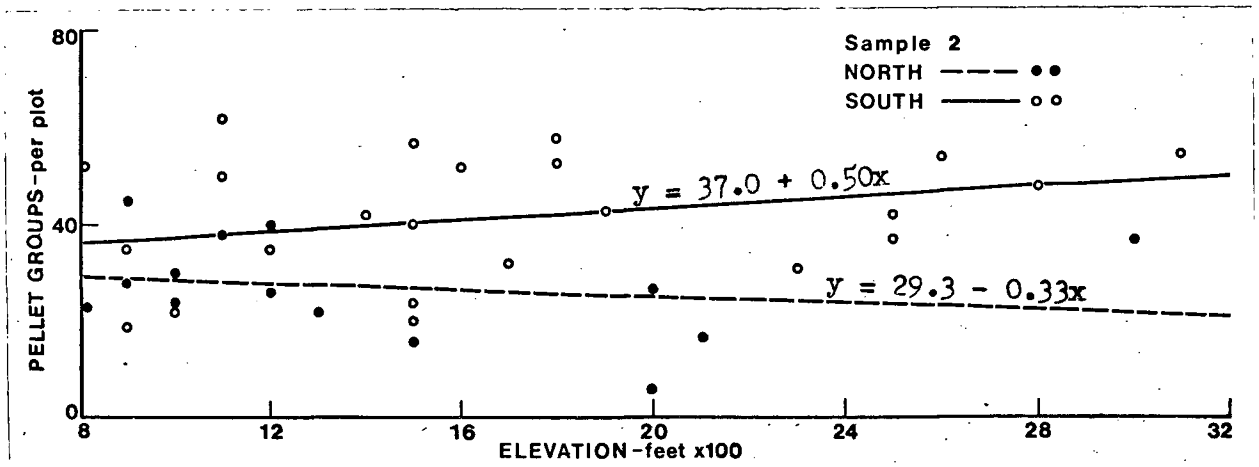

Figure 8b Response of deer to elevation on logged areas. Observations for second sampling and stratified for north and south aspects.

4.1.2.3 Site Index

Correlations of site index and elevation (Table 5) on first and second samplings are similar. The regression analysis of this data indicates that the relationship of "deer use" to "site index" is negative except on the north aspect (Figures 9a and 9b). A similar negative relation exists with elevations in this sample (Section 4.1.2.2.).

4.1.3 Change of deer use with Elevation for the Two Sample Periods

Several references have been made to deer use of logged forests at various elevations (Section 4.1.1.2 and 4.1.2.2.). It was noted that a change occurred in the response to elevation between the two sampling periods. In the first period deer use declined with increased elevation, but in the second period use increased with elevation except on the north aspect where it showed a decline. This change is illustrated in Figure 10.

The average pellet groups per plot of the first sampling was adjusted to that of the second (the pellet groups per plot were proportionately reduced). Then the pellet

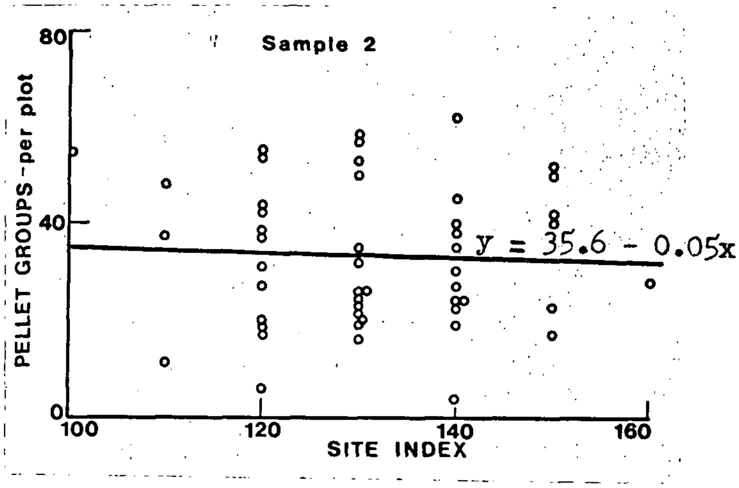

Figure 9a Response of deer to site index on logged areas. Observations for second sampling and for plots on all aspects.

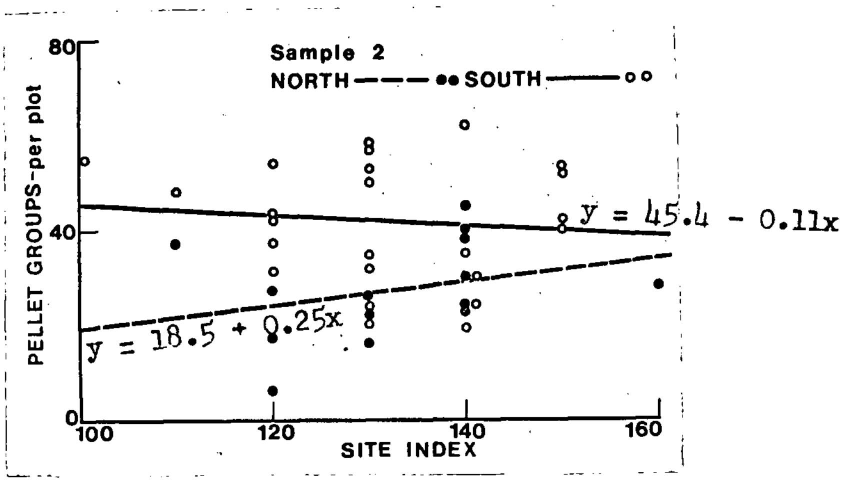

Figure 9b Response of deer to site index on logged areas. Observations for second sampling and stratified for north and south aspects.

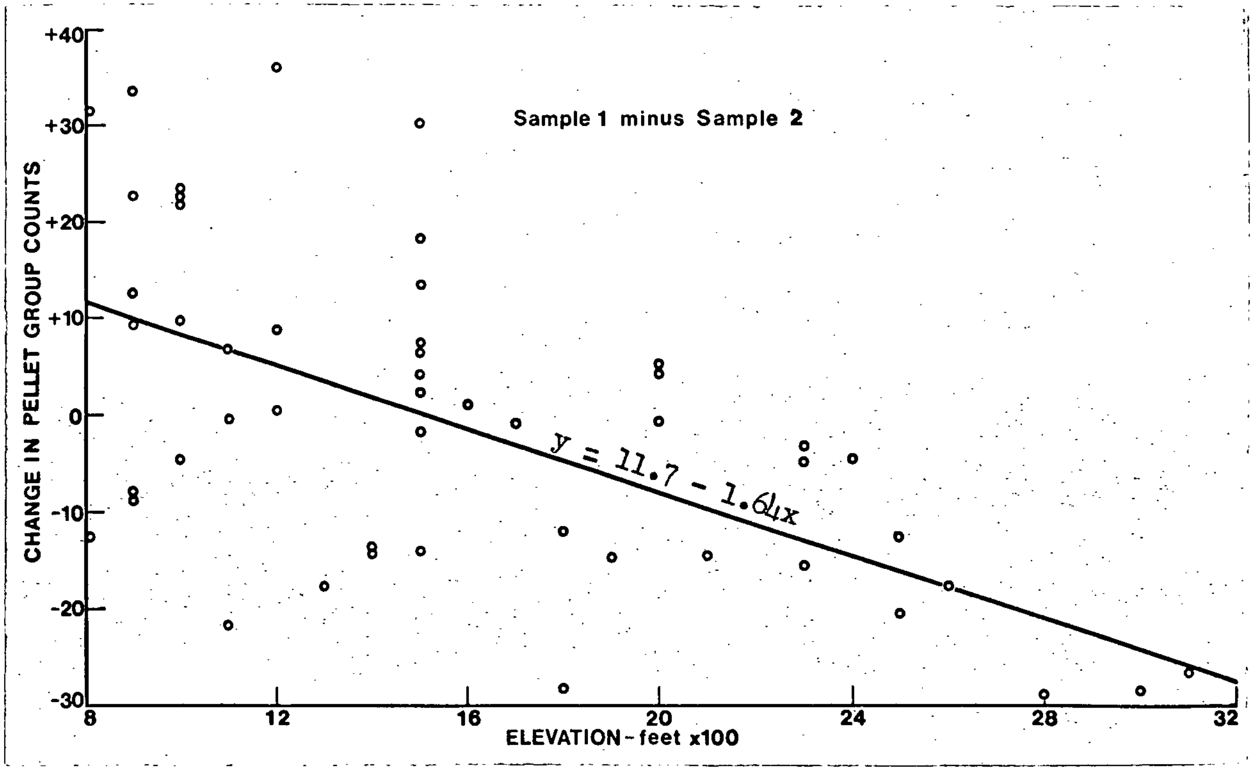

Figure 10 Change in deer use with elevation between two sampling periods.

groups per plot were subtracted from the adjusted pellet group counts for the corresponding plot data of the first sampling. A regression analysis of this difference with elevation indicates that the regression is highly significant P=.01) and with a coefficient of determination of 0.36 (Appendix 9).

4.14 Change of Snowfall for the Two Sampling Periods

The change in deer use with elevation occurred simultaneously with a significant change in snowfall for the winter preceding the sample. Two tables have been constructed to show the snowfall from 1966 to 1970 at Woss Camp (Table 6) and from 1963 to 1970 at 9 locations in the Pacific Northwest and at various elevations (Table 7). The two winters of particular interest are those occurring in 1968-69 and in 1969-70. Table 6 illustrates an important difference in snowfall between these winters. In the first winter the snowfall was exceptionally heavy compared to the long term mean, and in the second winter the snowfall was exceptionally light. Similar observations can be made for the snowfall data in Table 7. Columns 8 and 10 show the snowfall difference from the long term mean for the winters of 1968-69 and 1969-70 respectively.

4.15 Vegetation

A sample of vegetation on each plot is given in Appendix 10. The information provided gives the species

Table 6

Monthly Snowfall from 1966 to 1970
Woss Camp (Elevation 550 ft a.s.l.)

Winter Recorded	October	November	December	January	February	March
1966-67	0	0	0	24.1	0.1	0.6
1967-68	0	0	0	28.5	0	0
1968-69	0	4.0	20.5	82.0	26.75	0
1969-70	0	0	0	7.5	0	0
Avg. Snow-fall by Month	0	1.0	5.1	35.5	6.7	.15

Data contributed by Canadian Forest Products Ltd.

Table 7

Snowfall At Several Coastal Drainage Basins and Snow Courses From 1963 to 1970
(A comparison is also made of the snowfall during 1969 and 1970 to the average for the years shown).

Location and Elevation	Average Snow Accumulation between February to March (inches) 1 1963	2 1964	3 1965	4 1966	5 1967	6 1968	7 1969	8 Deviation from avg.	9 1970	10 Deviation from avg.	11 Average
Upper Quinsam; Mid-eastern Vancouver Island (VI)2100 ft.	12.6*	43.2	32.1	42.3	48.1	32.1*	68.5*	+28.0	5.9	-34.6	40.5
Tripp Meadows; South (VI); 2700 ft	2.0	56.4	41.3	39.6	39.9	26.7	61.8	+21.9	5.6	-34.3	39.9
Lyford Mt.;South Central VI;3000 ft.	5.8	52.6	20.8	NA**		10.2*	61.8*	+35.5	0*	-26.3	26.3
Mt.Seymour; Mainland; 3650 ft.	73.4	208.4	130.1	146.2	166.4	129.8	165.5	+27.2	91.3	-47.0	138.3
Forbidden Plateau;East coast, central V.I. 3700 ft.	97.8	156.8*	99.3	171.4	177.9	155.7	197.8	+59.0	124.1	-14.7	138.8
Grouse Mt.; Mainland; 3800 ft.	51.0	169.1	105.1	130.0	153.1	107.8	140.5	+25.0	67.4	-48.1	115.5
Newcastle Ridge; East Coast, Northern V.I.; 3850 ft.	87.2	150.7	87.7	129.3	147.1	92.1	149.8*	+33.3	118.1	+ 1.6	116.5

Table 7 (continued)

	Average Snow Accumulation between February to March (inches)										
	1	2	3	4	5	6	7	8	9	10	11
Location and Elevation	1963	1964	1965	1966	1967	1968	1969	Deviation from avg.	1970	Deviation from avg.	Average
Burman Lake; Mid-central V.I.; 4100 ft.	98.4*	187.2	120.3	171.9*	191.1	107.5	191.3	+45.9	109.9	-35.5	145.41
Sno-bird Lake; South central V.I. 4585 ft.	NA	NA	NA	144.7	125.6*	97.5	148.4	+28.1	95.4	-24.9	120.3

* Measurements from less than three months not available.

**Not available

Information obtained from British Columbia Snow Survey Bulletins; Published by Dept. of Lands, Forests, and Water Resources, Victoria, B.C.

present and their relative cover, the average cover of all species and the range of cover in the samples taken.

4.2 Ecotone Study (Sub-project b)

Information obtained in the ecotone study permitted observations in three areas; a study of deer use (a) from the forest edge (b) from the road edge, and (c) with non-arborecent vegetation. The observations for this study are shown in Figures 11 to 29. The individual observations were grouped into classes, the means for each class were calculated (for both dependent and independent variables), the confidence limits (95%) estimated, and the means plotted into graphs. The means, confidence limits, number of individual observations per class, and the class limits are shown in Appendix 11a and 11b for the data "outside" and "inside" forest respectively. The range and median of the 95 percent confidence limits for the class midpoints of each figure are shown in the subscript of that figure.

In this study five plots were used (described in Appendix 5). Each plot was partially inside the matûre forest, the proportion varying from somewhat over one half to about one third the total plot area.

The distribution of pellet groups on each plot was calculated for both inside and outside forest as well as for stratified (with respect to distance from the forest edge) sections of the plot (Appendix 12). In all cases the $\frac{s^2}{\bar{x}}$ ratio was greater than one and the data fitted the negative binomial distribution the closest (when tested for normal, binomial, negative binomial and Poisson distributions).

Observations were stratified in numerous instances. The basis for stratification was, "time since burning" and "aspect" for the data outside the forest, and "aspect" alone inside the forest.

4.2.1 Forest Edge Effect

The relationships of deer use with distance from the forest edge are shown in Figures 13 to 21. Since the factors affecting deer use on recently logged forests and in mature forests are different to a certain extent, the two observations are recorded separately.

4.2.1.1 Outside Forest (Perpendicular to Upper Forest Edge)

The plots in this study were burned at two different periods, in 1961 and 1966 (actually plot 5 was burned in 1967). Vegetation on the burned plots tends to be fairly evenly distributed by species composition and cover. A view of the vegetation areas, representating plot 1 and plot 2 and 3, can be seen in Figures 11 and 12 respectively.

Abandoned roads appear to be important in the distribution of deer over logged areas. Although a section on the effect of roads is presented in Section 4.2.2. reference is made to them here since their presence introduces variability in deer use along the forest-logged area ecotone. In plots 2, 3, and 5 a road provided the border on the side farthest from the forest edge. In plots 1, 2, and 3 roads

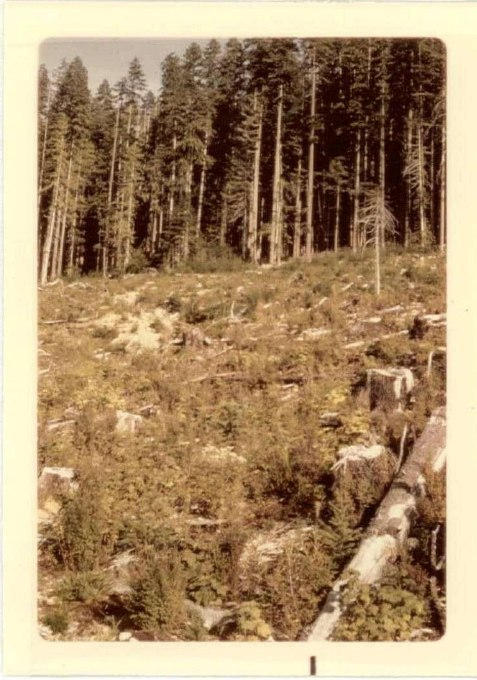

Figure 11 A view of the vegetation outside the forest on plot 1.

Figure 12 A view of the vegetation outside the forest on plots 2 and 3.

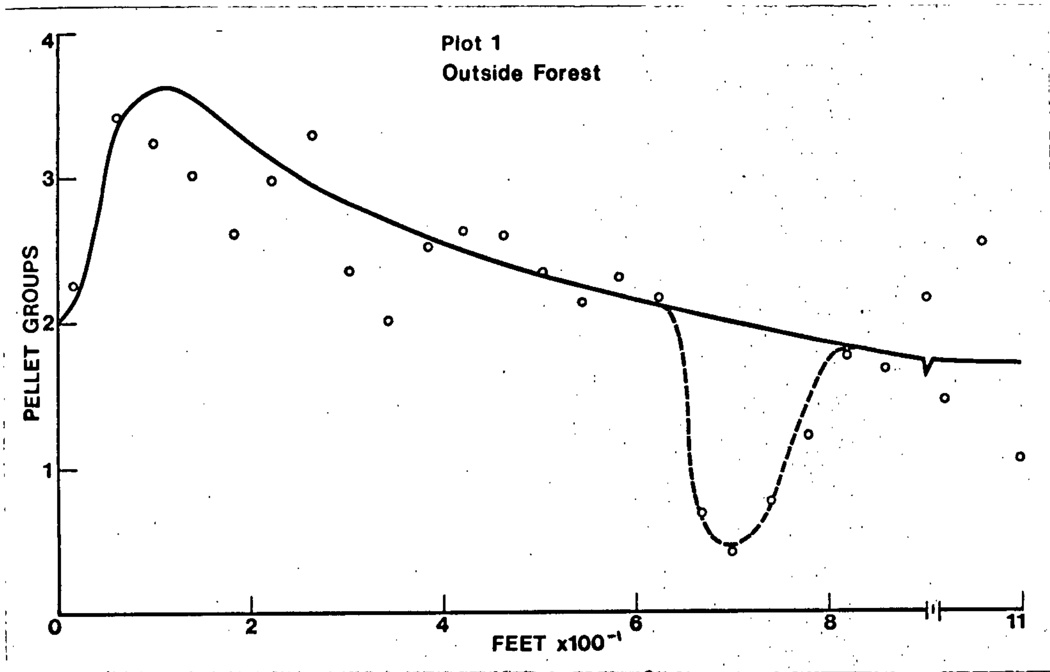

Figure 13a Effect of upper forest edge on deer use of a southern exposure logged and then in 1961 slash-burned. Broken line indicates effect of road on deer use.

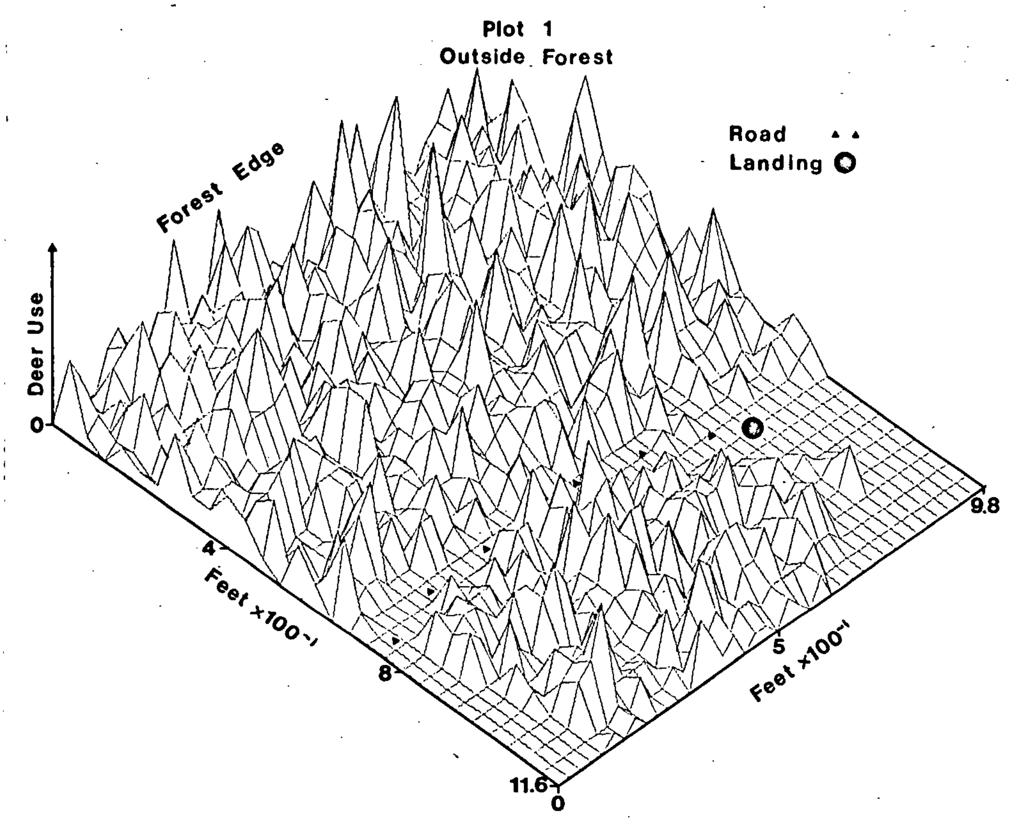

Figure 13b Pellet group distribution on a southern exposure and a 1961 burn.

Figure 13a (Confidence limits (95%) Range 0.24-0.82, Median 0.59)

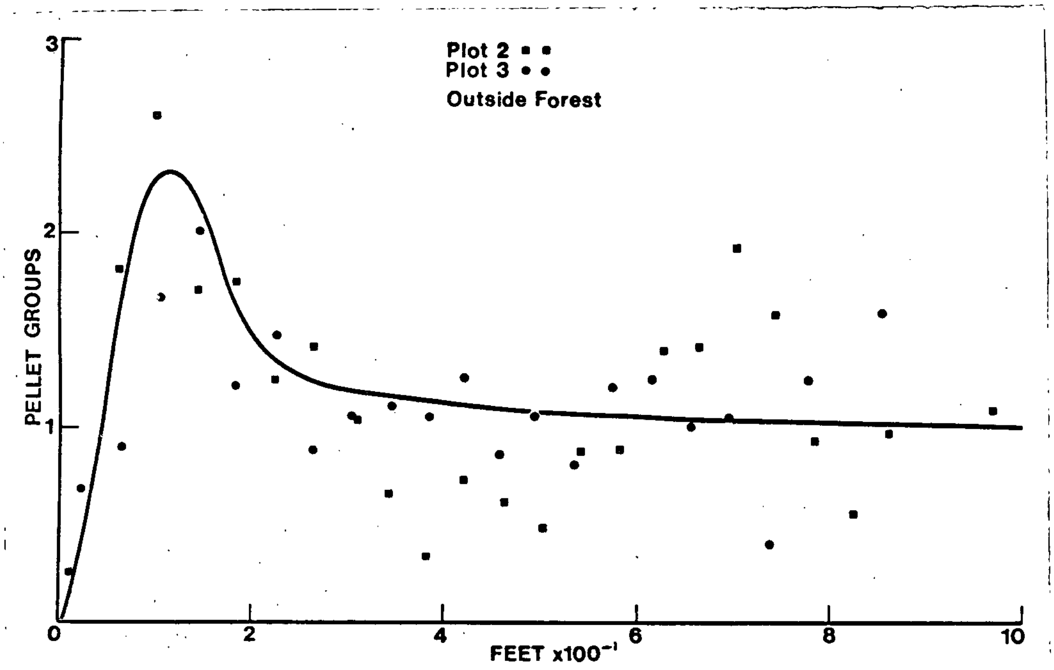

Figure 14a Effect of upper forest edge on deer use of a southern exposure logged and then in 1966 slash-burned. (Confidence limits (95%); Plot 2, Range 0.16-0.77; Median 0.46; Plot 3, Range 0.24-0.67, Median 0.49)

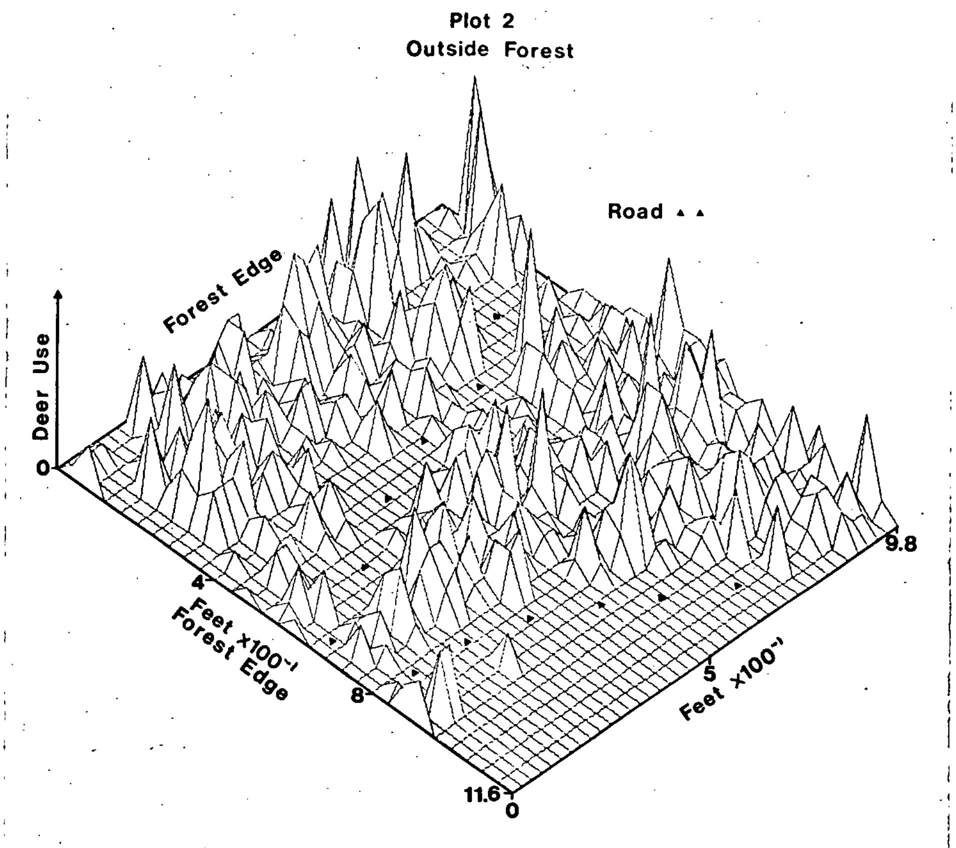

Figure 14b Pellet group distribution on a southern exposure and a 1966 burn.

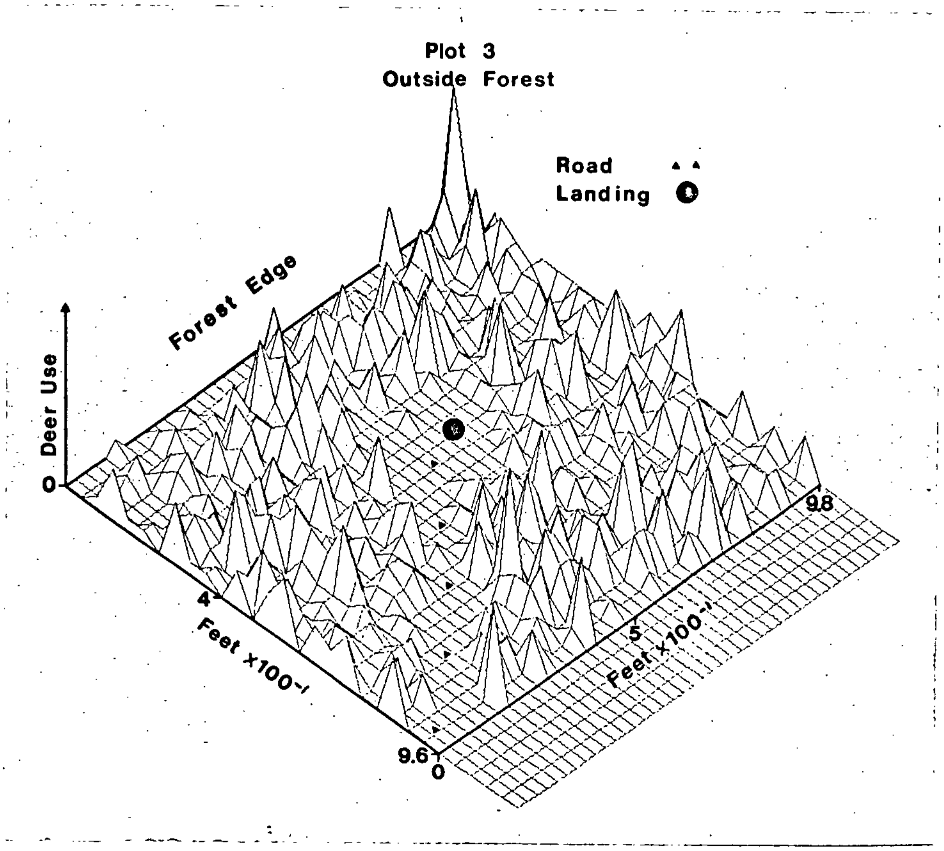

Figure 14c Pellet group distribution on a southern exposure and a 1966 burn.

also were on the plots. Their effect can best be seen in Figures 13b, 14b, and 14c, and an indication of it by the broken line in Figure 13a.

The general effect of the forest edge appears to be to increase deer use to a maximum about 100 to 200 feet from the edge. The deer use at the forest edge is altered by the presence or absence of a fireguard at the edge. Where a fireguard is present the use is zero (plots 2 to 5), but where it is absent the use at the forest edge is above zero (Plot 1).

On plots 2, 3 and 5 with a 1966 burn, the point of maximum use from the forest edge, peaks and declines rapidly. The deer use levels off rapidly at first and then, gradually with distance from the forest edge. These trends change on plots 1 and 4 with a 1961 burn. On the latter plots the deer use peaked rapidly, as in the former plots, but the decline in use from the forest edge was much more gradual.

The height of the curves in Figures 13a, 14a, 15a, and 16a vary. The extent of the difference seems to correspond with the estimated population of deer on each plot (Appendix 5). Plot 5 differs from this generalization by showing a higher curve in relation to the plot's estimated population.

A regression analysis was made of deer use with distance from the forest edge. Although the relationship is likely not linear, this assumption was made for ease in analysis.

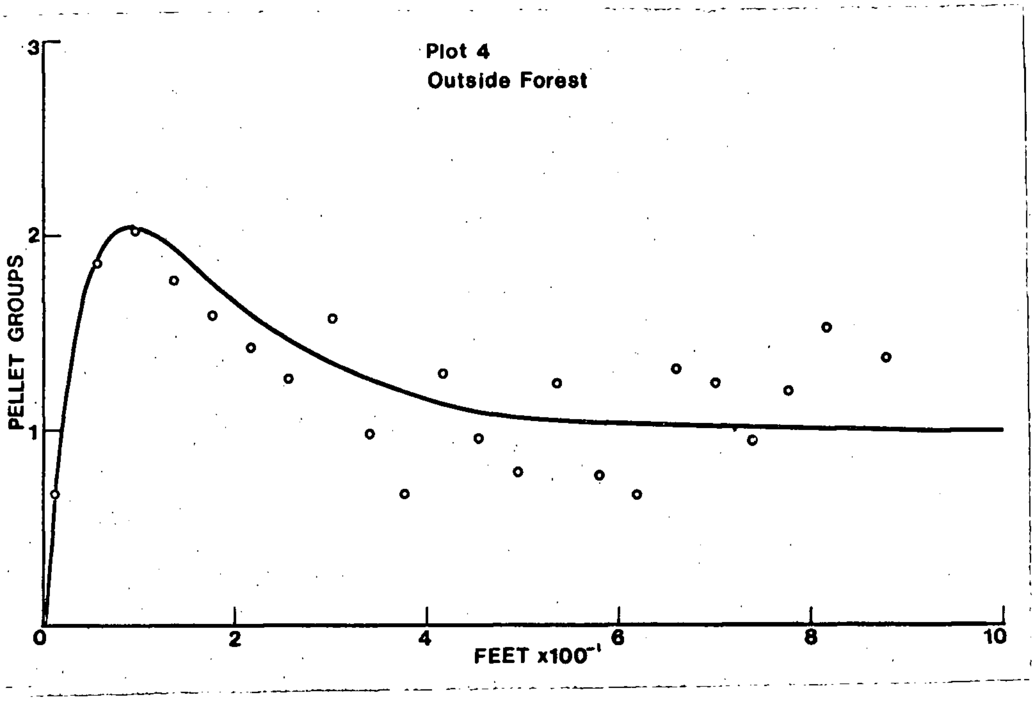

Figure 15a Effect of upper forest edge on deer use of a northern exposure logged and then in 1961 slash-burned. (Confidence limits (95%): Range 0.30-0.79, Median 0.52)

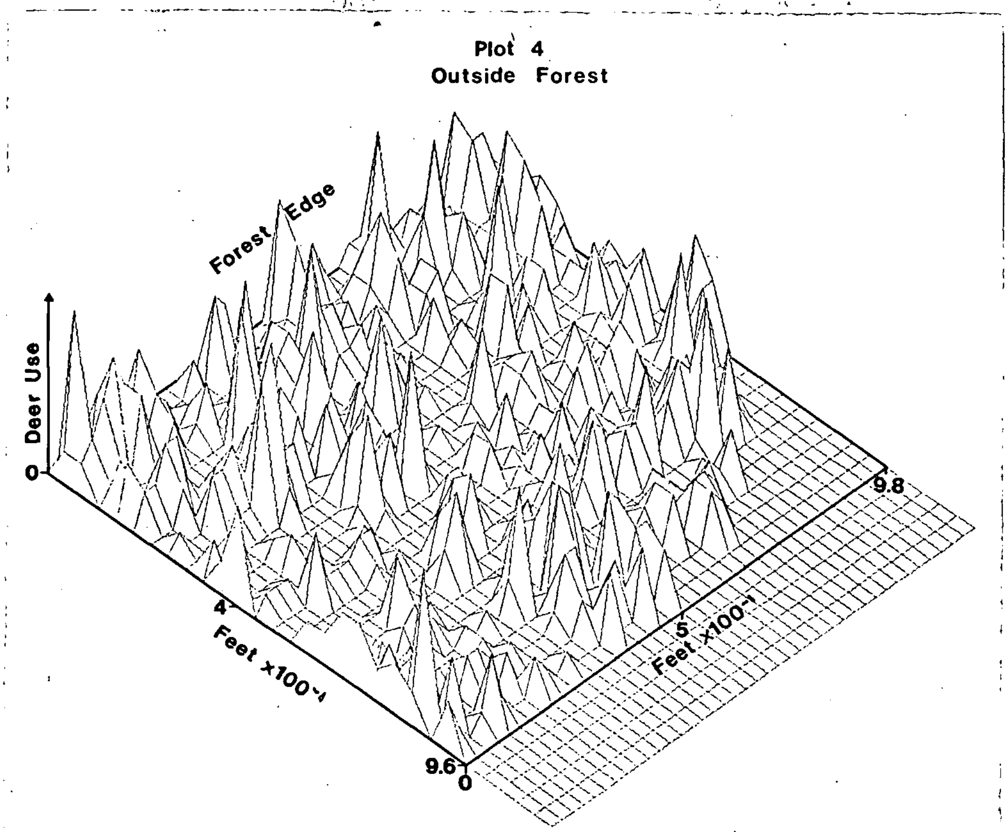

Figure 15b Pellet group distribution on a northern exposure and a 1961 burn.

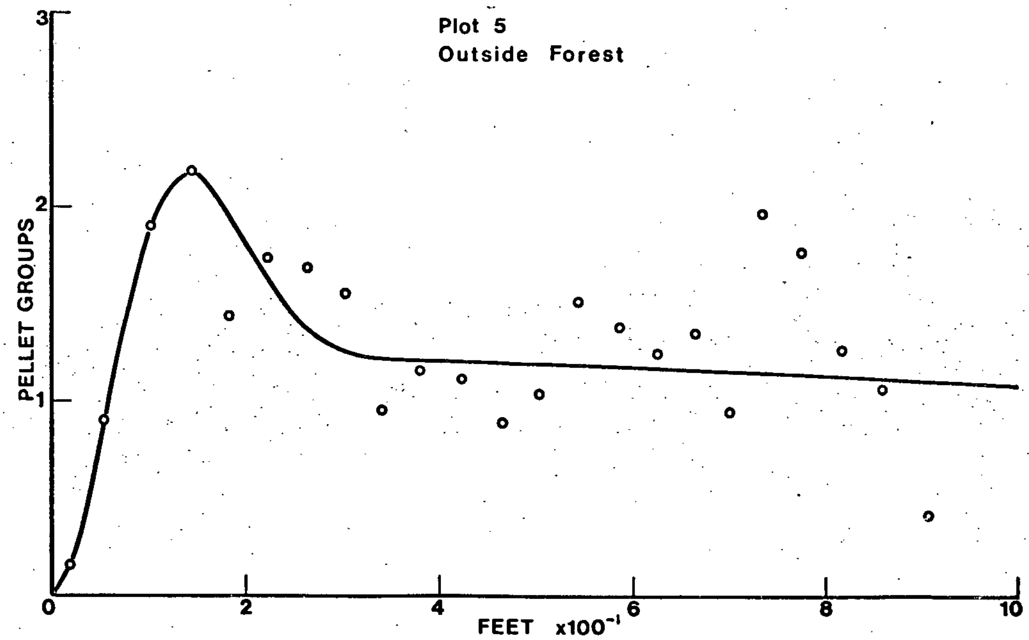

Figure 16a Effect of upper forest edge on deer use of a northern exposure logged and then in 1967 slash-burned. (Confidence limits (95%): Range 0.18-0.85, Median 0.58)

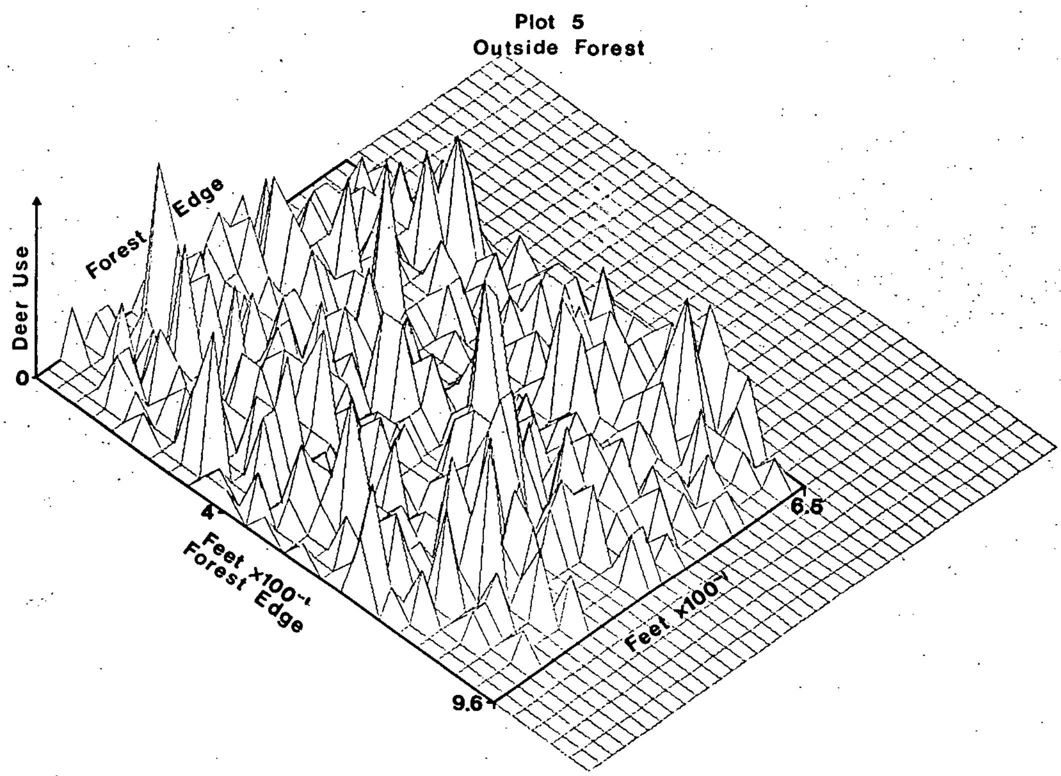

Figure 16b Pellet group distribution on a northern exposure and a 1967 burn.

For calculation the regression began at the point of maximum use which was usually less than 150 feet from the forest edge. The results are shown in Appendix 13. In all cases the regression coefficient was negative and, with one exception, highly significant (P=.01). The exception occurred in plot 3 where the regression was not significant at the P=.05 level.

4.2.1.2 Inside Forest (Perpendicular to Upper Forest Edge)

Deer use from the forest edge inside the forest is similar to that outside, however the former relationship does not appear to be determined by the latter. This conclusion is indicated by a comparison of the graphs for outside the forest (Figures 13 to 16) with the ones for inside the forest (Figures 17 and 18).

Figure 18 illustrates the response of deer to the forest edge on a north slope. Deer use reaches a peak in the forest about 100 feet from the edge and then drops to near zero at 400 feet. On the south aspect the decline is more gradual. The deer use is still considerable even at 1500 feet into the forest (Figure 17). A comparison of deer use on the north and south slopes inside the forest indicates that the peak use occurs at approximately the same distance from the edge. However, the use on the north aspect becomes unimportant within a short distance from the edge while on the south aspect the use is maintained at an important level for a considerable distance into the forest.

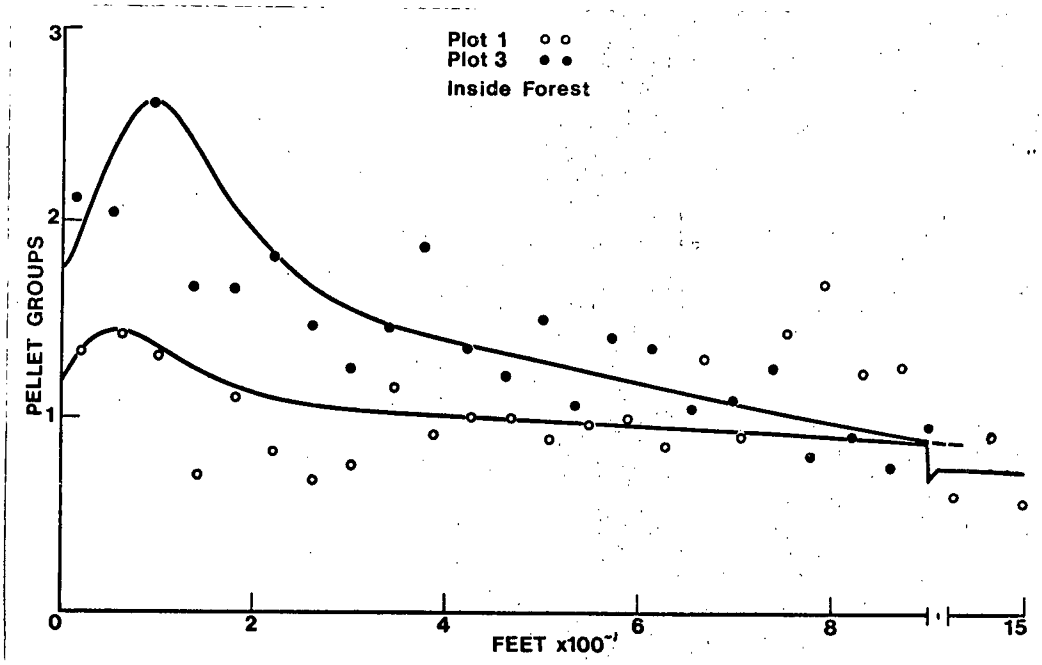

Figure 17a Effect of forest edge on deer use inside the forest on a south aspect. (Confidence limits (95%); Plot 1, Range 0.23-0.76, Median 0.45; Plot 3, Range 0.26-1.18, Median 0.64).

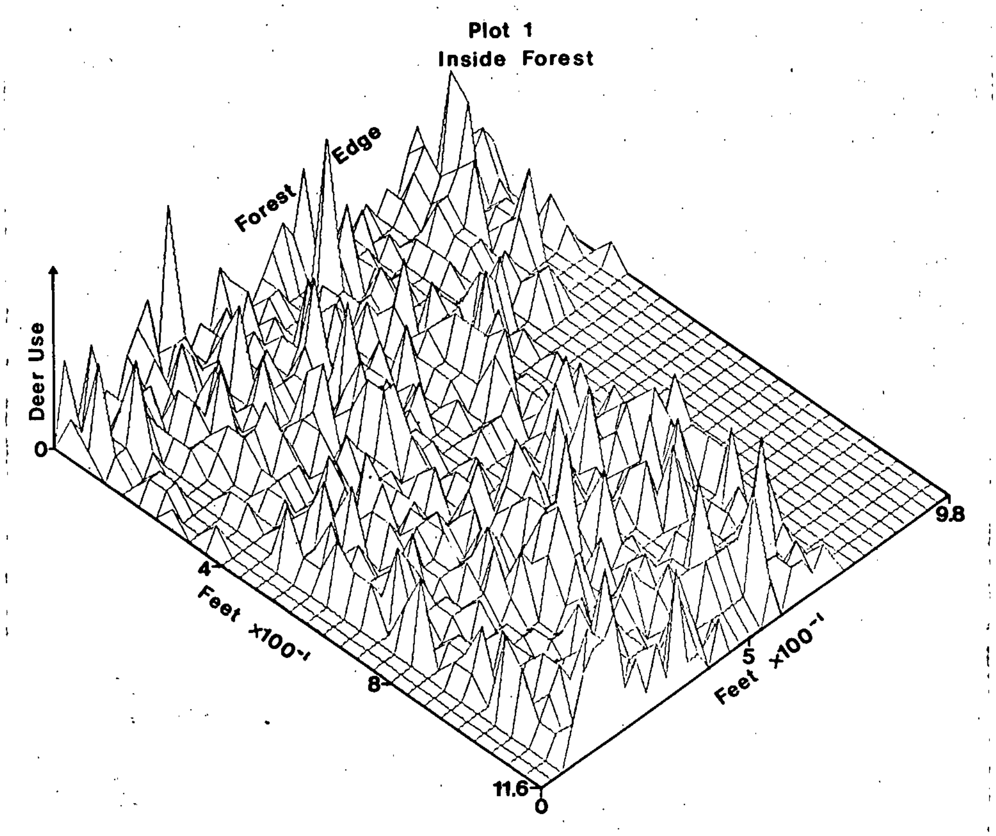

Figure 17b Distribution of pellet groups inside the forest on a south aspect. (Open transects, 400 feet from forest edge, not sampled).

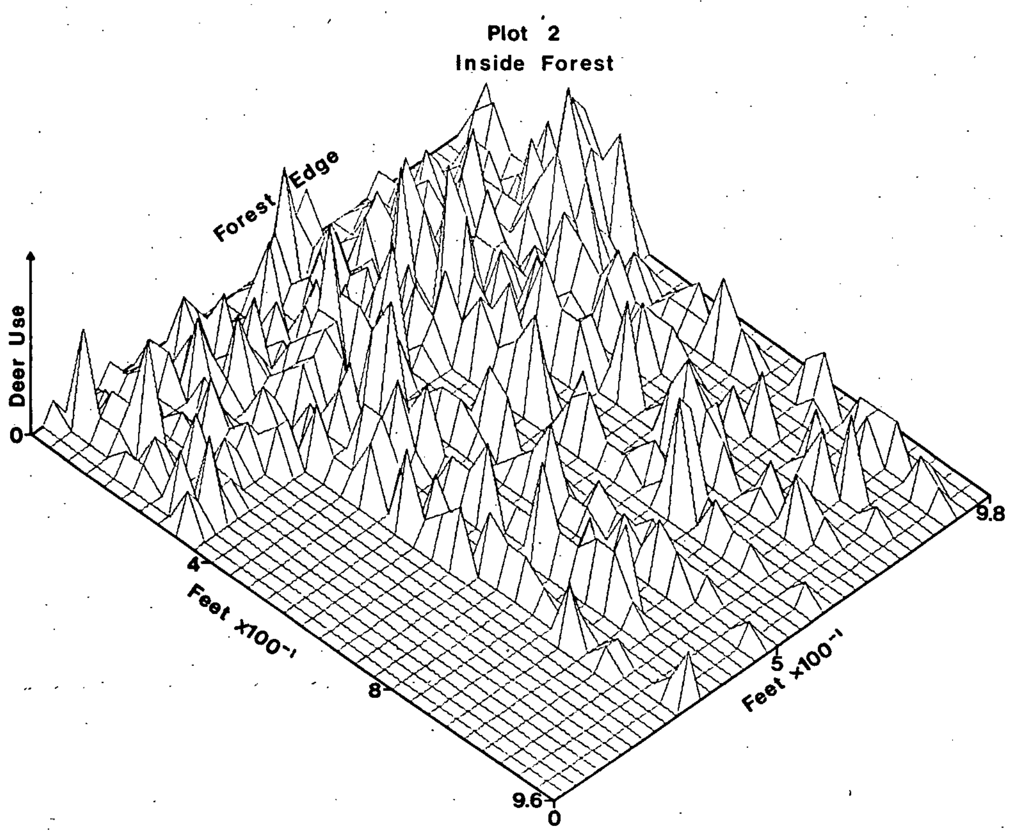

Figure 17c Distribution of pellet groups inside the forest on a south aspect (open transects, 360 feet from the forest edge, not sampled).

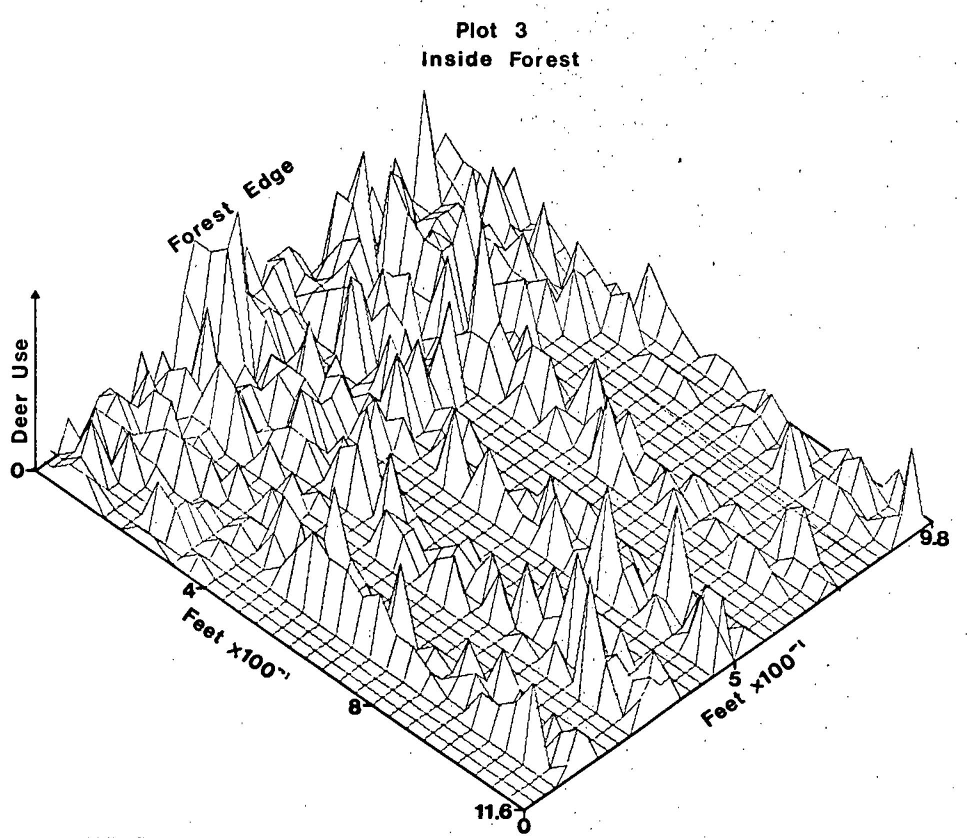

Figure 17d Distribution of pellet groups inside the forest on a south aspect (open transects, 400 feet from the forest edge, not sampled).

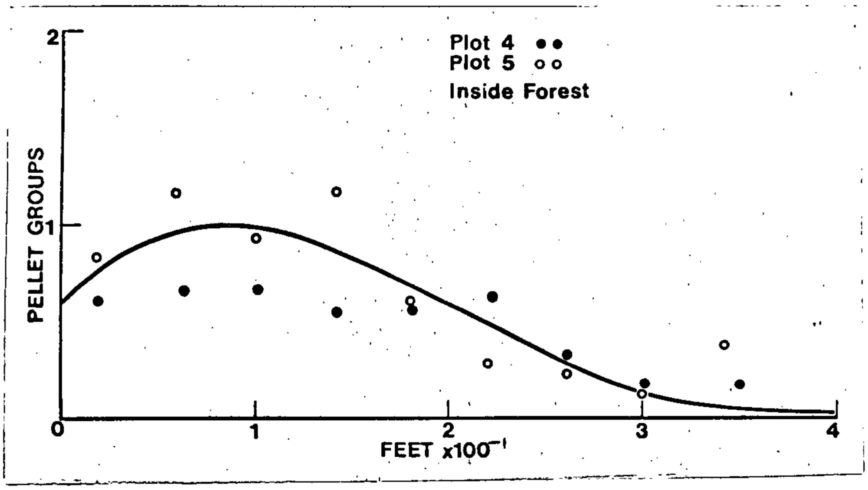

Figure 18a Effect of forest edge on deer use inside the forest on a north aspect. (Confidence limits (95%): Plot 4, Range 0.10-0.42, Median 0.37; Plot 5, Range 0.20-0.52, Median 0.33)

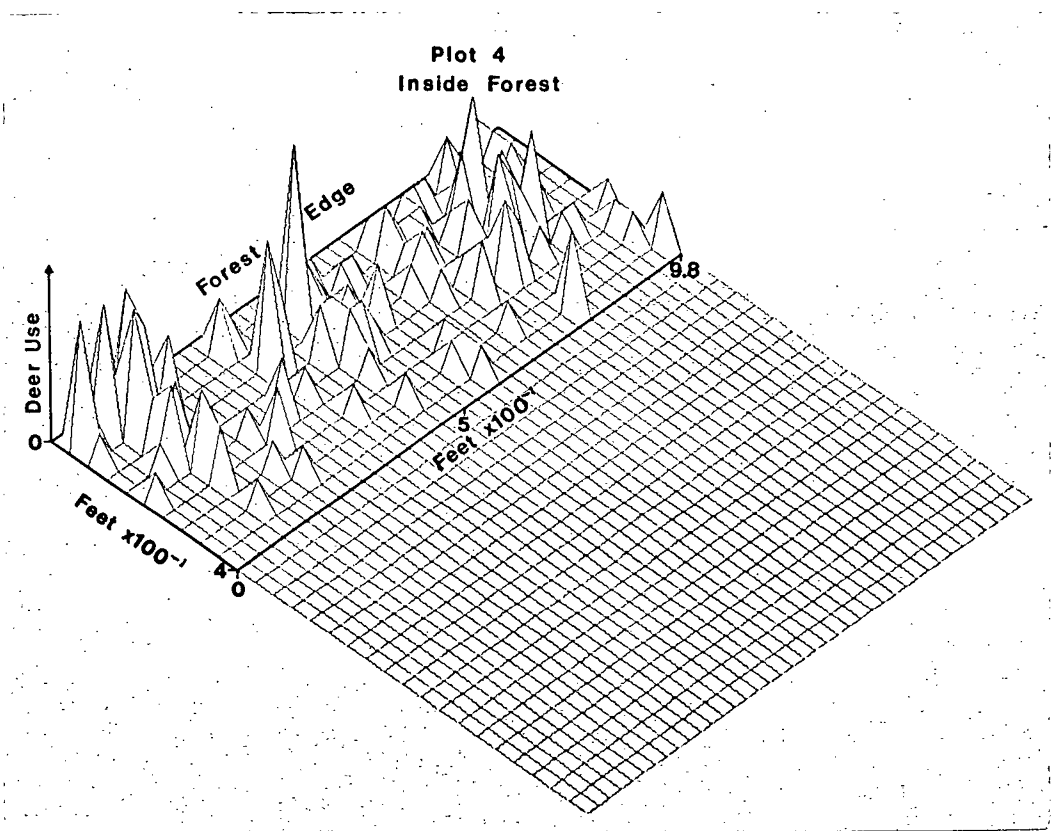

Figure 18b Distribution of pellet groups inside the forest on a north aspect.

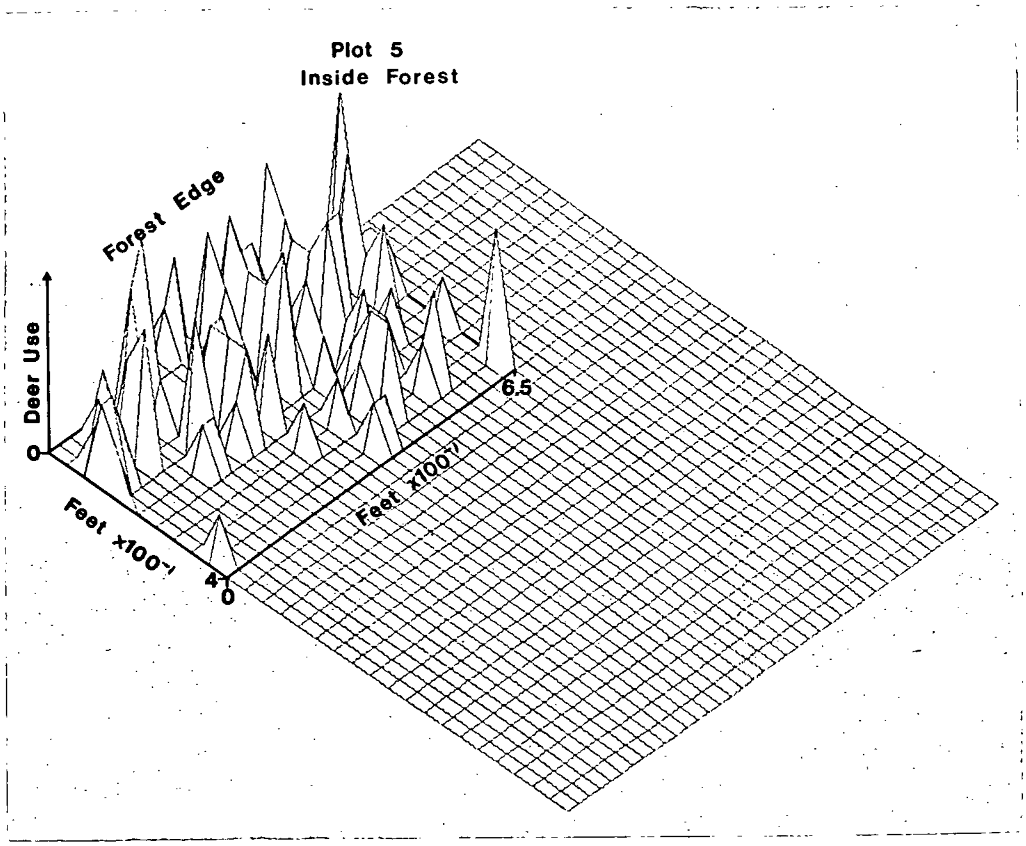

Figure 18c Distribution of pellet groups inside the forest on a north aspect.

Species composition within the forest differs from that outside. Also, inside the forest the species tend to be clumped. Two photographs in Figure 19 and 20 illustrate the varying conditions present on plots 2 and 3.

Regression analysis of "deer use" and " distance into the forest" are shown in Appendix 13. Here, as in the regression outside the forest (Section 4.2.1.1.), the regression began at the point of maximum deer use which was within 150 feet of the forest edge. The regression coefficients were all negative and in all but plot 1 the relationship was highly significant (P .01).

4.2.1.3 Outside Forest (Parallel to Upper Forest Edge)

A look at deer use from a second forest edge was possible on two plots, 2 and 5. This edge is perpendicular to the upper forest edge as well as to the elevation contours. Both plots are located on 1966 burns.

The effect of this edge differs from the upper one in that it does not encourage a point of peak utilization at a short distance from the edge. Instead, it depresses deer use on the edge but permits a rapid increase towards an upper level of use. This phenomenom occurred on both plots even though one (plot 5) did not have a fireguard (Figure 21).

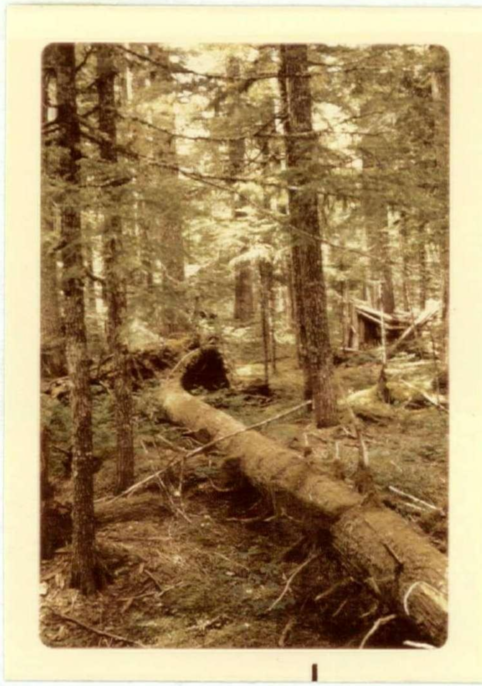

Figure 19 A view of a sparsely vegetated site inside the forest on a south aspect.

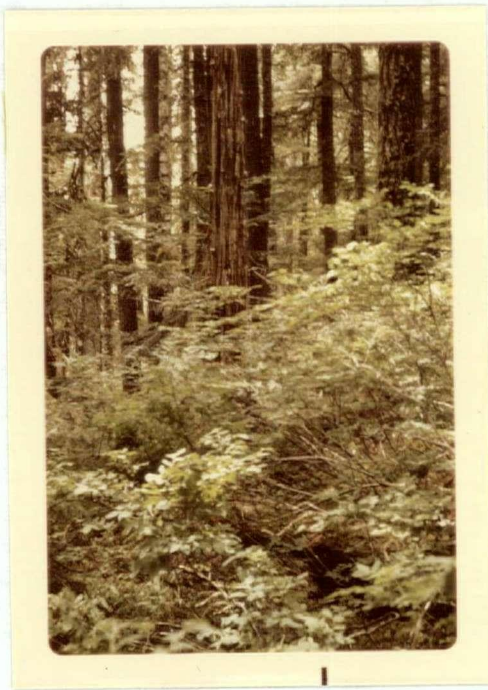

Figure 20 A view of a densely vegetated site, consisting primarily of Vaccinium spp., inside the forest on a south aspect.

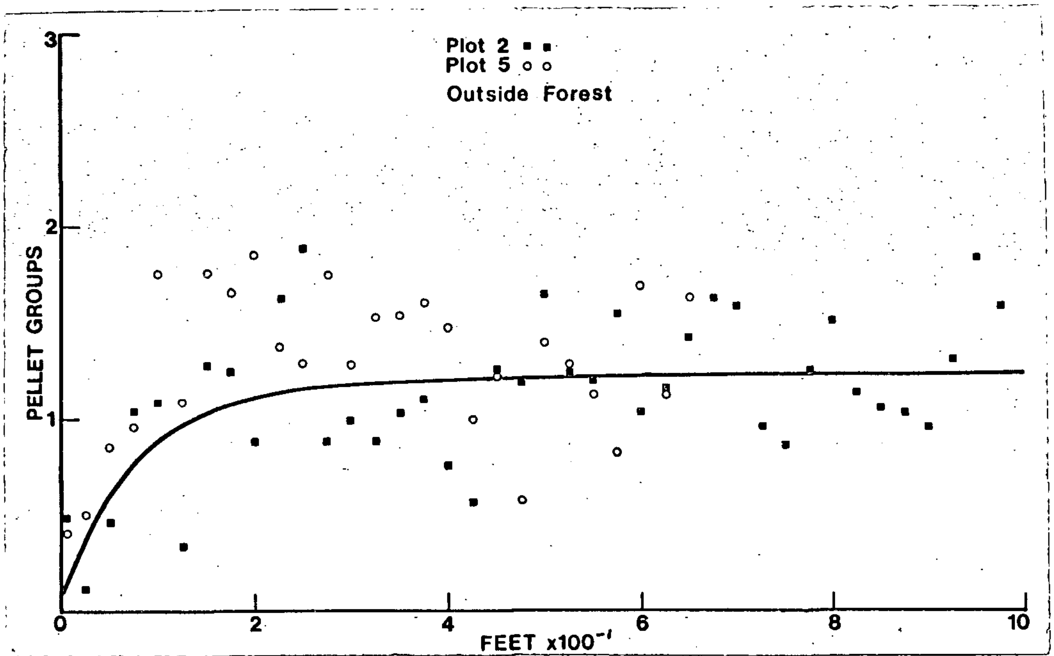

Figure 21 Effect of forest edge, crossing contours, on deer use of areas logged and then slash-burned in 1966 and 1967. (Confidence limits (95%): Plot 2, Range 0.14-0.95, Median 0.58; Plot 5, Range 0.25-0.98, Median 0.56).

4.2.2 Road Edge Effect

The data obtained from plots 1 and 2 was suitable, after minor adjustment, for estimating the effect of roads on deer use of recently logged areas. Figures 22a and 22b illustrate the influence of roads on deer use on 1961 and 1966 burns for two directions, viz. (1) from the road edge toward the upper forest edge and (2) away from the forest edge.

On the 1966 burn (Figure 22b) the use adjacent to the road is near zero but increases rapidly with distance from the edge. A minor peak of use is reached about 100 feet away and a major peak occurs about 250 feet from the road edge. The response is similar on the 1961 burn but differs with more moderate fluctuations at the peaks. On this plot the use towards the forest edge, from the road, hardly fluctuates at all and, in fact, appears to reach a gradual peak of use which recedes gradually (Figure 22a). The variations of deer use on the 1966 burn are also more moderate towards the forest edge than away from the edge.

4.2.3 Vegetation Effect

The vegetation in this study was recorded as described in Section 3.4. An estimate of the vegetation on each plot is given in Appendix 14. The response of deer to vegetation can be considered in terms of the individual species and all species combined. The data was analysed by plot

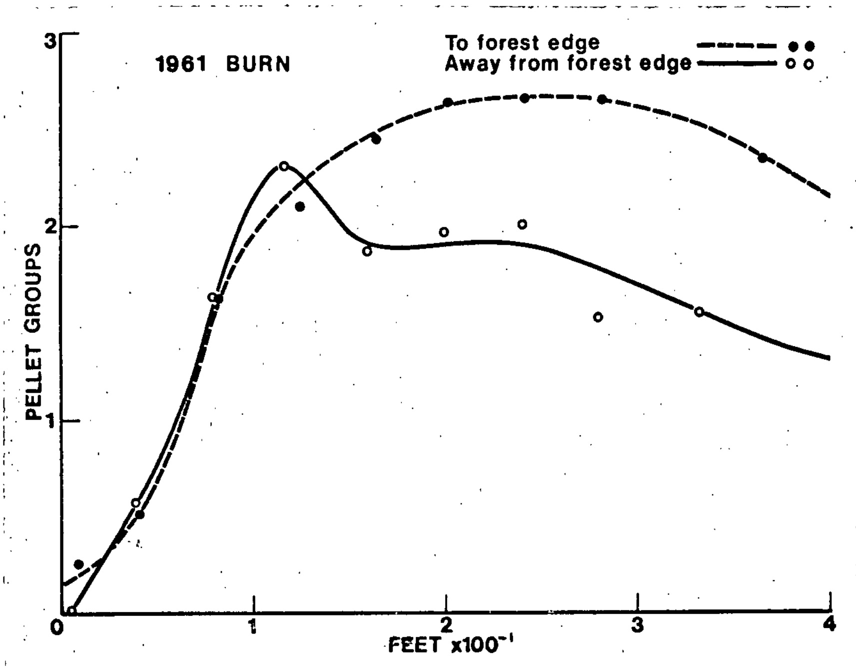

Figure 22a Effect of roads and verges on deer use of areas logged and then slash-burned in 1961. (Confidence limits (95%): To forest edge, Range 0.35-0.88, Median 0.59; Away from forest edge, Range, 0.00-0.78, Median 0.54).

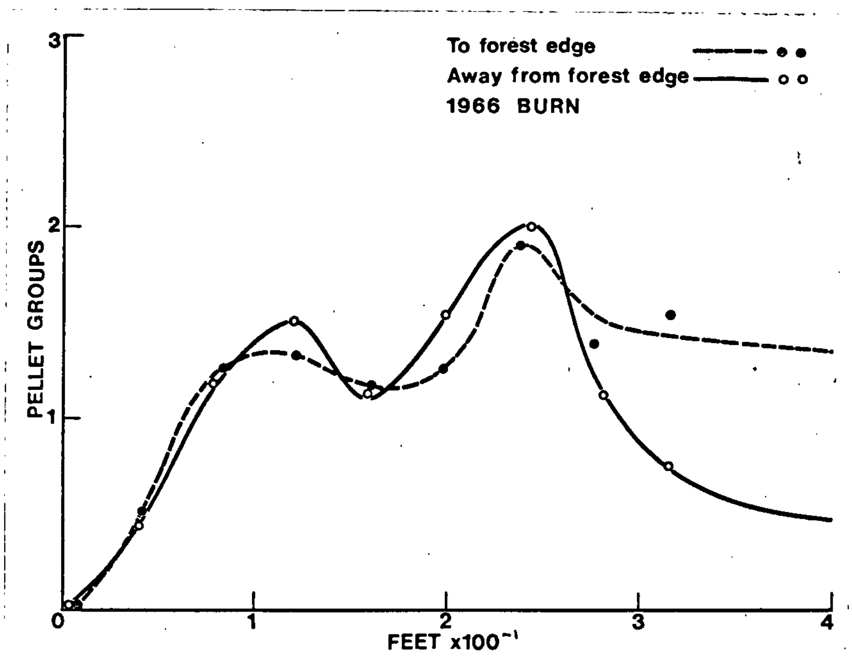

Figure 22b Effect of roads and verges on deer use of areas logged and then slash-burned in 1966. (Confidence limits (95%): To forest edge, Range 0.06-1.31, Median 0.33; Away from forest edge, Range 0.00-1.13, Median 0.55).

and stratified for inside and outside forest.

4.2.3.1 Individual Species

The analysis of individual species with deer use required numerous observations for a reasonably wide range of cover classes. More species than those analysed could qualify with the above requirements. Of the species which qualified only those which were considered important as deer food were used. These species were fireweed (Epilobium angustifolium) Figure 23a 23b: salal (Gautheria shallon) Figure 24: thimbleberry (Rubus parviflorus) Figure 25; salmonberry (Rubus spectabilis) Figure 26; trailing blackberry (Rubus ursinus) Figure 27; and huckleberry (Vaccinium spp.) Figures 28a, 28b, and 28c. Of these species, fireweed, thimbleberry, salmonberry and trailing blackberry occurred only outside the forest while salal and huckleberry occurred both inside and outside the forest. The data for salal on any plot outside the forest was not sufficient to permit its relation to deer use to be determined.

In several graphs the relationship of deer use with any one species was compared for two plots (Figures 23b, 25, 26, 27 and 28a. In Figures 23a, 24, 28b and 28c the observations of three plots are combined for individual species. This is permitted because of the similarity with which deer respond to the vegetation.

The response of deer to cover of most individual

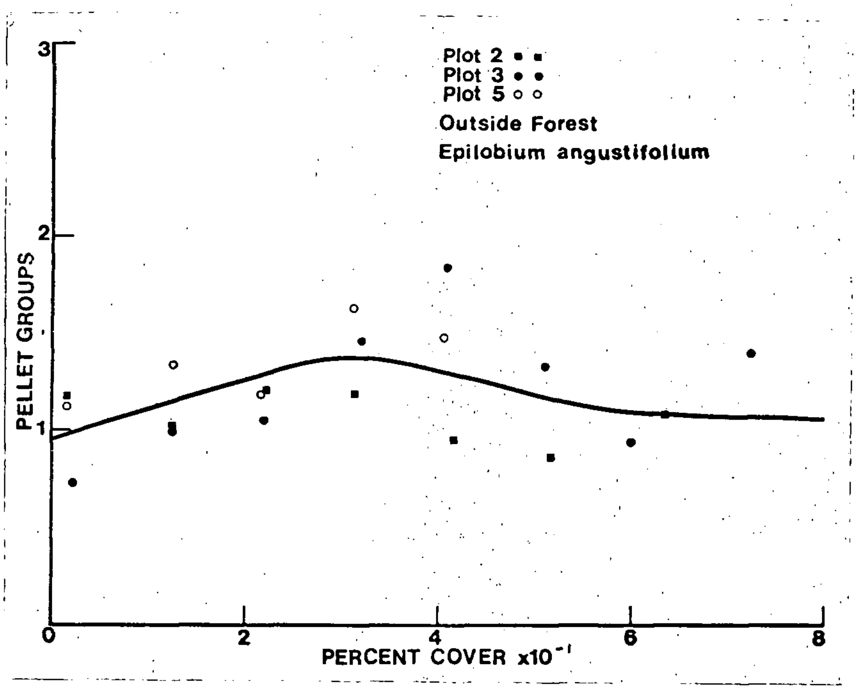

Figure 23a Response of deer to fireweed cover on 1966 burns. (Confidence limits (95%): Plot 2, Range 0.18-0.76, Median 0.26; Plot 3, Range 0.18-0.73, Median 0.26; Plot 5, Range 0.19-0.56, Median 0.24)

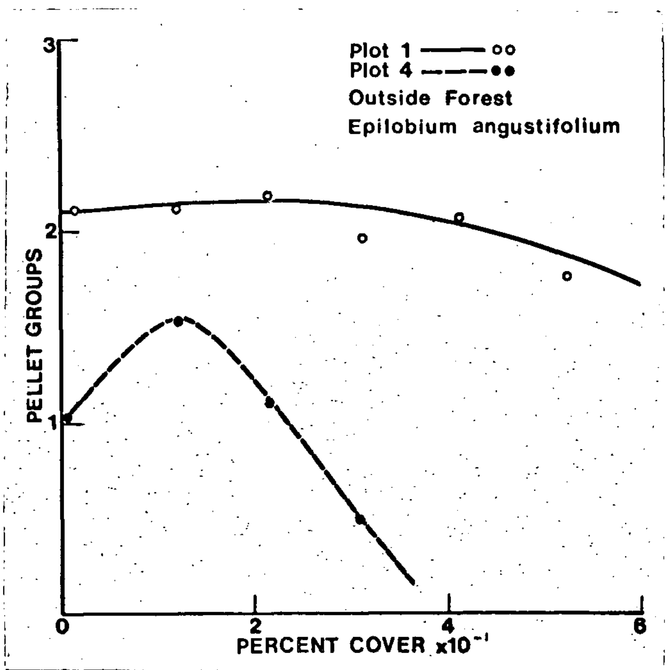

Figure 23b Response of deer to fireweed cover on 1961 burns. (Confidence limits (95%): Plot 1, Range 0.18-1.63, Median 0.28; Plot 4, Range 0.18-0.32, Median 0.20).

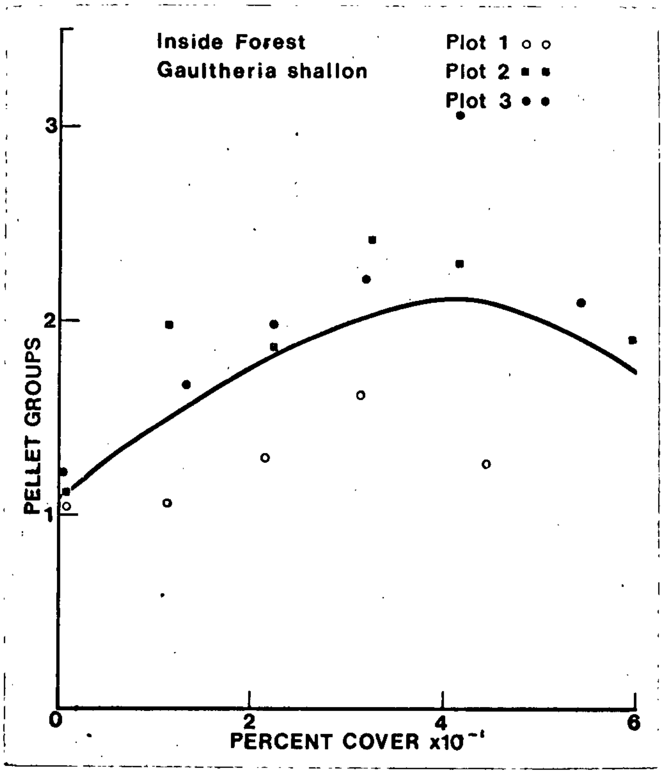

Figure 24 Response of deer to salal cover inside the forest on a south aspect. (Confidence limits (95%): Plot 1, Range 0.08-0.62, Median 0.51, Plot 2, Range 0.12-0.59, Median 0.59; Plot 3, Range 0.14-0.89, Median 0.48.

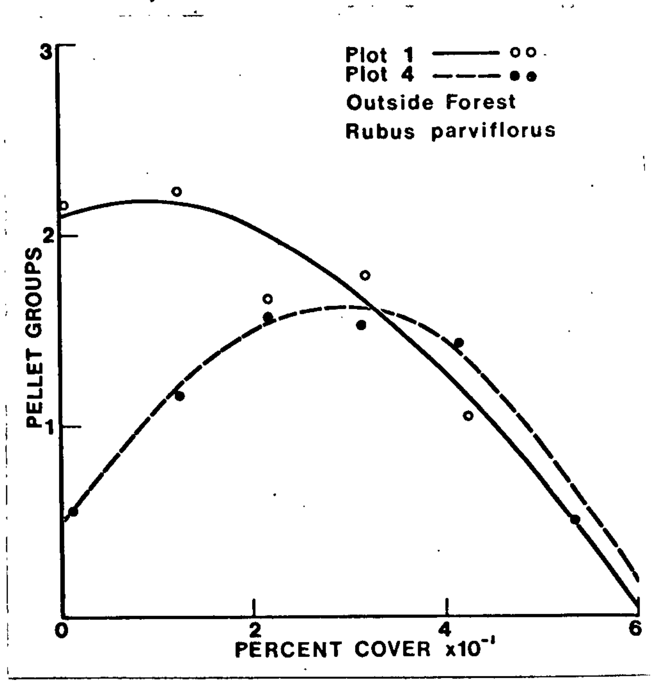

Figure 25 Response of deer to thimbleberry cover on 1961 burns. (Confidence limits (95%): Plot 1, Range 0.14-0.65, Median 0.40; Plot 4, Range 0.18-0.65, Median 0.24).

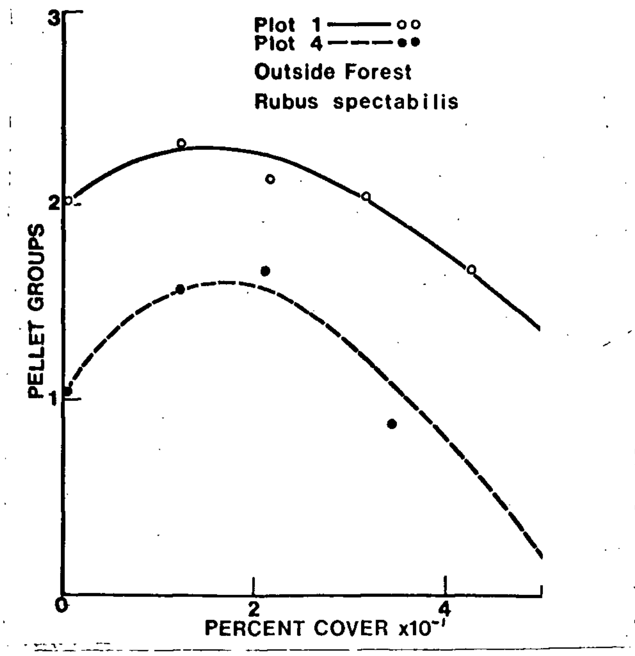

Figure 26 Response of deer to salmonberry cover on 1961 burns. (Confidence limits (95%) Plot 1, Range 0.16-2.18, Median 0.38; Plot 4, Range 0.14-0.83, Median 0.26).

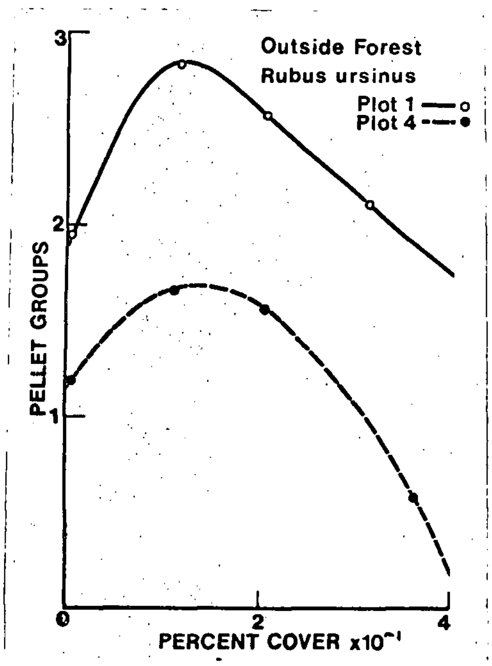

Figure 27 Response of deer to trailing blackberry cover on 1961 burns. (Confidence limits (95%): Plot 1, Range 0.12-1.23, Median 0.35, Plot 4, Range 0.12-1.32, Median 0.46).

species is parabolic. Such response indicates maximum utilization of a food species when its' cover on any area is not too scarce or too dominant. The parabolic form is strongly exibited for thimbleberry, salmonberry, trailing blackberry, and fireweed (on 1961 burn), less strongly for huckleberry (outside forest) and salal; and weakly for fireweed (1966 burn) and huckleberry (inside forest). The parabolic response of deer to individual species is weakest for those species which tend to dominate a large area, for instance, fireweed on a recent burn or huckleberry inside open forest. Conversely, it is strongest for those species which tend to occur in scattered patches of variable size.

4.2.3.2 All Species Combined

This section deals with the response of deer to the number and cover of all species on the plot. Most of the species represented in this analysis are those listed in Appendix 12.

The correlation of total vegetative cover with number of species is reasonably high. The correlation coefficient and coefficient of determination for both inside and outside forest of all plots is shown in Appendix 15. The coefficient of determination ranges from 0.17 to 0.48 with a median of between 0.27 and 0.31.

The relationships of deer to total vegetative cover are shown in Figures 29 to 32. In general, the response of

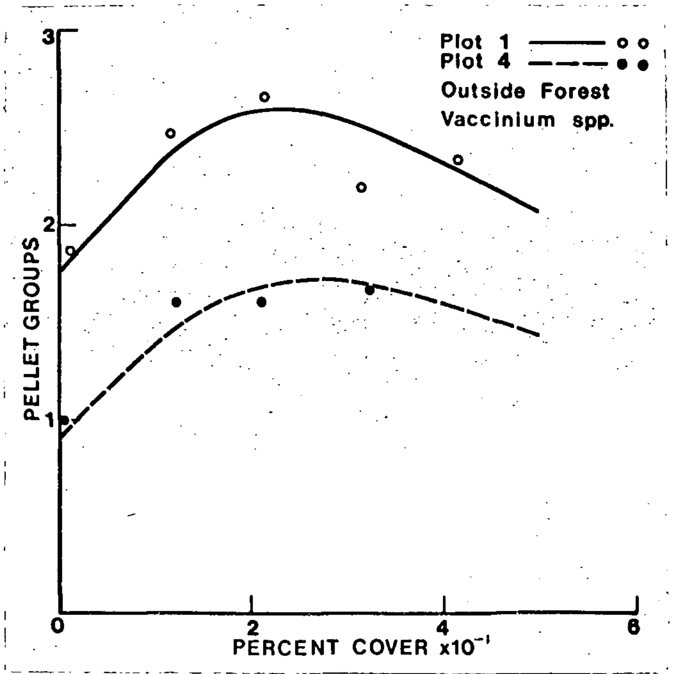

Figure 28a Response of deer to Vaccinium spp. cover on 1961 burns. (Confidence limits (95%): Plot 1, Range 0.14-0.55, Median 0.24; Plot 4, Range 0.14-1.16, Median 0.24).

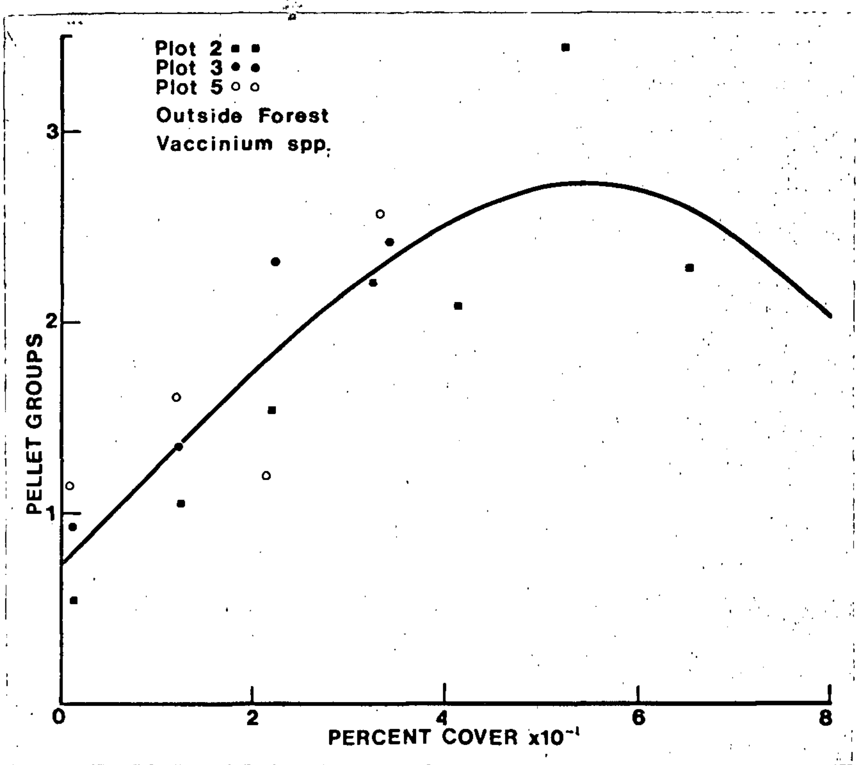

Figure 28b Response of deer to Vaccinium spp. cover on 1966 burns. (Confidence limits (95%): Plot 2, Range 0.08-1.27, Median 0.42; Plot 3, Range 0.10-1.15, Median 0.22; Plot 5, Range 0.14=2.37, Median 0.29).

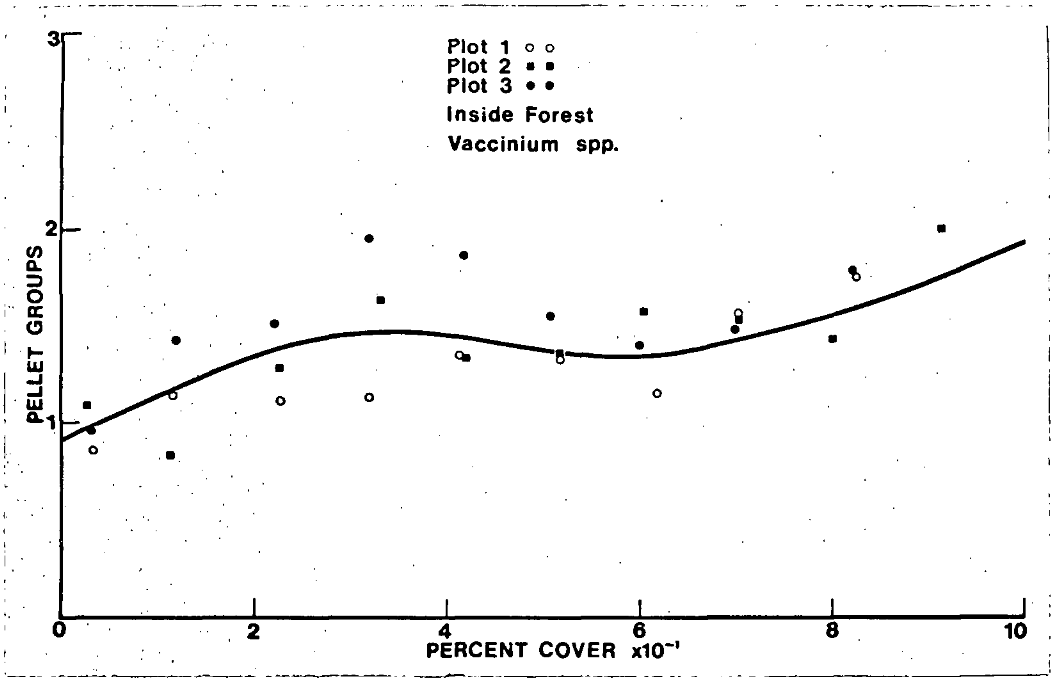

Figure 28c Response of deer to Vaccinium spp. cover inside the forest on a south aspect. (Confidence limits (95%): Plot 1, Range 0.10-0.86, Median 0.28, Plot 2, Range 0.26-1.57, Median 0.36; Plot 3, Range 0.22-0.91, Median 0.38).

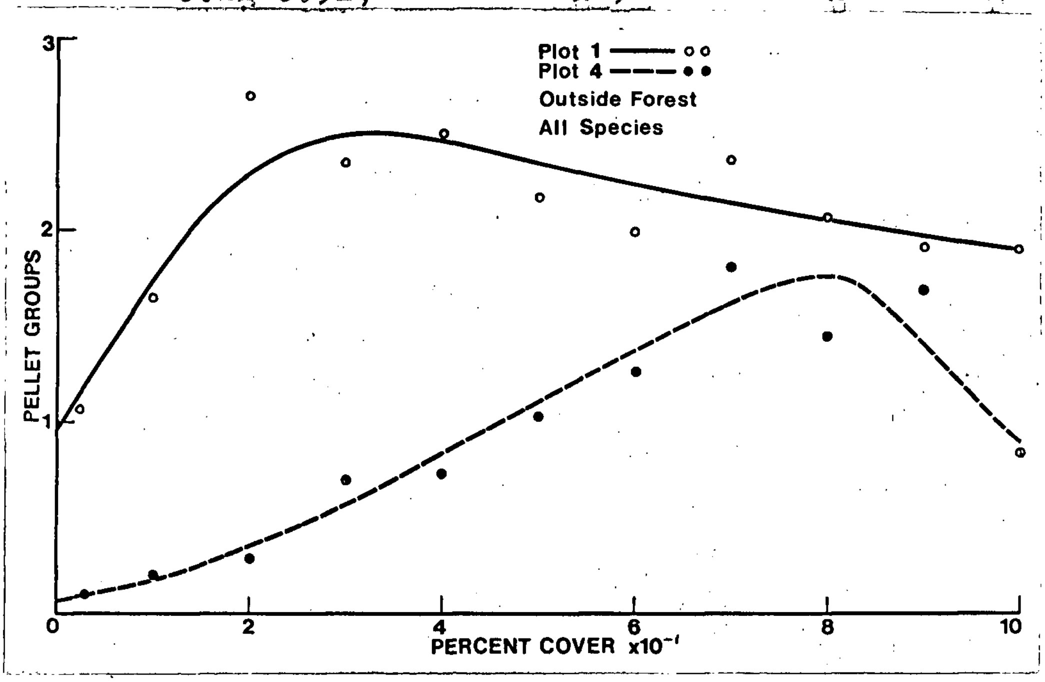

Figure 29 Response of deer to total vegetation cover on 1961 burns. (Confidence limits (95%): Plot 1, Range 0.32-0.69, Median 0.36; Plot 4, Range 0.11-0.46, Median 0.29).

deer use with total cover is a positive linear (or nearly so) relationship. This relationship is most obvious in the graph of Figures 30a and 31. Deviations from linearity occur in the other graphs.

Figures 30a and 31 represent plots 2 and 3 on a 1966 burn. These plots all support deer populations of about 80 deer per square mile. In both these plots the deer use on area with no vegetation is above zero.

Figure 29 presents a comparison of deer use with total cover for plots 1 and 4. Both plots were burned in 1961. The deer use in areas with no vegetation is well above zero in plot 1 while in plot 4 deer use is nearly zero. Deer use increases with increasing cover but varies significantly between the two plots. In plot 1 deer use peaks at 80 percent cover. At all densities of cover the use is greater on on plot 1 than on plot 4.

Several factors which may be responsible for the difference in the response of deer use with vegetative cover are the deer population, vegetative composition, and aspect for each plot. The estimated population on plot 1 is 19 deer per square mile while on plot 4 it is 43 deer per square mile (Appendix 5). Table 8 lists the commonly browsed plants for both shrubs and herbs on each plot. This comparison shows that shrubs occur in greater proportion for both plots, however

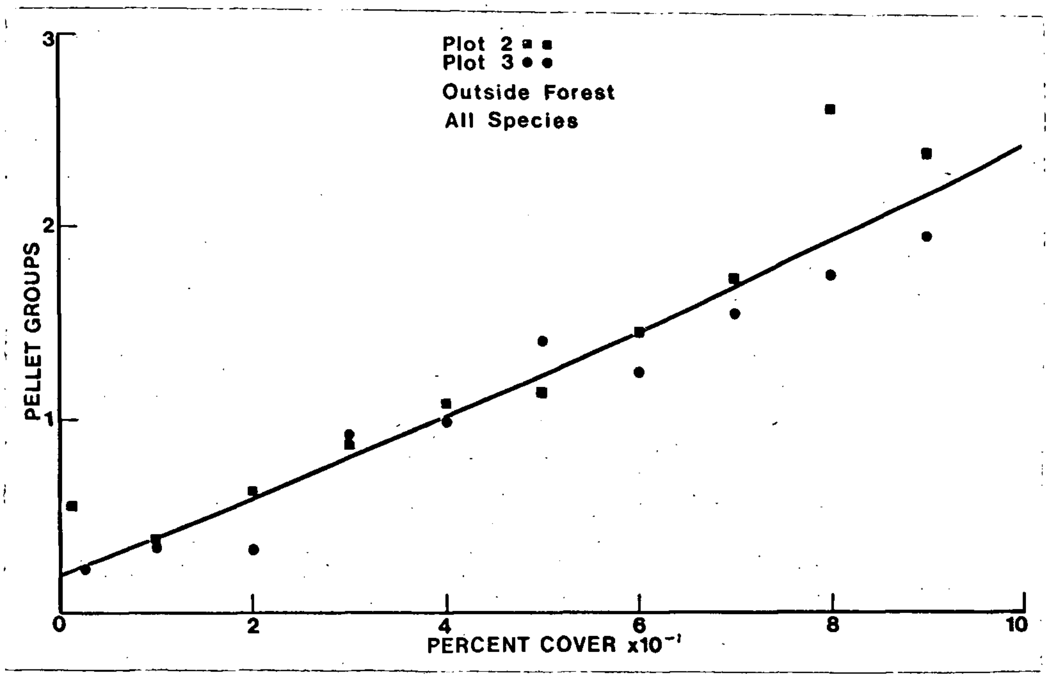

Figure 30a Response of deer to total vegetation cover on a 1966 burn with a south aspect. (Confidence limits (95%): Plot 2, Range 0.14-1.09, Median 0.25; Plot 3, Range 0.16-0.73, Median 0.26).

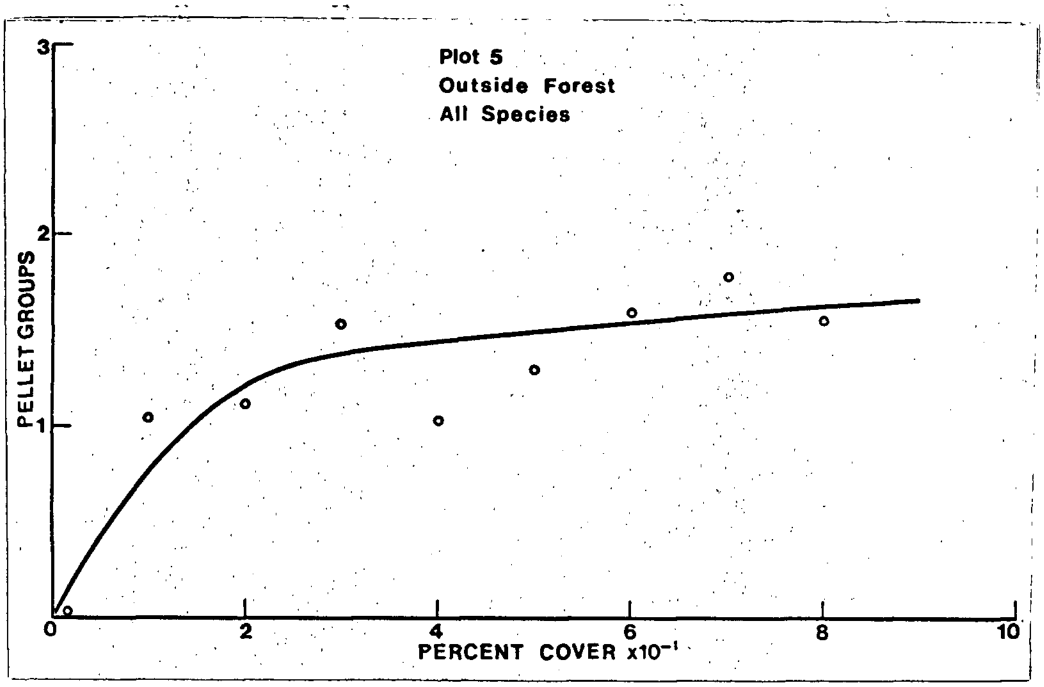

Figure 30b Response of deer to total vegetation cover on 1967 burn with a north aspect. (Confidence limits (95%): Plot 5, Range 0.08-1.02, Median 0.34).

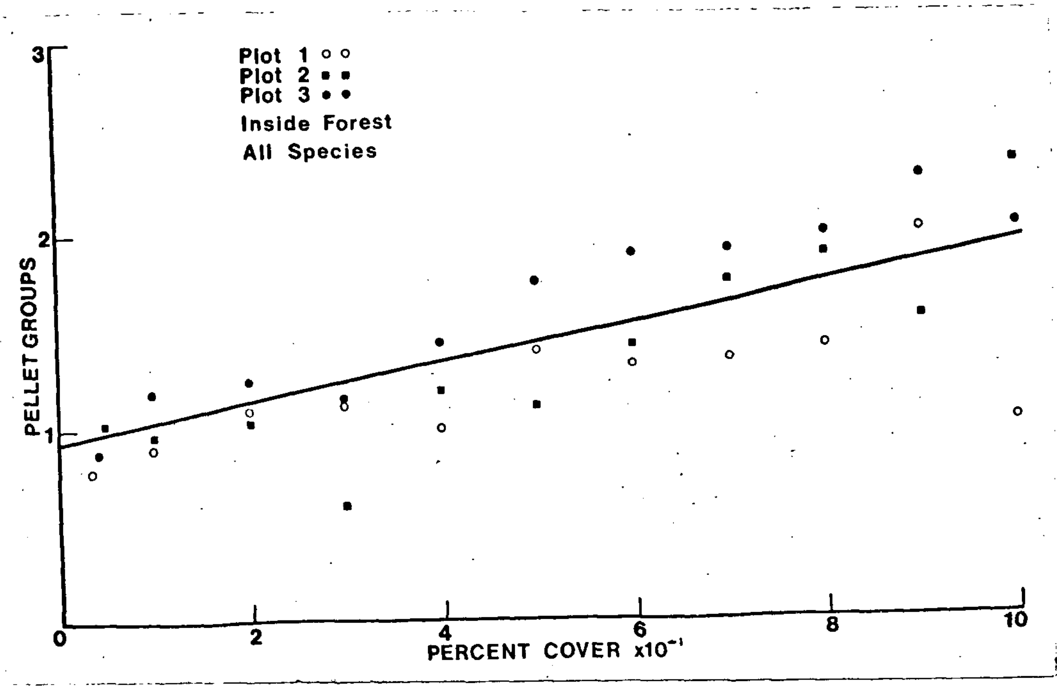

Figure 31 Response of deer to total vegetation cover inside the forest on a south aspect. (Confidence limits (95%): Plot 1, Range 0.10-0.62, Median 0.28; Plot 2, Range 0.26-1.90, Median 0.38; Plot 3, Range 0.22-1.20, Median 0.42).

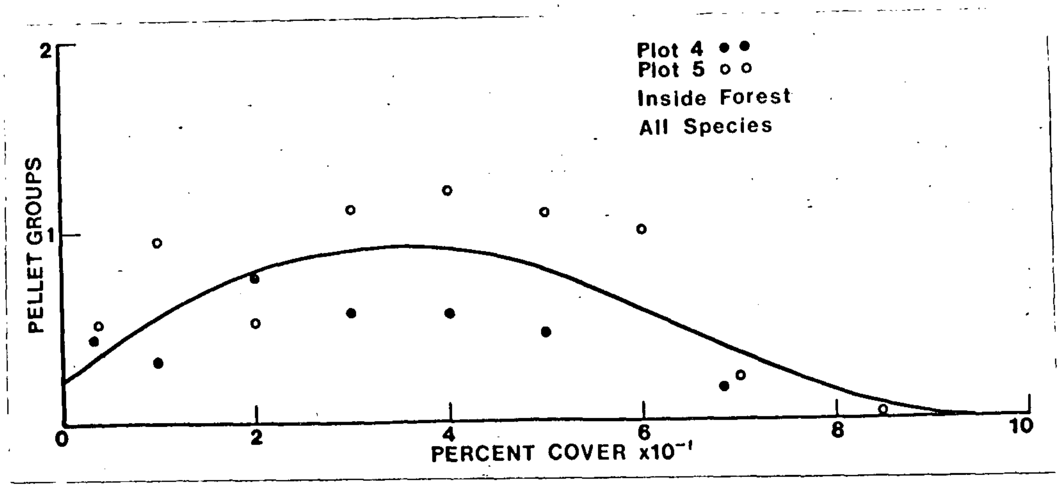

Figure 32 Response of deer to total vegetation cover inside the forest on a north aspect. (Confidence limits (95%): Plot 4, Range 0.14-0.55, Median 0.39; Plot 5, Range 0.06-0.74, Median 0.38).

the proportion of shrubs to herbs is much less in plot 1 (56:42) than in plot 4 (66:26). Closely allied to the quality of the vegetative cover is the productivity of the soil (site index). The site index of plot 1 is 150 while the site index of plot 4 is 160. Finally the aspect for plot 1 is south-east while for plot 4 the aspect is north-west. The way in which deer use differs on each plot may be explained on the basis of one or more of the above variables.

The deer use on plot 5 outside the forest indicates a trend with increasing plant cover that is similar to a combination of trends already revealed (Figure 30b). "Deer use" at zero plant cover is also zero, as in plot 4 outside forest. Both plot 4 and 5 have nearly northern aspects.

Table 8

Percent Cover Of Individual Species on Plots 1 and 4

Plant Form					
Shrub			Herb		
	Plot			Plot	
Species	1	4	Species	1	4
Huckleberry	6.8	6.2	Fireweed	12.1	8.7
Salal	0	0.3	Foam flower	0	0.3
Salmonberry	7.2	5.8	Grasses	0.9	0
Thimbleberry	6.3	19.1	Twin-flower	2.0	4.5
Trailing blackberry	3.4	1.9	Vanilla leaf	2.3	0
Total	23.7	33.3	Total	17.3	13.5

Information derived from Appendix 12.

After an initially rapid increase deer use begins to level off and assumes the trend which is found for plot 2 and 3 outside forest (Figure 30a). These two plots are both 1966 burns, similar to plot 5.

Figure 32 shows a trend of deer use with cover which deviates further from the other trends. This relationship occurred inside the forest on near north aspects (plots 4 and 5). Utilization of this area reaches a maximum where the vegetative is about 40 percent. Then, with increasing cover, the use drops to zero before 100 percent cover is achieved.

The response of deer to number of plant species on the plot is essentially a response to plant diversity. The study included both browsed and unbrowsed species. This characteristic of the observations may give a biased indication of the deer preference for plant diversity. However, assuming that as the number of species increases so do the species which are edible to deer, certain observations are noted. In all areas of this study, the utilization by deer does not increase as plant diversity increases. The utilization on an area either reaches a plateau or becomes depressed as the species number increases. The data for plots 2, 3 and 5 outside forest are combined in Figure 34. A note should be made that although the graph is drawn to begin above zero -- and actually does for the data of plots 2 and 3 -- the data of plot 5 actually shows zero utilization at zero species. The effect of plant diversity on the utilization of these plots (all 1966 burns) seems to be constant beyond 3 species (and at least up to 8).

Figure 33 gives a comparison of the response of deer to species diversity for plots 1 and 4 outside forest. The response on plot 4 is similar to that described in Figure 34 (above). It varies in that the response, on plot 4, increases exponentially, from zero, until the vegetative composition consists of four species. The response then levels off but continues to increase to at least 8 species. The response of deer use to species number found in plot 1 (Figure 33) typifies the relationships found in the remaining areas (Figure 35 and 36 -- representing plots inside forest for south and north aspect respectively). On these areas maximum utilization is reached on sites with more than zero and less than four species. On the north slope inside forest (Figure 36) the peak utilization was reached on sites with more than zero and less than four species. On the north slope inside forest (Figure 36) the peak utilization was reached between zero and two species, while on the south slope for both inside forest (Figure 34) and outside forest (Figure 33) maximum use was reached between two and four species.

4.3 Mature Forest Study (Sub-project c)

This study involved locating plots within the mature forest at various elevations on both north and south slopes (Appendix 6). The pellet group sampling accuracy for each

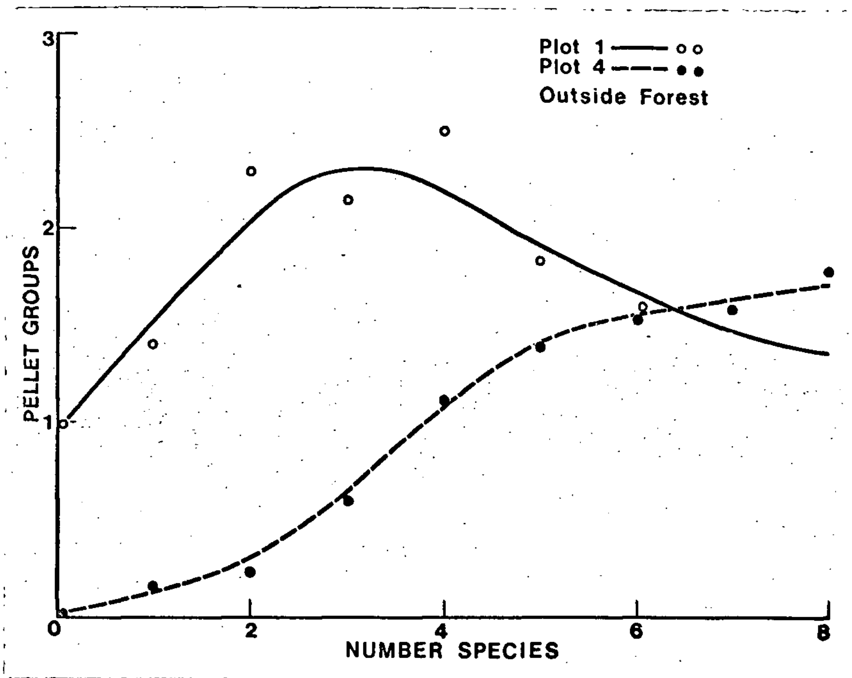

Figure 33 Response of deer to total number of plant species on 1961 burns. (Confidence limits (95%): Plot 1, Range 0.22-0.55, Median 0.32, Plot 4, Range 0.00-0.70, Median 0.25).

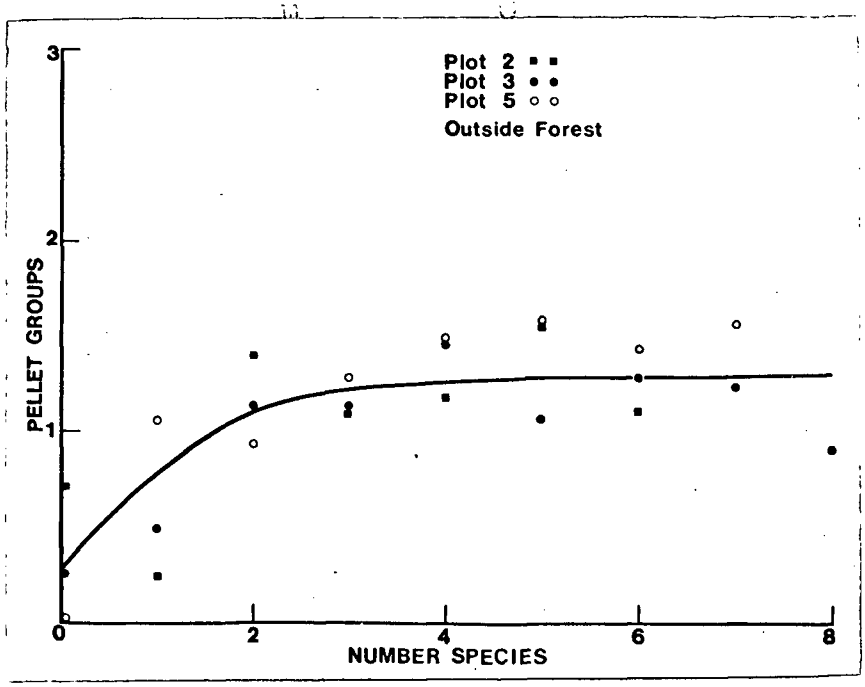

Figure 34 Response of deer to total number of plant species on 1966 burns. (Confidence limits (95%): Plot 2, Range 0.16-1.17, Median 0.28; Plot 3, Range 0.18-0.92, Median 0.31; Plot 5, Range 0.00-1.08, Median 0.26).

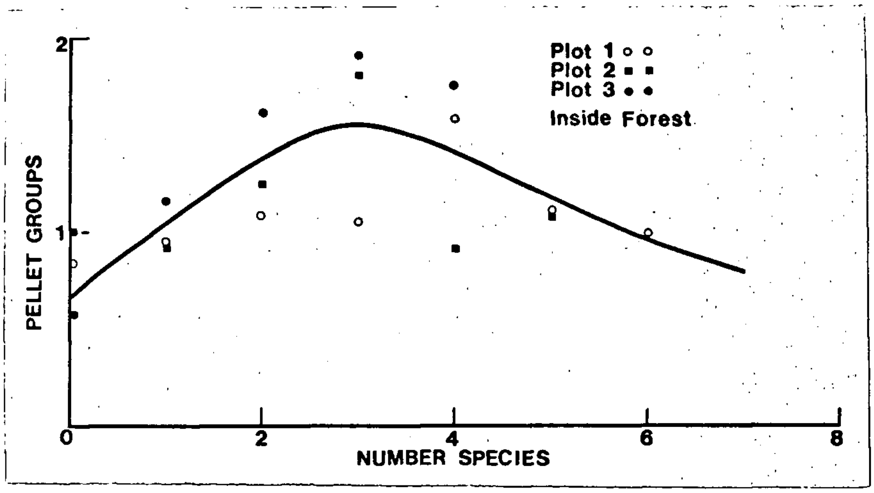

Figure 35 Response of deer to total number of plant species inside the forest on a south aspect. (Confidence limits (95%): Plot 1, Range 0.12-1.06, Median 0.18, Plot 2, Range 0.16-1.21; Median 0.25; Plot 3, Range 0.18-1.16, Median 0.40).

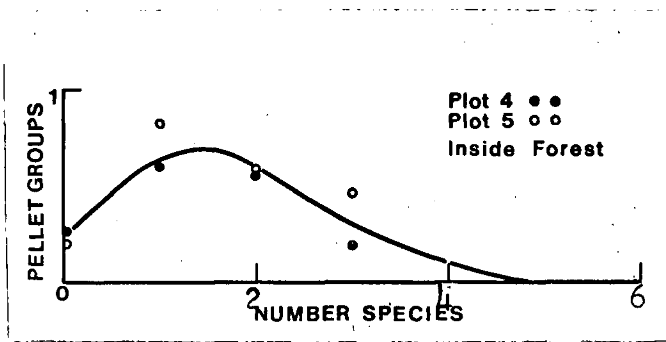

Figure 36 Response of deer to total number of plant species inside the forest on a north aspect. (Confidence limits (95%); Plot 4, Range 0.00-0.22, Median 0.18; Plot 5, Range 0.18-0.56, Median 0.22).

plot is shown in Appendix 16 while the vegetation sample is shown in Appendix 17. The pellet groups per plot, an estimate of deer use, were stratified for aspect and ploted against elevation (Figure 37)

Although the method of selecting plot locations could be greatly improved (see Section 3.7.1), the observations shown in Figure 37 do provide an indication of deer response with elevation in mature forests. Between the 400 to 2900 feet elevation range, the deer use increases with elevation while on the north aspect the reponse is poorly defined and possibly non-existent. A statistical analysis was not attempted on these data because of the small number of plots available.

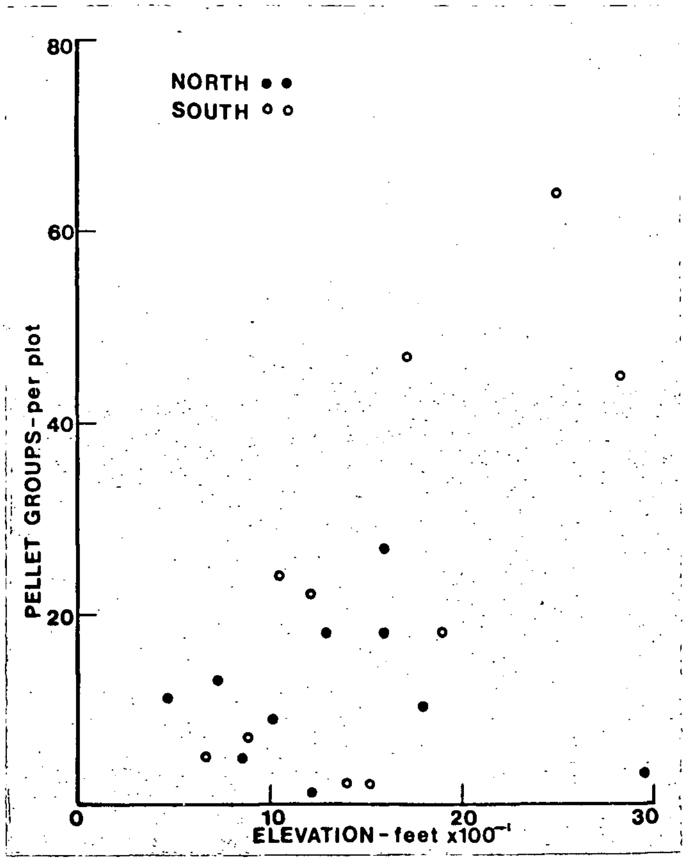

Figure 37 Response of deer to elevation in the mature forest. Observations stratified for north and south aspect.

5. DISCUSSION

The primary technique used in this study for estimating deer use was pellet group counts. The limitations of this technique were extensively reported by Neff (1968). The advantage of this technique, for this study, was that it provided a method to measure relative rates of deer use on each area. Furthermore, these measurements (pellet group counts) can be used in statistical analysis, for example, in determining the variation of the estimate or in regression analysis.

In a study such as this one, the pellet group count technique is used primarily for comparisons of use and environmental factors. Therefore an estimate of deer numbers is not required and the daily defecation rate of deer is a less important factor than in some other studies. The main source of variation results from uneven pellet group degradation between different plant communities (Low, 1959, in Neff, 1965) and possibly varying defecation rates with deer activities other than foraging.

The rates of pellet group degradation for environmental conditions similar to those found in the Nimpkish Valley were not available; however, a varying rate of degradation is assumed; the greatest difference would probably occur "outside" and "inside" the forest where the effect of rainfall on pellet groups would also differ most. Washing of the pellet groups would be greatest on the exposed burned areas.

No documentation could be found that the defecation rate varied with different activities (e.g. feeding and resting) in deer. Making this assumption seems reasonable even without substantiating evidence. Observations of deer in the field often reveals that defecation occurs readily when the animal is agitated. Thus it may be that defecation occurs more often when the animal is active (as in feeding) than when it is resting.

The effect of both sources of variation on pellet group counts would differ inside and outside the forest. Pellet groups would disintegrate faster outside the forest than inside. However, the area which will receive most defecation would depend on the source of food. Therefore the defecation rate will likely be greater outside the forest during spring, summer, and fall but greater inside the forest during winter.

These factors introduce unknown variation into the pellet group count technique. A direct comparison of deer use inside the forest and outside the forest should not be made without considering these factors.

The method of sampling the vegetation in this study was rather crude. Time limited greater precision in sampling. Therefore the observer estimated the cover on each sample to a 10 percent class. The cover contributed by each species within a sample was relative and proportionate to both the total cover and the number of species present.

Where the vegetation sample was used simply to provide an estimate of the vegetative composition on each plot (such as in sub-projects a and c) the method of sampling was adequate. However where the data was used in correlation analysis (as in sub-project b) a greater number of samples were required. This condition was satisfied for most analyses in sub-project b.

5.1 Permanent Plots (Sub-project a)

The observations obtained from the permanent plots gave an indication of the response of deer to plant succession, elevation and site index. Furthermore, the effect of aspect on deer use could be tested with each of the three factors listed previously. Also, since information was available from two sampling periods, and since the winters within each period differed drastically in severity, we were able to observe the effect of snow on deer for the three factors: plant succession, elevation, and site index.

5.1.1 Time Since Burning (Autogenic Succession)

The plots in this study were burned over a time span of 8 years. The time between the most recent burn and the first sample period was one year. Therefore in the second sample this time was extended one year so that the most recent burn during that period was two years old.

In general, the deer use increased significantly with time since the plots were burned (Figures 4 and 7). During both sampling periods the response to autogenic succession was stronger on the north aspect than on the south. This is particularly well illustrated in Figure 4b which shows an insignificant amount of use at the early seral stages and a maximum of use only a few years later. This contrasts to the response seen on the south aspect where the deer use forms a peak of high use on recently burned areas.

The differing response to autogenic succession between the two aspects is possibly a response to the differing importance of vegetation on each aspect. Since the climate on the north aspect is probably unfavorable to deer, especially in winter with respect to temperature and solar radiation (Loveless, 1967), a major attraction to deer would be an abundant supply of preferred vegetation. Such vegetation could occur only on burns more than several years old. On the other hand, open areas on the south aspect often provide a more suitable climate, particularly in cold weather. Therefore recent burns on these areas are readily utilized by a large indigenous population of deer.

The differing response of deer on the north and south aspects can be explained on the basis of the population size and the relative climatic and vegetative attractiveness on each slope. On the north aspect a relatively small population selects the most productive and preferred vegetation while on the south aspect the recently burned areas are quickly invaded, partly because of pressure from a larger population and partly because of the more equable climate on such areas.

The drop in deer use shown for the plots burned in 1962 and 1963 particularly in the first period, may be caused by the inclusion of plots from high elevations. Four of the five plots responsible for the decrease are located at elevations of 2500 feet and over. For the period of sample 1 deer use decreased with increased elevation.

Observation of deer use on individual plots indicates that maximum use occurs 8 years after burning. This can be seen in Figure 4a when use is maximum in 1961 and in Figure 7a where use is maximum in 1962. Studies by other authors have shown maximum use on areas 8 to 10 years after burning (Dasmann, 1964) and 4 years after burning (Gates, 1968).

5.1.2 Elevation

In this study, as in others (Dasmann and Taber, 1956; Leopold <u>et al</u>, 1951), the deer use of areas at various elevations was affected strongly by snow-fall. The first sampling period was preceded by a winter of heavy snowfall (Tables 6 and 7) and consequently the deer use declined with increased elevation (Figure 5). The winter in the second sample period however, was unusually mild and in this period the deer use generally increased with elevation (Figure 8).

The change in use, for the periods, is illustrated in Figure 10.

These observations suggest that the migration to lower elevations in winter is largely a function of snowfall. The observations of the second sample indicate a preference for areas at higher elevations when snow is scarce. These generalizations must be kept within the limitations of this study which were a range in elevation from 800 to 3100 feet. Furthermore it must be kept in mind that the use observed is on an annual basis while the conclusions were on a seasonal basis. The differential use of various elevations by season would, no doubt, introduce substantial variations.

5.1.3 Site Index

In this study site index was negatively and closely correlated negatively with elevation. This correlation may mask the effect of site index on deer use of logged forests.

Although the available evidence reduces in importance the effect of site index on deer, a response to this factor very likely exists. Since site index is a measure of plant productivity a high site index might sometimes imply higher nutrient values of plants during the growing season. Both increased plant productivity and quality increase the attractiveness of an area to deer. The effect of plant nutrition will be noticed particularly during the growing season while plant productivity will have its' greatest effect during periods of limited food supply.

5.1.4 Effect of Aspect

The effect of aspect on deer use of logged areas was not studied directly. Its effect could be seen in the regression analysis of deer use with time of burn, elevation and site index for the data stratified for north and south aspect (Figures 4 to 9). Observation of the data makes several trends noticeable; deer use on the north slope is lower than on the south, and deer respond more strongly to greater productivity on the north slope than on the south. The preference of deer for the south aspect, particularly in winter, is documented by Loveless (1967), Taber and Dasmann (1958), Julander (1966), and others. In most instances the response of deer to aspect was primarily determined by the temperature of the slopes. The response to greater productivity on the north slope seems to be a compensatory reaction to the lack of favorable climate. Therefore the later burn, lower elevation, and higher site index will be used comparatively more than their opposites on the north slope than on the south slope.

5.1.5 Differences Observed Between Samplings 1 and Samplings 2

The differences observed between the observations of sample 1 and sample 2 may be partially explained on the basis of snowfall in each sample period. The observations for the change in use of elevation has already been discussed (Section 5.1.2). In this case the explanation that deer were forced down to lower elevations by the snow should be acceptable. For time of burn and site index, however, the explanation must be on the basis of the importance of plant productivity to deer for each period.

In a severe winter the areas of highest plant productivity will provide the most available food supply (plants that emerge through the snowfall, and provide adequate diversity). Therefore the deer will respond more strongly to such areas in a severe winter than in a winter with little snowfall and relatively mild weather. The first sample period was preceded by a harsh winter and the response by deer to plant productivity was strong. The second period contained a mild winter and in this case the response to increased productivity was noticeably less.

5.2 Ecotone Study (Sub-project b)

5.2.1 Forest Edge

6.2.1.1 Outside Forest

Observations on the effect of deer use, of logged and burned areas from the forest edge were made with two edges; the upper (parallel to the elevation contours) and adjacent (perpendicular to elevation contours). There was no opportunity to study the lower edge since none of the ecotone plots had one.

The observations indicate that deer are affected most strongly by the upper forest edge. In all plots a peak of maximum use occurred about 150 feet from the upper edge (Figures 13-16) while no such peak of use occurred from the adjacent edge (Figure 21). Both forest edges showed, however, minimal use at the edge. The extent to which the use dropped on the upper edge was determined by the presence or absence of a fireguard. A fireguard has the effect of depressing deer use to zero at the edge. Deer use on the adjacent edge decline to near zero regardless of the presence or absence of a fireguard.

The observations of deer use with the two edges suggest that deer move perpendicular to the elevation contours. This could explain the strong positive responses of deer use to the upper forest edge and the negative response to the adjacent edge. Personal observations of deer movement in the field support this theory. In most sightings of travelling deer on logged forests the movement was generally perpendicular to the contours. Where two forest edges provided escape cover the deer would normally move toward the upper edge. This generalization did not hold true, however, when a deer was startled. In such a case it would take cover in the nearest forest.

The deer use declined with distance from the forest edge. This decline varied near the forest edge depending on the stage of plant succession. In plots 2, 3 and 5 (Figures 14 and 16) the decline was rapid from the peak use near the edge while in plots 1 and 4 (Figures 13 and 15) the decline was more gradual. The former plots were burned in 1966 and the latter plots were burned in 1961. The more gradual decline in use from the forest edge in plots 1 and 4 is probably a reflection on the greater attractiveness of the vegetation to deer in these plots. Deer will move farther from the forest edge in areas that provide greater plant productivity and diversity, as well as camouflagic protection, than they will in areas that do not provide this.

The decline in deer use from the forest edge was studied only up to 900 feet and at times a few hundred feet farther. The decline is gradual and generally consistent. Variation of deer use within the plot was often caused by the presence of roads. This is particularly evident in plot 3 (Figure 14a), and plot 1 (Figure 13a) where the variation caused by a road is marked with a broken line.

A hypothetical exercise with such data would be to estimate the size of a logged area which would provide maximum use to deer. Such a problem involves knowing the effect of the lower edge on deer use of logged areas. The use from the lower edge could be very similar as the use from the upper edge if deer did not have preferences for upper or lower edges. Arguments for and against the similarity of effect of both edges might include rates of snow accumulation and melt at each forest edge and preference of deer for the upper or lower elevations. Both of these arguments favor greater utilization near the upper edge (particularly on the south aspect). For this exercise, however, the assumption is made that the response to each forest edge is similar.

The peak of maximum use occurs approximately 150 feet from the forest edge. However the decline from the peak to a point of more gradual decrease extends the peak a further 50 feet from the edge in the 1966 burns (plots 2, 3, and 5) and up to 200 feet (this figure more arbitrary) in the 1961 burns (plots 1 and 4). Since deer use is near maximum on the 1961 burns (these plots were burned about 9 years ago) the estimate from these plots should be used to estimate the area providing maximum deer use. Assuming that the nearness of another forest edge will not change the pattern of deer use from either edge, we can estimate that the maximum use will be provided on a strip cut approximately 700 feet wide (200 ft. + 150 ft.) x 2 and parallel to the elevation contours. Estimates of other optimum sizes are shown in Section 1.5.4.

5.2.1.2 Inside Forest

Variation of deer use within the forest resulted from three main causes, (1) effect of forest edge, (2) effect of aspect, and (3) effect of vegetation. Deer use from the forest edge, into the forest, responded similarly to use patterns outside the forest. The response was similar in that a peak of use occurred about 150 feet from the edge and the use generally declined with distance from the forest edge (Figures 17 and 18).

The effect of aspect on deer use is well illustrated on plots 4 and 5, and plots 1, 2 and 3. The first set of plots are on a north aspect and the deer use declines to nearly zero within 400 feet from the edge. The second set of plots, however, occur on a south aspect and the deer use remains considerable even at 1500 feet in the forest.

The variation of deer use within the forest is largely contributed by the distribution of vegetation. No specific study was made to show the validity of this statement although observations in the field convey such an impression. Also the number of possible factors which could contribute to the variation of deer use in the forest particularly on a south aspect, are limited primarily to these.

5.2.2 Road Edge Effect

Reference has already been made to the effect of roads on deer use (Section 5.2.1.2). The effect of roads was to increase deer use adjacent to them while minimizing the use at the edge and on the roads (Figures 22a and 22b). Two peaks of use were measured, one about 100 feet from the road edge and the other, a larger peak of use, about 250 feet from the edge.

An explanation of a single peak of use could indicate that deer travel along a road, since it has fewer obstacles, then enter the plot to feed. A double peak of use, however, might indicate that deer test the vegetation near the road and then depart further from the road to feed. This latter possibility is very tenuous and serves only as an explanation where none other is available.

The peaks of use were moderated toward the forest edge. This indicates greater use toward that direction.

5.2.3 Vegetation Effect

5.2.3.1 Individual Species

The observations of deer use to the cover of individual species indicates that maximum utilization of a browse species occurs when its' cover on an area is not too scarce or too dominant. In effect, the deer are exhibiting a preference for a variety of plants rather than for a single species, even though that species may be preferred. The parabolic response of deer to individual species is most strongly displayed with those that occur in patches of varying size, for example salmonberry. In these situations the deer can display their preferences more accurately because of the greater choice of cover available to select from. The weakest response would occur with species that tended to cover large areas, like fireweed outside the forest and huckleberry inside a rather open forest. In these situations the deer have much less choice in the size of cover for species.

5.2.3.2 All Species Combined

The response of deer to total vegetative cover is of two general natures, linear and parabolic. A linear response with increasing cover, from zero to 100 percent, generally occurs on areas where the vegetative composition consists of species which, even at 100 percent cover, have stems that are sparse enough not to restrict the movement of deer. Such a generalization is exemplified by recent burns (1966 in this study) which have a vegetative composition that consists primarily of fireweed, and shrubs that were scarified by slash-burning (Figure 30a). A similar response, but with greater variation about the line, occurs also inside the forest on a south aspect (Figure 31). Although species such as huckleberry and salal often occur in groups, their stems are usually open enough to permit travel into and through such groups. Also such areas may be sought after for the added protection they afford from adverse climate and predators.

The parabolic response of deer to vegetation cover occurs on areas where the vegetation consists of species that can grow into dense clusters thereby impeding movement to deer. This condition occurs on late burns (1961 in this study) with species such as salmonberry and thimbleberry, that are often found in dense groups (Figure 29).

Such a parabolic response is also seen inside the forest on the north aspect (Figure 32). In this situation the effect of increasing the vegetation density on deer is to reinforce the original aversion to the colder and damper conditions usually found inside the forest on a north aspect.

A further modification of both the parabolic and linear responses to total vegetative cover, is made by aspect. With zero vegetative cover on the north aspect the use declines to zero, both inside and outside the forest, while on the south aspect the use is well above zero for no cover. This difference reflects the added use of utilizing the bare areas on the south slope for resting on. Such areas would usually be warmer and drier therefore attractive to deer in cold weather and after a rain. Also the population is higher on the south aspect, than the north, therefore competition for land could force utilization of the open areas.

An apparent conflict of explanation for deer use occurs between plot 1 and plot 4 (Figure 29). The early maximum use at 20 percent cover, on plot 1, may be the result of multi-use by deer, on relatively open areas, for both resting and feeding. The open areas on plot 4, however, were scarcely utilized because of their characteristics. In most cases they resulted from skid trails and consequently consisted of parent material. Furthermore the productivity on these areas was low as a result of the disturbances.

5.2.3.3 Species Number

The data of this study indicates that a limit exists where increasing species diversity no longer increases the preference of an area to deer. Some of the response, shown in Figures 33 to 36 is due no doubt, to the correlation of total cover with number of species. However, it seems reasonable that the number of preferred food species on any sample are limited to several with the remaining made up of either non-edible or non-preferred species. Furthermore, the method of sampling vegetation may be responsible for a decline of deer use with increasing number of species. This is because all species were recorded regardless of dominance. Therefore some species may hardly be noticed by deer and contribute little or nothing to the attractiveness of an area.

Where increasing number of species does not affect deer use, the response levels off as in Figure 34 and 33 (Plot 4). In other cases, however, the effect of increasing number of species on deer use is negative Figures 33 (plot 1), 35 and 36. The vegetation composition, in these situations, was not studied intensively enough to find a cause for this phenomenon. There is a possibility that this effect is the combined result of increasing the number of species with no effect on deer and the correlation of total number of species with total cover. This is particularly evident by the close similarity of response between increasing total cover and increasing number of species (Figures 29 and 33, 30a(b) and 34, and 32 and 36).

5.3 Mature Forest Study (Sub-project c)

The observations concerning deer use, within the forest, in relation to elevation for north and south slope was not analysed with statistics. The individual observations of deer use for each plot (Figure 37) appear to show some relationship with elevation and aspect. Deer use appears to increase with elevation on the south slope but is unaffected by elevation on the north slope. These observations were made from data that ranged from 400 to 2900 feet in elevation.

A comparison of data from two different sampling periods, each preceded by a winter opposite in severity, was not available to study the effect of snow on deer use within the mature forest. The observations of this study were made from samples which were taken after a mild winter. In this respect and also in the general trends of deer use with elevation that they portray, the observations are similar to those made on the logged forests during the second sample period (Figure 8b and Section 4.1.3). During this period, on the logged forests, the deer use increased with elevation on the south aspect and decreased on the north aspect.

An unqualified comparison for the two situations is invalid since the effect of snow inside and outside the forest is not identical. Snow usually accumulates to a greater depth outside the forest than inside. (Jeffrey, 1968; Stanton, 1966; and Rothacher, 1965). Furthermore, snow generally melts more rapidly outside the forest (Miller, 1955, and Anderson, 1956 in Jeffrey, 1968).

SUMMARY

1. A study was conducted in the Nimpkish Valley, Northern Vancouver Island, to evaluate the effect of forestry practices and forest characteristics on deer use of the forests. Three sub-projects were made: sub-project a was established to evaluate the effect of time of burning, elevation, and site index on deer use of recently logged forests; sub-project b attempted to assess the effect of both forest edge and vegetation on deer use of logged and mature forest; and sub-project c gave an indication of the effect of deer use with elevation in the mature forest. The effect of all factors on deer use in this study could be seen on the north and south aspects. The plots in sub-project a were sampled twice, once in 1969 and once in 1970. Since the winter of one sample period differed in severity from the other, the effect of snow on deer could be observed.

2. The technique for sampling deer use was pellet group counts. In sub-project a the plots were permanent while in the other two sub-projects the plots were temporary. In sub-project b and c the vegetation was sampled with the same plots that were used to sample the pellet groups. In sub-project a separate samples of vegetation were made during the summer of the second sampling period.

3. Deer use increased on areas with time that they were logged and slash-burned. Observations of individual

plots in this study indicate that maximum use occurs approximately 8 years after the area was burned.

4. The response of deer to elevation is generally determined by snow-fall. On the south aspect deer winter use is greater at upper elevations than the lower (for an altidudinal range between 800 and 3100 feet) unless they are forced down by heavy snow-fall.

5. Deer exhibit a preference for areas with the highest site index. Site index is closely correlated negatively with elevation and therefore the apparent response of deer use to site index is actually the response to the combined effect of site index and elevation.

6. The response of deer to time of burning, elevation and site index differs between the north and south aspects. On the north aspect the response of deer to more preferred food conditions is stronger than on the south aspect. The response of deer on the south aspect was thought to be altered, from the response seen on the north aspect, by higher deer populations and more favorable climatic conditions.

7. Deer use declined with distance from the upper forest edge for both into and away from the mature forest. The decline in deer use from the forest edge outside the forest, was altered by the presence of roads (see number 8 below). Inside the forest the decline of deer use was affected by aspect and vegetation. On the north aspect deer use declined rapidly to near zero within 400 feet of the forest

edge while on the south aspect deer use was considerable even at 1500 feet from the edge. Vegetation was considered to have a significant effect upon deer use. This latter conclusion was based primarily upon personal observations.

8. Roads are probably used by deer for travelling on. The pellet group count on the road and road edge is nearly zero however the count adjacent to the edge is above normal indicating that deer travel along the road then leave it to feed.

9. Deer exhibit a preference for a variety of plant species. The response of deer use to the cover of individual species is generally parabolic. For all species combined the response of deer to increasing cover is generally positive and linear. Deviations from a linear response are thought to result from the effect of aspect and autogenic succession.

10. Observations on the response of deer to plant diversity indicate that food preference for deer does not continue to increase with increasing species diversity. After an initial increasing response, food preference tends to level off or decrease with increasing number of plant species. This response may be caused by a limited number of preferred plant species and also by the fact that all plant species, regardless of their edibility were included in the analysis.

11. The response of deer to elevation and aspect, in the mature forest, was similar to the response on the logged

forest during the second sample period. Elevation on the north aspect appears to have little or no effect on deer use. On the other hand, deer use increases with elevation on the south aspect. The elevation range of this study was between 400 to 2900 feet.

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PERSONAL COMMUNICATION

Goodell, B.C. 1971. Professor of Forestry Hydrology, U.B.C., Vanc., B.C.

APPENDIX 1

AVERAGE MONTHLY PRECIPITATION IN THE NIMPKISH VALLEY (Woss Camp)

(Contributed by Canadian Forest Products Ltd.)

1.a. PRECIPITATION

Woss Camp

Month	Number of Years Recorded	Average Monthly Precipitation (inches)	Range of Precipitation (inches)
January	13	12.79	3.89 - 27.18
February	15	9.05	2.79 - 19.62
March	15	8.40	2.63 - 14.97
April	15	6.23	1.72 - 14.72
May	19	2.37	.42 - 5.73
June	22	2.08	.05 - 4.87
July	22	1.95	.04 - 5.18
August	22	2.75	.30 - 7.22
September	22	4.96	.89 - 8.90
October	13	12.63	5.58 - 22.78
November	13	12.48	5.04 - 27.61
December	12	14.05	6.17 - 19.62
TOTAL		89.74	

1.b SNOWFALL

Woss Camp
1954 - 1969

Months	Average Snowfall by Month (inches of snow)	Range of Snowfall (inches of snow)
November	2.5	0 - 27
December	9.6	0 - 76
January	15.6	0 - 82
February	6.4	0 - 27
March	5.3	0 - 26
April	.2	0 - 2
TOTAL	39.6	

APPENDIX 2

FIRE HISTORY OF THE NIMPKISH VALLEY

Approximate Date of Burn	Age of Present Stand	Size $(Mile)^2$	Location
1940 - 59		6 - 10	Vernon Camp
1920 - 39	17	1 - 5	SW Vernon Lake
		1 - 5	NE Vernon Lake
1914	41 - 60	1	NE Vernon Lake
		1	NE Woss Lake
		1	N Woss Camp
		1	NE Kaipit Creek
1894	61 - 80	1	E Vernon Camp
		1 - 5	S Woss Camp
		1 - 5	SE Nimpkish Lake
1844	120	11 - 15	NW Woss Lake; along Nimpkish River to S end Nimpkish Lake and S to Atluck Lake
		1 - 5	NE Nimpkish Lake
1560 - 1759	270	1 - 5	NE Edge Woss Lake
		41 - 50	Vernon Lake
1360 - 1559	400	21 - 30	Nimpkish Lake
		16 - 20	Woss Camp to Schoen Lake; along Nimpkish River
		1 - 5	NW Woss Lake
	540	6 - 10	Woss Camp, Woss Lake, Vernon Lake
		16 - 20	SE corner of Timber License
960 - 1359	620	1 - 5	W Klaklahama Lake
			S Vernon Camp
	750	1 - 5	W Klaklahama Lake
		1 - 5	S Woss Lake
	1000	1	W Klaklahama Lake
Before 960	1000+	400+	On higher altitudes (7,200')

APPENDIX 3

ESTIMATED POPULATION OF DEER IN THE NIMPKISH VALLEY FROM 1958 to 1964

(Canfor Information)

Time	Est. Deer per Square Mile
January - June, 1958	2.49
July - December 1958	2.34
January - June, 1959	2.83
July - December, 1959	5.21
January - June, 1960	4.41
June, 1960 - May, 1961	7.43
June, 1961 - June, 1962	29.40
July, 1962 - June, 1963	13.70
Spring - Fall, 1963	24.10
Fall, 1963 - Spring, 1964	13.32
Spring to Fall, 1964	65.42

APPENDIX 4

DESCRIPTION OF PERMANENT PLOTS

Plot No.	Year Logged	Year Burned	Year Planted	Aspect	Site Index	Elevation (ft x 100)	Pellet Groups per plot - Sample I	Pellet Groups per plot - Sample II*
1	1961	1961	1965	N	160	9	93	28
2	1961	1961	1963	S	150	8	126	52
3	1960	1960	1965	N	140	10	81	30
4	1960	1960	1965	N	140	12	74	40
5	1960	1961	1968	S	140	15	106	40
6	1964	1964	1966	N	140	8	86	
7	1964	1964	1966	N	140	10	71	24
8	1964	1965	1966	N	130	12	94	26
9	1966	1966	Not Pl.	S	140	9	67	35
10	1965	1965	1968	S	140	11	61	62
11	1967			S	140	9	63	19
12	1965	1965	Not Pl.	S	130	10	68	23
13	1965	1965	1968	S	130	12	54	35
14	1965	1965	1968	S	130	11	86	50
15	1965	1965	1968	-	130	9	48	19
16	1966	1966-67	1967	N	140	8	16	23
17	1962	1963	1966	N	140	9	56	45
18	1962	1963	1966	N	140	11	57	38
19	1963	1963	1966	-	150	9	39	17
20	1965	1965	Not Pl.	-	140	10	21	4
21	1966	1966	Not Pl.	S	130	15	65	57

APPENDIX 4 (continued)

DESCRIPTION OF PERMANENT PLOTS

Plot No.	Year Logged	Year Burned	Year Planted	Aspect	Site Index	Elevation (ft x 100)	Pellet Groups per plot - Sample I	Pellet Groups per plot - Sample II*
22	1966	1966	Not Pl.	S	130	18	62	53
23	1966	1966	Not Pl.	S	130	18	45	58
24	1966	1968	Not Pl.	-	110	23	12	11
25	1967	1967	Not Pl.	N	130	13	7	22
26	1965	1967	Not Pl.	S	150	14	43	42
27	1965	1967	1967	-	140	15	51	27
28	1966	1967	Not Pl.	-	150	20	42	23
29	1962	1964	1967	S	150	16	80	52
30	1963	1964	1968	S	130	17	47	32
31	1963	1963	1966	S	140	15	43	24
32	1962	1962	1968	S	120	26	55	54
33	1962	1962	1968	S	120	25	57	42
34	1962	1962	1968	-	120	23	76	55
35	1966	1967	Not Pl.	S	120	23	22	31
36	1962	1963	1968	S	110	28	29	48
37	1962	1963	Not Pl.	S	100	31	43	55
38	1966	1967	1968	S	120	25	25	37
39	1966	1966	1967	N	110	30	13	37
40	1966	1967	Not Pl.	-	120	14	9	20
41	1966	1966	Not Pl.	N	120	21	4	17
42	1965	1966	Not Pl.	-	120	25	10	19
43	1964	1965	Not Pl.	N	120	20	40	27

APPENDIX 4 (continued)

DESCRIPTION OF PERMANENT PLOTS

Plot No.	Year Logged	Year Burned	Year Planted	Aspect	Site Index	Elevation (ft x 100)	Pellet Groups per plot - Sample I	Pellet Groups per plot - Sample II*
44	1963	1965	1968	N	130	15	45	16
45	1965	1966	Not Pl.	N	120	20	17	6
46	1965	1965	1967	-	130	10	31	25
47	1964	1965	1967	S	130	15	58	20
48	1964	1965	1968	S	120	19	43	43
49	1963	1963	1968	-	120	15	55	38
50	1966	1966	Not Pl.	-	130	15	43	26

*Number of pellet groups adjusted for uneven sampling interval. The interval was based on a period of 350 days.

APPENDIX 5

DESCRIPTION OF ECOTONE STUDY AREAS

Plot No.	Year Logged	Year Burned	Year Planted	Elevation (feet)	Site Index	Aspect	No. Deer per sq. mile*
1	1961	1961	1963	800-1500	150	SE	79
2	1966	1966	Not Pl.	1700-2000	160	S	89
3	1966	1966	Not Pl.	1700-2000	130	S	81
4	1961	1961	1963?	800-1300	130	NW	43
5	1967	1967	Not Pl.	1200-1500	130	NE	33

*Estimate taken from Table 4. The permanent plots which were also located on the Ecotone Study areas were (in consecutive order to the above): 2, 23, 22, 1, and 25.

APPENDIX 6

DESCRIPTION OF MATURE FOREST PLOTS

Plot No.	Elevation (feet)	Aspect	Slope (percent)	Plot No.	Elevation (feet)	Aspect	Slope (percent)
1	1900	SE	40	11	2840	S	30
2	1730	SW	55	12	1700	N	30
3	1220	N	40	13	420	N	20
4	1040	N	50	14	700	N	90
5	1530	S	40	15	840	N	20
6	1920	N	50	16	1500	NE	35
7	1400	S	30	17	670	S	10
8	1210	S	30	18	870	S	35
9	2500	S	60	19	1050	S	15
10	2860	N	20	20	1000	N	55

APPENDIX 7

SAMPLING ACCURACY OF PELLET GROUPS ON PERMANENT PLOTS*

Sample 1

Plot No.	Avg. No. Pellet Groups per Sample	Standard Error of mean	Confidence Limits (95%)
1	2.38	0.30	0.59
2	3.15	0.40	0.80
3	2.02	0.32	0.65
4	1.90	0.34	0.68
5	2.65	0.34	0.68
6	2.15	0.44	0.88
7	1.94	0.37	0.74
8	2.34	0.35	0.70
9	1.68	0.24	0.49
10	1.52	0.28	0.56
11	1.58	0.28	0.57
12	1.70	0.26	0.53
13	1.35	0.26	0.52
14	2.15	0.29	0.58
15	1.20	0.28	0.56
16	0.42	0.14	0.28
17	1.51	0.24	0.47
18	1.42	0.24	0.49
19	0.98	0.19	0.38
20	0.54	0.14	0.29
21	1.62	0.35	0.71
22	1.55	0.30	0.61
23	1.12	0.21	0.42
24	0.30	0.12	0.23
25	0.18	0.07	0.14
26	1.08	0.22	0.44
27	1.28	0.28	0.55
28	1.05	0.18	0.35
29	2.05	0.33	0.67
30	1.18	0.24	0.48

APPENDIX 7 (continued)

SAMPLING ACCURACY OF PELLET GROUPS ON PERMANENT PLOTS*

Sample 1

Plot No.	Avg. No. Pellet Groups per Sample	Standard Error of Mean	Confidence Limits (95%)
31	1.08	0.24	0.49
32	1.38	0.25	0.51
33	1.42	0.26	0.52
34	1.98	0.34	0.68
35	0.55	0.15	0.29
36	0.72	0.19	0.38
37	1.07	0.28	0.56
38	0.62	0.15	0.30
39	0.32	0.12	0.24
40	0.22	0.07	0.15
41	0.10	0.07	0.14
42	0.25	0.11	0.22
43	1.00	0.19	0.38
44	1.12	0.20	0.41
45	0.42	0.15	0.30
46	0.78	0.20	0.40
47	1.45	0.29	0.58
48	1.08	0.22	0.43
49	1.38	0.27	0.55
50	1.08	0.22	0.44

APPENDIX 7 (continued)

SAMPLING ACCURACY OF PELLET GROUPS ON PERMANENT PLOTS*

Sample 2

Plot No.	Avg. No. Pellet Groups per Sample	Standard Error of Mean	Confidence Limits (95%)
1	0.72	0.172	0.34
2	1.44	0.272	0.55
3	0.78	0.190	0.38
4	1.02	0.227	0.46
5	1.02	0.216	0.44
6	Not Recorded		
7	0.58	0.180	0.36
8	0.65	0.137	0.28
9	0.85	0.188	0.38
10	1.50	0.224	0.45
11	0.48	0.107	0.22
12	0.55	0.129	0.26
13	0.85	0.170	0.35
14	1.20	0.169	0.34
15	0.451	0.121	0.25
16	0.57	0.149	0.30
17	1.05	0.162	0.32
18	0.90	0.191	0.37
19	0.40	0.106	0.22
20	0.10	0.059	0.12
21	1.30	0.329	0.66
22	1.20	0.261	0.53
23	1.34	0.206	0.42
24	0.25	0.085	0.17
25	0.50	0.130	0.26
26	0.93	0.164	0.33
27	1.10	0.167	0.34
28	0.50	0.107	0.22
29	1.17	0.170	0.35

APPENDIX 7 (continued)

SAMPLING ACCURACY OF PELLET GROUPS ON PERMANENT PLOTS*

Sample 2

Plot No.	Avg. No. Pellet Groups per Sample	Standard Error of Mean	Confidence Limits (95%)
30	0.70	0.161	0.32
31	0.52	0.132	0.26
32	1.26	0.183	0.38
33	0.92	0.171	0.35
34	1.20	0.187	0.38
35	0.68	0.146	0.30
36	1.05	0.172	0.35
37	1.20	0.172	0.35
38	0.78	0.145	0.30
39	0.80	0.221	0.48
40	0.42	0.107	0.22
41	0.35	0.126	0.26
42	0.38	0.128	0.26
43	0.58	0.128	0.26
44	0.33	0.093	0.19
45	0.13	0.056	0.11
46	0.52	0.129	0.26
47	0.42	0.124	0.25
48	0.87	0.155	0.31
49	0.78	0.182	0.37
50	0.53	0.123	0.25

*Each plot consists of 40 samples.

APPENDIX 8

STATISTICS AND MULTIPLE REGRESSION ANALYSIS ON DATA FROM PERMANENT PLOTS

Sample I - Plots on all Aspects (Unstratified)

Variable	Mean	Range
Year Burned	1964.6	1960-1968
Elevation (ft x 100)	15.7	8-31
Site Index	131.4	100-160
*Pellet Groups - per plot	50.8	4-126

*In all cases the dependent variable is pellet groups.

Independent Variables (In combination or alone)	Statistics for individual independent variables in combination or alone		Statistics for independent variables in combination or alone		
	Regression Coefficient	Variance Ratio (F)	Multiple Correlation Coefficient (R)	R^2	Variance Ratio (F)
Time Burn	+7.021	25.115			
Elevation	-0.673	1.054			
Site Index	+0.610	3.294			
			0.733	0.537	17.806**
Time Burn	+6.892	24.371			
Site Index	+0.868	15.091			
			0.726	0.527	26.152**
Time Burn	+8.25	28.768			
			0.612	0.375	28.768**
Elevation	-1.880	11.291			
			0.436	0.190	11.291**
Site Index	+1.144	18.787			
			0.530	0.281	18.787**

APPENDIX 8 (continued)

Sample I - Plots on North Aspect

Variable	Mean	Range
Year Burn	1964.07	1960-1967
Elevation (ft x 100)	13.87	8-30
Site Index	133.33	110-160
Pellet Groups - per plot	50.27	4-94

Independent Variables (In combination or alone)	Statistics for individual independent variables in combination or alone		Statistics for independent variables in combination or alone		
	Regression Coefficient	Variance Ratio (F)	Multiple Correlation Coefficient (R)	R^2	Variance Ratio (F)
Time Burn	+8.748	5.378			
Elevation	-1.997	0.903			
Site Index	-0.183	0.021			
			0.799	0.638	6.467**
Time Burn	+8.417	8.604			
Elevation	-1.737	2.839			
			0.798	0.637	10.551**
Time Burn	+10.746	16.00			
			0.743	0.552	16.00 **
Elevation	- 3.193	7.886			
			0.614	0.378	7.886*
Site Index	+ 1.789	11.070			
			0.678	0.460	11.070**

APPENDIX 8 (continued)

Sample I - Plots on South Aspect

Variable	Mean	Range
Time Burn	1964.57	1961-1967
Elevation (ft x 100)	16.96	8-31
Site Index	130.87	100-150
Pellet Groups	58.61	22-26

Independent Variables (In combination or alone)	Statistics for individual independent variables in combination or alone		Statistics for independent variables in combination or alone		
	Regression Coefficient	Variance Ratio (F)	Multiple Correlation Coefficient (R)	R^2	Variance Ratio (F)
Time Burn	+7.672	23.985			
Elevation	-2.233	8.845			
Site Index	+0.264	0.513			
			0.862	0.744	18.382**
Time Burn	+7.975	28.655			
Elevation	-2.670	38.258			
			0.858	0.737	27.998**
Elevation	-2.212	11.801			
			0.600	0.360	11.801**
Time Burn	+6.151	6.394			
			0.483	0.233	6.394*
Site Index	+1.157	13.567			
			0.626	0.392	13.567**

APPENDIX 8 (continued)

Sample II - Plots on all Aspects (Unstratified)

Variable	Mean	Range
Time Burn	1964.61	1960-1968
Elevation (ft x 100)	15.88	8-31
Site Index	131.22	100-160
Pellet Groups	33.20	4-62

Independent Variables (In combination or alone)	Statistics for individual independent variables in combination or alone		Statistics for independent variables in combination or alone		
	Regression Coefficient	Variance Ratio (F)	Multiple Correlation Coefficient (R)	R^2	Variance Ratio (F)
Time burn	+2.496	6.224			
Elevation	+0.849	3.203			
Site Index	+0.166	0.476			
			0.434	0.188	3.485*
Time Burn	+2.657	7.546			
Elevation	+0.605	3.709			
			0.424	0.180	5.046*
Time Burn	+2.425	6.036			
			0.337	0.114	6.036*
Elevation	+0.497	2.236			
			0.213	0.045	2.236^{NS}
Site Index	-0.0495	0.086			
			0.043	0.00	0.086^{NS}

APPENDIX 8 (continued)

Sample II - Plots on North Aspect

Variable	Mean	Range
Time Burn	1964.07	1960-1967
Elevation (ft x 100)	14.28	8-30
Site Index	132.87	110-160
Pellet Groups	27.07	6-45

Independent Variables (In combination or alone)	Statistics for individual independent variables in combination or alone		Statistics for independent variables in combination or alone		
	Regression Coefficient	Variance Ratio (F)	Multiple Correlation Coefficient (R)	R^2	Variance Ratio (F)
Time Burn	+2.864	2.807			
Elevation	-0.018	0.000			
Site Index	-0.121	0.043			
			0.551	0.304	1.453^{NS}
Time Burned	+2.854	3.385			
Site	-0.112	0.153			
			0.551	0.304	2.397^{NS}
Time Burned	+2.44	4.995			
			0.542	0.294	4.995*
Elevation	-0.332	0.492			
			0.198	0.039	0.492^{NS}
Site Index	+0.248	1.176			
			0.299	0.089	1.176^{NS}

APPENDIX 8 (continued)

Sample II - Plots on South Aspect

Variable	Mean	Range
Time Burn	1964.57	1961-1967
Elevation (ft x 100)	16.96	8-31
Site Index	130.87	100-150
Pellet Groups	41.91	19-62

Independent Variables (In combination or alone)	Statistics for individual independent variables in combination or alone		Statistics for independent variables in combination or alone		
	Regression Coefficient	Variance Ratio (F)	Multiple Correlation Coefficient (R)	R^2	Variance Ratio (F)
Time Burn	+0.906	0.337			
Elevation	+0.762	1.039			
Site Index	+0.198	0.292			
			0.324	0.105	0.743^{NS}
Time Burn	+1.133	0.591			
Elevation	+0.433	1.029			
			0.302	0.091	1.004^{NS}
Elevation	+0.498	1.445			
			0.254	0.064	1.445^{NS}
Time Burn	+1.430	0.977			
			0.211	0.044	0.977^{NS}
Site Index	-0.105	0.243			
			0.107	0.011	0.243^{NS}

Null hypothesis; $Ho = B_1 = B_2 = B_3 = 0$

N.S. Not significant at P0.05.

* Significant at P0.05.

** Significant at P0.01.

APPENDIX 9

Regression Analysis on Data Illustrating Changing Deer Use with Elevation In a Two Year Period for Logged Forest

Plot No.	Sample I* - Sample II	Elevation (ft x 100)
1	33.7	9
2	31.6	8
3	23.7	10
4	9.0	12
5	30.3	15
6	N.A.	8
7	23.1	10
8	36.3	12
9	9.4	9
10	-21.6	11
11	22.8	9
12	22.1	10
13	0.8	12
14	7.0	11
15	12.8	9
16	-12.4	8
17	- 7.9	9
18	- 0.2	11
19	- 8.9	9
20	+ 9.9	10
21	-13.9	15
22	-11.9	18
23	-28.2	18
24	- 3.0	23
25	-17.4	13
26	-13.5	14
27	+ 6.8	15
28	+ 4.8	20
29	+ 1.1	16
30	- 0.8	17
31	+ 4.5	15

APPENDIX 9 (continued)

Plot No.	Sample I* - Sample II	Elevation (ft x 100)
32	-17.5	26
33	- 4.2	25
34	- 4.6	23
35	-16.4	23
36	-28.8	28
37	-26.5	31
38	-20.4	25
39	-28.4	30
40	-14.0	14
41	-14.4	21
42	-12.4	25
43	- 0.5	20
44	+13.8	15
45	+ 5.3	20
46	- 4.4	10
47	+18.5	15
48	-14.5	19
49	- 1.5	15
50	+ 2.5	15

Mean x (Sample I - Sample II) = -0.376
Mean y (elevation - ft x 100) = 15.28
Slope (b) = -1.64
Correlation coefficient (r) = 0.596
Coefficient of determination (r^2) = 0.355
t (47df) = 4.085**

* For this exercise the data of sample I was adjusted so that the average pellet groups per plot was the same as in sample II. This required multiplying the count in each plot by a constant.

Null hypothesis; Ho b = 0

**Significant at P0.01

APPENDIX 10

Sample Of Species Composition And Cover On Permanent Plots

Plot No.	Class*	Species**
1	A	Gs, Ru, Pm, D, Am, At, Tt, Ead
	B	V, Lb, Rs
	C	Ea, Rp
	D	
	E	
	60(30-80)***	
2	A	Ru, At, Ss, Pa
	B	Ea, V, Lb
	C	
	D	
	E	
	30(5-100)	
3	A	S, Cc, Lb, Rs, Pm, Am, Ss
	B	
	C	Ea, V
	D	Gs
	E	
	70(10-100)	
4	A	Gs, Lb, Pm, Ss, Pa
	B	Rs, Am
	C	Ea, V, Ru
	D	
	E	
	65(30-90)	
5	A	V, Cc, Rs, Ru, Pm, At, Ss
	B	Am
	C	Lb
	D	Ea
	E	
	75(50-100)	
7	A	Ea, V, Gs, Cc, Am, At
	B	Sr
	C	Lb, Rs, Ru, Pm, Ss, Pa
	D	
	E	
	75(30-90)	
8	A	Ea, V, Gs, Cc, Rs, Pa, Am
	B	
	C	Lb
	D	
	E	
	35(0.80)	
9	A	V, S, Cc, Ru, Ss, Mn, At, Ead
	B	Lb
	C	Ea, Gs
	D	Pa
	E	
	85(60-90)	

APPENDIX 10 (continued)

Sample of Species Composition And Cover On Permanent Plots

Plot No.	Class	Species	Plot No.	Class	Species
10	A	Ea, Rs, Ru, Pm, D, Am, Sr, Gr	11	A	Ea, V, Rp, Rs, Ru, Pm, Ss, Gr, Ead, At
	B	V, Mn, Pa		B	Gs, Cc, Pa, Am
	C	Lb		C	Lb
	D	Gs		D	Mn
	E			E	
	70(20-90)			80(60-100)	
12	A	Ea, Cc, Lb, Mn	13	A	Ea, S, Gs, Cc, Rs, Ru, Ss, Am, At
	B	V		B	Pa
	C	Pa		C	V, Lb
	D	Gs		D	
	E			E	
	70(20-90)			55(20-90)	
14	A	V, Rs, Pm	15	A	Ea, S, Lb, Rs, Pa
	B	Cc, Af, Ss		B	Cc
	C	Ea		C	
	D	Lb		D	V, Gs
	E			E	
	80(60-100)			85(60-100)	
16	A	D, Am, At, Af, Ead	17	A	V, Cc, Lb, Ss, Am, Sr, Tt, Gr
	B	Cc, Lb, Rs, Pm		B	Rp
	C	Ea, V		C	
	D			D	Ea, Rs
	E			E	
	55(0-90)			85(60-100)	
18	A	Gs, Lb, Rp, Ru, Af, Pa, Am, At, Gr	19	A	G, Gs, Rs, Ss, Am, Gr
	B	V, Rs, Ss		B	
	C	Ea, Cc		C	Cc, Lb
	D			D	
	E			E	
	65(0.90)			65(5-90)	

APPENDIX 10 (continued)

Sample of Species Composition and Cover on Permanent Plots

Plot No.	Class	Species	Plot No.	Class	Species
20	A	Gs, Ss, Am, Pa	21	A	V, S, Gs, Lb, Af, Ss, Mn
	B	V, Lb		B	Gr, Ead
	C	Cc		C	
	D	Ea		D	Ea
	E			E	
	60(40-70)			65(40-100)	
22	A	V, S, Ccc, Lb, Pm, Ead	23	A	S, Gs, Cc, Lb, Ss, Gr
	B	Gs, Mn, Ss		B	
	C			C	Ea, V
	D	Ea		D	
	E			E	
	65(10-100)			45(10-80)	
24	A	Ea, S, Cc, Lb, Am	25	A	V, S, Lb, Rs, Pm, Ss, Pa, Sr, Mn
	B			B	
	C	V		C	
	D			D	Ea
	E			E	
	20(5-70)			45(30-70)	
26	A	V, S, Gs, Cc, Am, Mn, Ead	27	A	Cc, Rp, Rs, Ru, Pm, Af, Am, At, Sr, Mn
	B	Pa		B	Ea, V, Pa
	C	Lb		C	Lb
	D	Ea		D	
	E			E	
	60(40-90)			70(30-100)	

APPENDIX 10 (continued)

Sample of Species Composition and Cover on Permanent Plots

Plot No.	Class	Species	Plot No.	Class	Species
28	A	V, Pa	29	A	V, Ru, Pa, Sr, Mn, At
	B	S		B	
	C			C	
	D			D	Ea, Lb.
	E	Ea		E	
	65(50-90)			70(60-80)	
30	A	S, Gs, Gr	31	A	V, S, Rs, Ru, Pm, Sr, Gr, At, Pa
	B			B	
	C	Lb		C	Rp
	D	Ea		D	Ea, Lb
	E			E	
	55(20-100)			85(50-100)	
32	A	V, Cc, Af, Am, Tt, Gr, Ss	33	A	Cc, Am, Ff, Pa, Ss
	B			B	V
	C			C	Lb
	D	Ea, Lb		D	Ea
	E			E	
	80(60-100)			70(30-90)	
34	A		35	A	S, Lb, Am
	B	Lb		B	V
	C	Cc		C	
	D	Ea, V		D	Ea
	E			E	
	80(50-100)			55(20-80)	

APPENDIX 10 (continued)

Sample of Species Composition and Cover on Permanent Plots

Plot No.	Class	Species
36	A	V
	B	
	C	Ea, Lb, Pa
	D	
	E	
	55(10-80)	
37	A	V, Af, Tt, Ead, Ss
	B	Pa
	C	Lb
	D	Ea
	E	
	50(5-100)	
38	A	V, S, Am, Pa
	B	
	C	
	D	Ea, Lb
	E	
	80(70-100)	
39	A	S, Lb, Tt, Ead
	B	V
	C	
	D	Ea
	E	
	65(20-80)	
40	A	V, S, Cc, Lb, Gr, Pa
	B	Ea
	C	
	D	
	E	
	30(5-70)	
41	A	S, Cc, Lb, Af,S
	B	
	C	Ea
	D	V
	E	
	50(20-60)	
42	A	Ea, S, Lb, Af
	B	Cc
	C	V
	D	
	E	
	40(20-60)	
43	A	V, Cc, Lb, At, Ss
	B	Ea
	C	
	D	
	E	
	20(5-60)	

APPENDIX 10 (continued)

Sample of Species Composition and Cover on Permanent Plots

Plot No.	Class	Species	Plot No.	Class	Species
44	A	S, Rp, Am, Pa	45	A	S, Rs, Am, Ead, Ss
	B	V, Lb		B	Ea, Gs, Cc
	C			C	V, Lb
	D	Ea		D	
	E			E	
	65(40-80)				
46	A	Cc, Rs, Pm, Ss	47	A	S, Ss, B, Am, Sr
	B	V		B	V
	C	Ea, Lb		C	Lb
	D	Gs		D	Ea
	E			E	
	70(30-90)				
48	A	S, Pa	49	A	Cc, Rs, Ff, Ss, Pa
	B			B	V
	C	V, Lb		C	Ea, Lb
	D	Ea		D	
	E			E	
	70(50-80)			45(5-80)	
50	A	V, Ss, Am, Gr, Ead			
	B				
	C	Ea, S			
	D	Lb			
	E				
	50(20-70)				

APPENDIX 10 (continued)

* Percent cover by each class: A, 1-5; B, 6-10, C, 11-20; D, 21-50; E, 51+

**Botanical name represented by each species symbol:

	Symbol	Botanical Name[1]
1	Af	*Athyrium filix-femina* (L.) Roth
2	Am	*Anaphalis margaritacea* Beuth.
3	At	*Achlys triphylla* (D.C.)
4	Cc	*Cornus canadensis* L.
5	Ea	*Epilobium angustifolium* L.
6	Ead	*Epilobium adenocaulon* Haus.
7	Gr	*Graminae* spp.
8	Gs	*Gaultheria shallon* Pursh.
9	Lb	*Linnaea borealis* L.
10	Mn	*Mahonia nervosa* (Pursh.) Nutt.
11	Pa	*Pteris aquilina* L.
12	Pm	*Polystichum munitum* (Kaulf.) Presl.
13	Rp	*Rubus paruiflorus* Nutt.
14	Ps	*Rubus spectabilis* Pursh.
15	Ru	*Rubus ursinus* Cham. & Sch.
16	S	*Senecia* spp. L.
17	Sr	*Sambucus racemosa* L.
18	Ss	*Struthiopteris spicant* (L) Weis.
19	Tt	*Tiarella trifoliata* L.
20	V	*Vaccinium* spp. L.

***Average total cover and range (in brackets) of samples within each permanent plot

[1] Common name can be found at end of Appendix 14.

Plot 6 not recorded.

APPENDIX 11a

A Summary of Pellet Group Variation Within Classes - Outside Forest

Distance Out of Forest - Perpendicular
to Upper Forest Edge

Plot I

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441	481	521	561
Number samples	51	46	42	47	44	45	46	42	43	43	46	47	47	43	45
Mean (Y)	2.27	3.43	3.24	3.02	2.61	2.98	3.22	2.36	2.02	2.53	2.63	2.60	2.36	2.14	2.33
Confidence Limits (95%)	0.58	0.17	0.73	0.56	0.71	0.69	0.77	0.54	0.51	0.73	0.66	0.64	0.42	0.56	0.67

	601	641	681	721	761	801	841	881	921	961	1001	1041	1081	1121
	44	57	44	39	31	33	31	30	30	28	28	27	46	
	2.16	0.68	0.43	0.75	1.21	1.74	1.67	2.16	1.80	1.60	1.46	2.54	1.07	1.48
	0.54	0.34	0.24	0.40	0.44	0.71	0.61	0.73	0.63	0.55	0.59	0.82	0.47	0.52

Plot 2

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441	481	521
Number samples	53	43	46	47	46	45	49	40	41	43	46	44	44	45
Mean (Y)	0.25	1.81	2.59	1.70	1.74	1.24	1.41	1.05	0.66	0.33	0.72	0.61	0.59	0.87
Confidence Limits (95%)	0.16	0.75	0.77	0.72	0.53	0.48	0.64	0.40	0.42	0.20	0.46	0.32	0.28	0.32

	561	601	641	681	721	761	801	841	881
	44	42	40	41	45	43	43	42	105
	0.89	1.40	1.42	1.93	1.58	0.93	0.56	0.98	1.08
	0.40	0.60	0.52	0.61	0.57	0.36	0.32	0.48	0.28

APPENDIX 11a (continued)

A Summary of Pellet Group Variation Within Classes - Outside Forest

Distance Out of Forest - Perpendicular to Upper Forest Edge

Plot 3

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441	481	521
Number samples	41	38	38	38	37	38	40	40	37	36	33	36	35	38
Mean (Y)	0.68	0.89	1.66	2.00	1.22	1.47	0.88	1.07	1.11	1.06	1.27	0.86	1.06	0.82
Confidence Limits (95%)	0.69	0.37	0.51	0.67	0.43	0.53	0.38	0.41	0.53	0.53	0.49	0.45	0.57	0.37

	561	601	641	681	721	761	801
	40	40	40	40	40	40	116
	1.22	1.25	0.90	1.05	0.40	1.25	1.59
	0.41	0.52	0.34	0.42	0.24	0.65	0.32

Plot 4

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441	481	521
Number samples	49	40	40	40	38	40	44	40	34	36	34	38	36	38
Mean (Y)	0.67	1.85	2.02	1.77	1.58	1.42	1.27	1.57	0.97	0.67	1.29	0.95	0.78	1.24
Confidence Limits (95%)	0.30	0.79	0.69	0.71	0.73	0.50	0.50	0.71	0.63	0.36	0.65	0.52	0.43	0.47

	561	601	641	681	721	761	801	841
	40	38	42	38	34	35	35	56
	0.77	0.66	1.31	1.24	0.94	1.20	1.51	1.36
	0.46	0.34	0.52	0.68	0.53	0.59	0.65	0.46

APPENDIX 11a (continued)

A Summary of Pellet Group Variation Within Classes - Outside Forest

Distance Out of Forest - Perpendicular
to Upper Forest Edge

Plot 5

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441	481	521
Number samples	30	21	26	22	23	23	25	27	22	27	27	26	23	27
Mean (Y)	0.20	0.90	1.88	2.18	1.43	1.74	1.68	1.56	0.95	1.15	1.11	0.88	1.04	1.52
Confidence Limits (95%)	0.18	0.63	0.78	0.69	0.48	0.68	0.76	0.62	0.43	0.60	0.43	0.45	0.52	0.78

Lower Limit of Class (ft)	561	601	641	681	721	761	801	841	881
Number samples	28	24	26	21	24	26	27	27	29
Mean (Y)	1.39	1.25	1.35	0.95	1.96	1.77	1.26	1.07	0.41
Confidence Limits (95%)	0.49	0.54	0.58	0.44	0.85	0.68	0.64	0.47	0.27

APPENDIX 11a (continued)

Distance Out of Forest - Parallel to Upper Forest Edge

Plot 2

Lower limit of Class (ft)	0	25	50	75	100	125	150	175	200	225	250	275	300
Mean (Y)	0.46	0.12	0.46	1.04	1.08	0.35	1.21	1.26	0.88	1.64	1.88	0.88	0.96
Confidence Limits (95%)	0.39	0.14	0.44	0.54	0.78	0.29	0.63	0.82	0.54	0.76	0.93	0.56	0.56

	325	350	375	400	425	450	475	500	525	550	575	600	625
	0.88	1.04	1.12	0.76	0.58	1.27	1.20	1.65	1.25	1.22	1.56	1.04	1.12
	0.50	0.64	0.64	0.44	0.37	0.66	0.78	0.95	0.45	0.76	0.74	0.49	0.58

	650	675	700	725	750	775	800	825	850	875	900	925	950	975
	1.43	1.63	1.58	0.96	0.87	1.28	1.52	1.14	1.06	1.03	0.97	1.31	1.84	1.59
	0.94	0.92	0.76	0.57	0.45	0.65	0.80	0.68	0.41	0.53	0.53	0.57	0.76	0.84

Plot 4

Lower limit of Class (ft)	0	25	50	75	100	125	150	175	200	225	250	275	300
Mean (Y)	0.41	0.50	0.86	0.95	1.76	1.10	1.76	1.67	1.86	1.38	1.30	1.76	1.29
Confidence Limits (95%)	0.35	0.50	0.67	0.50	0.71	0.52	0.98	0.94	0.69	0.65	0.73	0.77	0.54

	325	350	375	400	425	450	475	500	525	550	575	600	625	650
	1.54	1.55	1.62	1.48	1.00	1.24	0.59	1.40	1.30	1.14	0.83	1.70	1.14	1.64
	0.62	0.56	0.88	0.69	0.42	0.42	0.25	0.58	0.46	0.46	0.54	0.73	0.56	0.56

APPENDIX 11a (continued)

Road Edge Effect

Plot 1

	Lower Limits of Class (feet)								
	0	21	61	101	141	181	221	261	301
Towards Forest Edge									
Number Samples	19	33	35	31	31	30	32	31	25
Mean (Y)	0.26	0.51	1.63	2.10	2.45	2.63	2.66	2.65	2.34
Confidence Limits (95%)	0.36	0.35	0.55	0.59	0.75	0.67	0.61	0.88	0.44
Away from Forest Edge									
Number Samples	16	27	27	26	30	27	27	25	75
Mean (Y)	0	0.59	1.63	2.31	1.87	1.96	2.00	1.52	1.55
Confidence Limits (95%)	0	0.51	0.53	0.74	0.63	0.78	0.76	0.54	0.38

Plot 2

	Lower Limits of Class (feet)								
	0	21	61	101	141	181	221	261	301
Towards Forest Edge									
Number Samples	51	81	94	82	79	74	76	38	11
Mean (Y)	0.04	0.52	1.26	1.33	1.18	1.27	1.91	1.40	1.54
Confidence Limits (95%)	0.66	0.23	0.31	0.33	0.30	0.33	0.54	0.49	1.31
Away from Forest Edge									
Number Samples	40	57	55	36	31	26	24	16	8
Mean (Y)	0	0.44	1.18	1.50	1.13	1.54	2.00	1.12	0.75
Confidence Limits (95%)	0	0.21	0.36	0.55	0.52	0.71	0.71	0.54	1.13

<u>Epilobium angustifolium</u> - Outside Forest, Plot 1 - 5

	Lower Limits of Class (Percent)										
	0	6	16	26	36	46	56	66	76	86	96
Plot 1											
Number Samples	491	344	228	103	18	10					
Mean (Y)	2.11	2.12	2.18	1.96	2.06	1.70					
Confidence Limits (95%)	0.18	0.22	0.28	0.34	1.25	1.63					
Plot 2											
Number Samples	433	184	191	166	59	31	13				
Mean (Y)	1.18	1.02	1.21	1.20	0.95	0.87	1.08				
Confidence Limits (95%)	0.18	0.24	0.24	0.26	0.36	0.43	0.76				
Plot 3											
Number Samples	152	169	221	188	90	29	17	15			
Mean (Y)	0.74	0.99	1.05	1.46	1.83	1.34	0.94	1.40			
Confidence Limits (95%)	0.26	0.20	0.18	0.26	0.38	0.66	0.53	0.73			
Plot 4											
Number Samples	392	346	109	18							
Mean (Y)	1.04	1.53	1.11	0.50							
Confidence Limits (95%)	0.18	0.20	0.28	0.32							
Plot 5											
Number Species	178	185	129	63	23						
Mean (Y)	1.13	1.34	1.19	1.63	1.48						
Confidence Limits (95%)	0.23	0.19	0.24	0.38	0.56						

APPENDIX 11a (continued)

Rubus parviflorus - Outside Forest, Plot 1 - 4

	Lower Limits of Class (Percent)						
	0	6	16	26	36	46	56
Plot 1							
Number Samples	796	244	98	36	20		
Mean (Y)	2.17	2.23	1.67	1.78	1.05		
Confidence Limits (95%)	0.14	0.28	0.40	0.65	0.48		
Plot 4							
Number Samples	163	219	256	170	35	22	
Mean (Y)	0.57	1.16	1.56	1.52	1.43	0.50	
Confidence Limits (95%)	0.18	0.23	0.24	0.29	0.65	0.33	

Rubus spectabilis - Outside Forest, Plot 1 - 4

	Lower Limits of Class (Percent)						
	0	6	16	26	36	46	56
Plot 1							
Number Samples	711	305	125	44	9		
Mean (Y)	2.02	2.31	2.14	2.05	1.67		
Confidence Limits (95%)	0.16	0.24	0.38	0.61	2.18		
Plot 4							
Number Samples	542	245	70	8			
Mean (Y)	1.04	1.56	1.67	0.88			
Confidence Limits (95%)	0.14	0.26	0.50	0.83			

Rubus ursinus - Outside Forest, Plot 1 - 4

	Lower Limits of Class (Percent)						
	0	6	16	26	36	46	56
Plot 1							
Number Samples	953	179	46	16			
Mean (Y)	1.95	2.84	2.57	2.12			
Confidence Limits (95%)	0.12	0.35	0.79	1.23			
Plot 4							
Number Samples	755	89	16	5			
Mean (Y)	1.18	1.66	1.56	0.60			
Confidence Limits (95%)	0.12	0.46	1.32	1.11			

Vaccinium spp - Outside Forest, Plot 1 - 5

	Lower Limits of Class (Percent)										
	0	6	16	26	36	46	56	66	76	86	96
Plot 1											
Number Samples	741	304	110	36							
Mean (Y)	1.87	2.47	2.67	2.19							
Confidence Limits (95%)	0.14	0.24	0.40	0.55							
Plot 2											
Number Samples	518	175	168	120	53	25	18				
Mean (Y)	0.54	1.06	1.54	2.21	2.08	3.44	2.28				
Confidence Limits (95%)	0.08	0.22	0.26	0.42	0.60	1.27	1.05				
Plot 3											
Number Samples	611	174	72	24							
Mean (Y)	0.93	1.36	2.31	2.42							
Confidence Limits (95%)	0.10	0.22	0.50	1.15							

Vaccinium spp - Outside Forest, Plot 1 - 5 (continued)

	Lower Limits of Class (Percent)										
	0	6	16	26	36	46	56	66	76	86	96
Plot 4											
Number Samples	522	262	72	9							
Mean (Y)	0.98	1.61	1.61	1.67							
Confidence Limits (95%)	0.14	0.24	0.44	1.16							
Plot 5											
Number Samples	378	136	60	7							
Mean (Y)	1.14	1.62	1.20	2.57							
Confidence Limits (95%)	0.14	0.29	0.36	2.37							

APPENDIX 11a (continued)

Cover; All Species - Outside Forest, Plot 1 - 5

	Lower Limits of Class (Percent)										
	0	6	16	26	36	46	56	66	76	86	96
Plot 1											
Number Samples	84	102	118	153	111	125	138	140	104	97	22
Mean (Y)	1.07	1.65	2.57	2.35	2.50	2.17	1.98	2.37	2.06	1.92	1.91
Confidence Limits (95%)	0.38	0.38	0.34	0.32	0.42	0.42	0.36	0.36	0.38	0.36	0.69
Plot 2											
Number Samples	134	103	89	116	117	119	195	135	58	11	
Mean (Y)	0.57	0.39	0.63	0.87	1.08	1.14	1.44	1.73	1.59	2.36	
Confidence Limits (95%)	0.22	0.14	0.22	0.26	0.28	0.30	0.25	0.30	0.74	1.09	
Plot 3											
Number Samples	70	39	44	59	102	139	166	154	78	30	
Mean (Y)	0.24	0.36	0.34	0.92	0.98	1.40	1.24	1.53	1.73	1.93	
Confidence Limits (95%)	0.16	0.26	0.26	0.32	0.26	0.28	0.24	0.26	0.50	0.73	
Plot 4											
Number Samples	37	24	21	37	52	121	166	166	141	75	25
Mean (Y)	0.11	0.21	0.29	0.70	0.73	1.04	1.27	1.81	1.45	1.68	0.84
Confidence Limits (95%)	0.11	0.21	0.29	0.45	0.32	0.31	0.28	0.32	0.28	0.46	0.45
Plot 5											
Number Samples	28	37	67	91	117	98	86	43	14		
Mean (Y)	0.04	1.05	1.12	1.54	1.04	1.30	1.60	1.79	1.57		
Confidence Limits (95%)	0.08	0.51	0.30	0.34	0.22	0.26	0.34	0.59	1.02		

Number Species - Outside Forest, Plot 1 - 5

	Lower Limits of Class										
	0	1	2	3	4	5	6	7	8	9	10
<u>Plot 1</u>											
Number Samples	42	55	177	276	262	185	197				
Mean (Y)	0.98	1.40	2.29	2.14	2.50	2.33	1.60				
Confidence Limits (95%)	0.55	0.44	0.32	0.22	0.28	0.32	0.24				
<u>Plot 2</u>											
Number Samples	98	44	203	384	251	78	19				
Mean (Y)	0.71	0.25	1.40	1.10	1.18	1.56	1.11				
Confidence Limits (95%)	0.30	0.22	0.28	0.16	0.22	0.44	1.17				
<u>Plot 3</u>											
Number Samples	31	27	147	268	217	98	53	29	11		
Mean (Y)	0.26	0.48	1.13	1.14	1.46	1.07	1.28	1.24	0.91		
Confidence Limits (95%)	0.31	0.31	0.28	0.18	0.21	0.28	0.42	0.59	0.92		
<u>Plot 4</u>											
Number Samples	15	18	29	70	198	261	177	74	23		
Mean (Y)	0	0.17	0.24	0.61	1.12	1.39	1.53	1.59	1.78		
Confidence Limits (95%)	0	0.25	0.18	0.34	0.21	0.24	0.25	0.44	0.70		
<u>Plot 5</u>											
Number Samples	18	29	107	163	160	69	21	14			
Mean (Y)	0	1.07	0.94	1.29	1.49	1.57	1.43	1.57			
Confidence Limits (95%)	0	0.66	0.26	0.21	0.23	0.36	0.71	1.08			

APPENDIX 11b

A Summary of Pellet Group Variation Within Classes - Inside Forest
Distance Into Forest - Perpendicular to Upper Forest Edge

Plot 1

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441
Number Samples	56	40	42	44	44	45	47	44	47	46	31	27
Mean (Y)	1.34	1.42	1.31	0.71	1.11	0.82	0.68	0.75	1.15	0.91	1.00	1.00
Confidence Limits (95%)	0.42	0.54	0.48	0.28	0.34	0.34	0.32	0.30	0.36	0.30	0.51	0.53
	481	521	561	601	641	681	721	761	801	841	881	921
	27	28	28	27	27	31	27	28	29	27	30	27
	0.89	0.96	1.00	0.85	1.30	0.90	1.44	1.68	1.24	1.26	0.73	0.96
	0.35	0.41	0.43	0.35	0.49	0.35	0.51	0.59	0.49	0.55	0.39	0.29
	961	1001	1041	1081	1121	1161	1201	1241	1281	1321	1361	1401
	27	27	28	27	27	29	23	23	23	23	23	23
	1.26	1.81	1.11	1.48	1.93	1.34	1.48	1.13	0.87	0.65	0.48	0.61
	0.41	0.70	0.47	0.57	0.76	0.45	0.60	0.58	0.54	0.37	0.23	0.41
	1441	1481	1521									
	22	23	35									
	0.91	0.57	0.60									
	0.46	0.39	0.24									

APPENDIX 11b (continued)

A Summary of Pellet Group Variation Within Classes - Inside Forest

Distance Into Forest - Perpendicular to Upper Forest Edge

Plot 2

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441
Number Samples	49	43	42	46	40	48	43	42	31	17	15	16
Mean (Y)	0.59	0.95	1.17	1.35	1.37	1.02	2.33	1.93	2.32	1.41	2.47	1.81
Confidence Limits (95%)	0.34	0.38	0.34	0.42	0.46	0.44	0.69	0.51	0.73	0.82	1.15	0.78

Lower Limit of Class (ft)	481	521	561	601	641	681	721	761	801	841	881	921
Number Samples	16	15	15	16	15	16	17	14	16	14	17	14
Mean (Y)	2.37	1.40	1.67	1.06	1.47	0.94	1.59	1.21	1.31	1.36	1.29	1.14
Confidence Limits (95%)	0.64	0.81	0.87	0.49	0.85	0.57	0.80	1.00	0.57	1.18	0.70	0.54

Lower Limit of Class (ft)	961	1001	1041
Number Samples	15	16	41
Mean (Y)	1.20	0.38	0.39
Confidence Limits (95%)	0.74	0.32	0.26

APPENDIX 11b (continued)

A Summary of Pellet Group Variation Within Classes - Inside Forest
Distance Into Forest - Perpendicular to Upper Forest Edge

Plot 3

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321	361	401	441
Number Samples	41	39	40	40	40	40	38	40	35	24	20	18
Mean (Y)	2.12	2.03	2.62	1.67	1.65	1.82	1.47	1.25	1.46	1.87	1.35	1.22
Confidence Limits (95%)	0.65	0.71	0.83	0.54	0.48	0.75	0.55	0.38	0.61	0.95	0.86	0.70

Lower Limit of Class (ft)	441	481	521	561	601	641	681	721	761	801	841	881
Number Samples	18	20	14	20	20	20	20	19	20	20	20	19
Mean (Y)	1.22	1.50	1.07	1.40	1.35	1.05	1.10	1.26	0.80	0.90	0.75	0.95
Confidence Limits (95%)	0.70	0.82	0.98	0.88	0.73	0.52	0.67	0.76	0.54	0.48	0.54	0.78

Lower Limit of Class (ft)	921	961	1001	1041	1081	1121	1161	1201
Number Samples	20	20	20	20	19	18	14	31
Mean (Y)	1.50	1.55	1.55	1.35	1.32	1.50	1.29	1.29
Confidence Limits (95%)	0.90	0.79	0.88	0.56	0.80	0.86	0.52	0.46

A Summary of Pellet Group Variation Within Classes - Inside Forest
Distance Into Forest - Perpendicular to Upper Forest Edge

Plot 4

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321
Number Samples	50	36	40	38	40	38	38	40	56
Mean (Y)	0.62	0.67	0.67	0.55	0.57	0.63	0.34	0.13	0.18
Confidence Limits (95%)	0.37	0.41	0.42	0.37	0.28	0.39	0.24	0.10	0.14

Plot 5

Lower Limit of Class (ft)	0	41	81	121	161	201	241	281	321
Number Samples	29	25	27	24	25	24	26	27	28
Mean (Y)	0.83	1.16	0.93	1.17	0.60	0.29	0.23	0.19	0.39
Confidence Limits (95%)	0.45	0.49	0.27	0.52	0.33	0.23	0.20	0.24	0.33

APPENDIX 11b (continued)

Gaultheria shallon - Inside Forest, Plot 1 - 3

	0	6	16	26	36	46	56
Plot 1							
Number Samples	1142	16	28	27	19		
Mean (Y)	1.04	1.06	1.29	1.63	1.26		
Confidence Limits (95%)	0.08	0.51	0.51	0.62	0.50		
Plot 2							
Number samples	535	31	33	39	41	10	
Mean (Y)	1.12	1.97	1.85	2.41	2.29	1.90	
Confidence Limit (95%)	0.12	0.75	0.63	0.65	0.59	0.85	
Plot 3							
Number samples	536	59	61	66	36	31	
Mean (Y)	1.21	1.66	1.98	2.21	3.06	2.10	
Confidence Limits (95%)	0.14	0.42	0.52	0.48	0.89	0.75	

APPENDIX 11b (continued)

Vaccinium - Inside Forest, Plot 1 - 5

	Lower Limits of Class (Percent)										
	0	6	16	26	36	46	56	66	76	86	96
Plot 1											
Number Samples	558	174	144	118	98	61	32	26	21		
Mean (Y)	0.87	1.15	1.12	1.14	1.35	1.36	1.16	1.54	1.76		
Confidence Limits (95%)	0.10	0.22	0.20	0.22	0.28	0.34	0.45	0.45	0.86		
Plot 2											
Number Samples	115	77	110	99	90	63	64	38	25	8	
Mean (Y)	1.10	0.84	1.28	1.64	1.43	1.46	1.58	1.55	1.44	2.00	
Confidence Limits (95%)	0.30	0.26	0.32	0.36	0.32	0.38	0.36	0.55	0.51	1.57	
Plot 3											
Number Samples	164	106	136	131	109	55	47	27	14		
Mean (Y)	0.96	1.43	1.51	1.95	1.87	1.56	1.40	1.48	1.79		
Confidence Limits (95%)	0.22	0.38	0.28	0.35	0.34	0.46	0.46	0.51	0.91		
Plot 4											
Number Samples	278	67	20	11							
Mean (Y)	0.44	0.60	0.35	0.82							
Confidence Limits (95%)	0.12	0.26	0.31	0.78							
Plot 5											
Number Samples	55	76	57	32	10						
Mean (Y)	0.65	0.71	0.35	0.94	0.80						
Confidence Limits (95%)	0.24	0.24	0.16	0.43	0.75						

APPENDIX 11b (continued)

Number Species - Inside Forest, Plot 1 - 5

	Lower Limits of Class										
	0	1	2	3	4	5	6	7	8	9	10
Plot 1											
Number Samples	148	385	339	202	107	37	14				
Mean (Y)	0.84	0.95	1.09	1.06	1.59	1.22	1.50				
Confidence Limits (95%)	0.18	0.12	0.14	0.16	0.32	0.39	1.06				
Plot 2											
Number Samples	12	103	338	198	26	12					
Mean (Y)	1.00	0.93	1.25	1.81	0.92	1.08					
Confidence Limits (95%)	1.21	0.24	0.16	0.25	0.47	0.79					
Plot 3											
Number Samples	22	217	431	106	13						
Mean (Y)	0.59	1.16	1.62	1.92	1.77						
Confidence Limits (95%)	0.40	0.20	0.18	0.41	1.16						
Plot 4											
Number Samples	58	168	104	36	10						
Mean (Y)	0.26	0.58	0.56	0.19	0						
Confidence Limits (95%)	0.18	0.18	0.22	0.16	0						
Plot 5											
Number Samples	5	93	88	44							
Mean (Y)	0.20	0.82	0.58	0.45							
Confidence Limits (95%)	0.56	0.22	0.18	0.24							

Cover, All Species - Inside Forest, Plot 1 - 5

	Lower Limits of Class (Percent)										
	0	6	16	26	36	46	56	66	76	86	96
Plot 1											
Number Samples	446	119	88	86	82	82	96	94	88	42	9
Mean (Y)	0.79	0.90	1.08	1.12	0.99	1.39	1.31	1.34	1.40	1.98	1.00
Confidence Limits (95%)	0.10	0.22	0.24	0.30	0.24	0.34	0.28	0.28	0.28	0.51	0.62
Plot 2											
Number Samples	56	69	42	50	62	52	82	117	93	57	9
Mean (Y)	1.02	0.96	1.02	0.60	1.18	1.10	1.41	1.74	1.87	1.53	2.33
Confidence Limits (95%)	0.38	0.38	0.40	0.26	0.40	0.38	0.32	0.32	0.36	0.36	1.90
Plot 3											
Number Samples	126	62	57	76	90	89	80	98	66	34	11
Mean (Y)	0.88	1.19	1.23	1.13	1.43	1.74	1.89	1.90	1.97	2.26	2.00
Confidence Limits (95%)	0.22	0.42	0.42	0.30	0.38	0.42	0.44	0.42	0.46	0.61	1.20
Plot 4											
Number Samples	183	65	39	34	19	19	17				
Mean (Y)	0.45	0.34	0.77	0.59	0.58	0.47	0.18				
Confidence Limits (95%)	0.14	0.22	0.48	0.39	0.55	0.38	N.A.*				
Plot 5											
Number Samples	25	39	32	25	18	11	11	31	38		
Mean (Y)	0.52	0.95	0.53	1.12	1.22	1.09	1.00	0.23	0.03		
Confidence Limits (95%)	0.33	0.38	0.20	0.45	0.55	0.62	0.74	0.18	0.06		

*Not available

APPENDIX 12

Distribution of Pellet Groups on Five Ecotone Study Areas

Location Plot No. and Distance from forest edge (ft)	Mean($\bar{x}$)	Variance(s^2)	$\frac{s^2}{\bar{x}}$	Distribution (Chi-Squares) Negative Binomial	Poisson
1, Outside Forest (OF) 0-350	2.83	4.96	1.75	5.84*	86.62
1, (OF); 350-1000	1.69	3.32	1.96	31.58	328.46
1, (OF); 0-1000	2.09	4.19	2.00	35.63	542.39
1, Inside Forest (IF) 0-350	1.03	1.71	1.66	7.76	76.09
1,IF; 350-1200	1.08	1.46	1.35	2.52*	44.48
I, IF: 0-1200	1.06	1.55	1.46	1.85***	100.48
2, OF: 0-350	1.35	3.95	2.92	12.45	389.30
2, OF: 350-1200	0.99	2.12	2.14	9.64	246.78
2, OF; 0-1200	1.13	2.86	2.53	11.47	666.86
2, IF; 0-350	1.40	2.82	2.01	10.82	101.42
2, IF; 350-1000	1.30	2.12	1.63	6.30	61.71
2, IF; 0-1000	1.34	2.43	1.81	12.74	157.82
3, OF; 0-350	1.21	2.64	2.18	2.18**	161.42
3, OF: 350-900	1.13	2.22	1.96	15.28	269.85
3, OF; 0-900	1.16	2.40	2.07	25.14	340.89
3, IF; 0-350	1.79	3.71	2.07	7.25	137.82
3, IF; 350-1200	1.29	2.38	1.84	6.80	126.70
3, IF; 0-1200	1.54	3.15	2.04	11.08	322.61
4, OF; 0-350	1.45	3.93	2.71	8.73	227.56
4, OF; 350-900	1.08	2.57	2.38	5.87	283.82
4, OF; 0-900	1.23	3.12	2.54	6.29	507.05

APPENDIX 12 (continued)

Distribution of Pellet Groups on Five Ecotone Study Areas

Location Plot No. and Distance from forest edge (ft)	Mean($\bar{x}$)	Variance(s^2)	$\frac{s^2}{\bar{x}}$	Distribution (Chi-Squares) Negative Binomial	 Poisson
4, IF; 0-350	0.50	1.09	2.18	0.66**	89.76
5, OF; 0-350	1.30	2.26	1.74	2.19*	38.56
5, OF; 350-900	1.21	2.03	1.68	3.74	73.01
5, OF: 0-900	1.24	2.12	1.71	5.34	111.21
5, IF; 0-350	0.65	0.87	1.34	3.86	18.08

Null hypothesis: There is no difference between the observed and expected distributions

*Significant at P = 50

**Significant at P = 20

*** Significant at P = 10

None significant at P = 05

APPENDIX 13

Linear Regression of Deer Use From Near the Forest Edge

Plot	Distance from forest edge regression begin (ft)	Regression Coefficient	Multiple Correlation Coefficient	Variance Ratio (F)	Significance
1, IF (Inside Forest)	40	-.00001	.003	.013	N.S.
1, OF (Outside Forest)	40	-.00181	.278	96.285	**
2, IF	120	-.00095	.186	19.751	**
2, OF	81	-.00060	.095	8,978	**
3, IF	82	-.00059	.122	10.653	**
3, OF	120	-.00004	.006	.027	N.S.
4, IF	1	-.00159	.173	11.604	**
4, OF	80	-.00058	.079	4,885	*
5, IF	40	-.00365	.381	34.119	**
5, OF	125	-.00072	.115	6.697	**

N.S. - Not significant at P0.05

* - Significant at P0.05

** - Significant at P0.01

APPENDIX 14

Vegetation Occurrence on Ecotone Plots 1 to 5
(Percent Cover)

Plot No.	Species* Present	Mean	Standard Deviation	Range
1 (Outside Forest)	Rp	6.3	9.7	0 - 60
	Rs	7.2	9.4	0 - 50
	Ru	3.4	6.5	0 - 40
	Ea	12.1	11.3	0 - 60
	V	6.8	8.5	0 - 45
	At	2.3	6.9	0 - 70
	Pm	1.4	4.0	0 - 30
	Ss	2.6	6.1	0 - 70
	Gr	0.9	3.8	0 - 35
	Pa	1.1	6.0	0 - 85
	Af	0.4	2.3	0 - 30
	Lb	2.0	5.3	0 - 55
	All	47.1	27.4	0 - 100
1 (Inside Forest)	Nf	0.4	2.5	0 - 30
	Rs	0.1	1.4	0 - 30
	Rn	0.2	1.5	0 - 35
	Rg	0.2	1.6	0 - 25
	V	19.0	20.2	0 - 90
	At	2.4	6.7	0 - 50
	Pm	0.4	2.3	0 - 30
	Mn	2.0	6.7	0 - 60
	Ss	0.7	3.4	0 - 40
	Cc	3.7	7.6	0 - 40
	D	0.01	0.4	0 - 15
	Pa	0.4	3.4	0 - 50
	Af	0.2	2.0	0 - 25
	Gs	2.1	7.8	0 - 60
	All	31.2	29.4	0 - 100
2 (Outside Forest)	Ead	0.2	1.0	0 - 15
	Rs	0.08	1.1	0 - 25
	Ea	16.3	15.5	0 - 70
	V	14.2	15.5	0 - 80
	Ss	0.2	1.9	0 - 30
	Cc	5.3	9.3	0 - 45
	Af	0.2	1.6	0 - 25
	Gs	0.4	2.7	0 - 35
	Tt	0.5	15.2	0 - 50
	S	5.4	9.4	0 - 55
	All	40.7	25.0	0 - 90

APPENDIX 14 (continued)

Vegetation Occurrence on Ecotone Plots 1 to 5
(Percent Cover)

Plot No.	Species Present	Mean	Standard Deviation	Range
2 (Inside Forest)	Mf	0.7	4.7	0 - 70
	V	33.7	23.1	0 - 100
	At	0.7	4.3	0 - 40
	Ss	0.8	4.3	0 - 45
	Cc	6.8	9.1	0 - 45
	Gs	7.2	14.0	0 - 80
	All	50.7	28.2	0 - 100
3 (Outside Forest)	Ead	1.3	4.4	0 - 35
	Ea	23.5	15.7	0 - 90
	V	6.0	8.5	0 - 50
	Mn	1.0	3.7	0 - 30
	Ss	1.3	4.2	0 - 30
	Cc	1.5	4.0	0 - 25
	Lb	2.4	5.2	0 - 40
	Gs	4.3	7.8	0 - 50
	Tt	0.2	1.5	0 - 30
	S	7.2	8.9	0 - 40
	All	49.9	23.6	0 - 00
3 (Inside Forest)	V	28.0	20.3	0 - 90
	Cc	4.0	7.0	0 - 40
	Gs	9.6	15.5	0 - 70
	All	42.7	27.6	0 - 100
4 (Outside Forest)	Rp	19.1	12.6	0 - 80
	Rs	5.8	7.7	0 - 50
	Ru	1.9	5.1	0 - 50
	Ea	8.7	8.2	0 - 35
	V	6.2	7.7	0 - 40
	Pm	4.7	7.3	0 - 35
	Ss	3.7	6.5	0 - 35
	Pa	1.1	5.0	0 - 40
	Af	0.3	1.8	0 - 35
	Lb	4.5	6.0	0 - 30
	Gs	0.3	2.0	0 - 25
	Tt	0.3	1.7	0 - 25
	All	60.2	23.1	0 - 100
4 (Inside Forest	V	5.5	7.9	0 - 45
	At	2.1	8.1	0 - 20
	Pm	6.2	10.8	0 - 70
	Ss	1.5	4.9	0 - 50
	Lb	0.2	1.4	0 - 20
	All	15.8	17.9	0 - 90

APPENDIX 14 (continued)

Vegetation Occurrence on Ecotone Plots 1 to 5
(Percent Cover)

Plot No.	Species Present	Mean	Standard Deviation	Range
5 (Outside Forest)	Rs	0.1	1.5	0 - 30
	Ea	14.6	11.6	0 - 50
	V	6.1	8.0	0 - 50
	Mn	2.9	7.2	0 - 40
	At	1.7	4.6	0 - 25
	Lb	2.1	4.8	0 - 30
	S	8.3	8.8	0 - 40
	All	40.2	19.3	0 - 80
5 (Inside Forest)	V	16.1	10.9	0 - 45
	Mn	4.3	8.8	0 - 55
	Gs	16.8	25.6	0 - 90
	All	40.0	29.1	0 - 100

*Species represented by code.

Code	Botanical Name	Common Name
Af	_Athyrium filix-femina_ (L.) Roth.	Lady fern
Am	_Anaphalis margaritacea_ Beuth	Pearly everlasting
At	_Achlys triphylla (D.C.)_	Vanilla leaf
Cc	_Cornus canadensis_ L.	Bunch berry
D	_Dryopteris_ spp. Adans	Wood-fern
Eg	_Epilobium angustifolium_ L	Fireweed
Ead	_Epilobium adenocaulou_ Haus	Northern willow-herb
Gr	_Graminae_ spp.	
Gs	_Gaultheria shallon_ Pursh.	Salal
Lb	_Linnaea borealis_ L.	Twin-flower
Mf	_Menziesia ferruginea_ Smith.	False azalea
Mn	_Mahonia nervosa_ (Pursh.) Nutt.	Oregon grape
Pa	_Pteris aquilina_ L	Bracken
Pm	_Polystichum munitum_ (Kaulf.)Presl	Sword fern
R	_Rosa_ spp.	Rose
Rp	_Rubus parviflorus_ Nutt	Thimble berry
Rs	_Rubus spectabilis_ Pursh.	Salmonberry
Ru	_Rubus ursinus_ Cham. + Sch.	Trailing blackberry
S	_Senecio_ Spp L.	Groundsel
Sr	_Sambucus racemosa_ L.	Red Elderberry
Ss	_Struthiopteris spicant_ L. Scop.	Deer fern
Tt	_Tiarella trifoliata_ L	Foam flower
V	_Vaccinium_ spp. L	Huckleberry
All	Total of all species	

APEENDIX 15

Correlation of Total Vegetative Cover with Number Species for Ecotone Plots 1 to 2

Plot		Correlation Coefficient (r)	Coefficient of determination (r^2)
1, Inside Forest	=	0.61	0.37
1, Outside Forest	=	0.69	0.48
2, Inside Forest	=	0.41	0.17
2, Outside Forest	=	0.51	0.26
3, Inside Forest	=	0.46	0.21
3, Outside Forest	=	0.43	0.18
4, Inside Forest	=	0.61	0.37
4, Outside Forest	=	0.56	0.31
5, Inside Forest	=	0.69	0.48
5, Outside Forest	=	0.52	0.27

APPENDIX 16

Sampling Accuracy of Mature Plots*

Plot No.	Avg. No. Pellet Groups per Sample	Standard Error of Mean	Confidence Limits (95%)
1	0.60	0.13	0.27
2	1.57	0.20	0.41
3	0.03	0.03	0.07
4	0.30	0.12	0.24
5	0.07	0.04	0.09
6	0.33	0.14	0.28
7	0.07	0.04	0.09
8	0.73	0.16	0.34
9	0.21	0.26	0.53
10	0.31	0.056	0.11
11	1.50	0.21	0.42
12	1.28	0.23	0.68
13	0.36	0.13	0.27
14	0.63	0.11	0.34
15	0.17	0.07	0.14
16	0.60	0.20	0.41
17	0.17	0.03	0.14
18	0.23	0.12	0.25
19	0.80	0.19	0.38
20	0.60	0.18	0.37

*Each plot consists of 30 samples.

APPENDIX 17

Sample Of Species Composition And Cover On Mature Forest Plots

Plot No.	Class*	Species**	Plot No.	Class	Species
1	A		2	A	V Mn
	B			B	
	C	V		C	
	D	Gs		D	Gs
	E			E	
	50(0-80)***			41(0-80)	
3	A	Pm At	4	A	Cc Pm Mn Af
	B	Ss		B	V At
	C	V		C	Ss
	D			D	
	E			E	
	31(0-80)			42(0-70)	
5	A	Cc Mn	6	A	Ss
	B	Gs		B	
	C	V		C	V
	D			D	
	E			E	
	26(1-60)			11(0-50)	
7	A	Pm At Ss	8	A	V Pm
	B	V		B	Ss
	C			C	
	D			D	
	E			E	
	18(0-50)			13(0-40)	
9	A	Mf	10	A	At
	B	Gs		B	
	C			C	
	D	V		D	
	E			E	V
	45(1-80)			52(1-90)	

APPENDIX 17 (continued)

Sample Of Species Composition And Cover on Mature Forest Plots

Plot No.	Class	Species	Plot No.	Class	Species
11	A		12	A	At Ss
	B			B	Cc
	C			C	
	D	V		D	V
	E			E	
	34(10-60)			32(0-80)	
13	A	Ss	14	A	V Rp
	B	V Pa		B	At
	C	Gs Pm		C	Gs Pm
	D			D	
	E			E	
	45(20-80)			49(20-8)	
15	A	V Pa At Rp	16	A	Cc At Ss
	B	Pm		B	
	C	Gs		C	V
	D			D	
	E			E	
	35(1-80)			17(0-70)	
17	A	Pm Pa Mn At	18	A	Gs V
	B	Gs V		B	
	C			C	
	D			D	Mn
	E			E	
	26(0-80)			35(0-70)	
19	A	V Mn	20	A	Pm Ss At
	B			B	V
	C			C	
	D			D	
	E	Gs		E	
	76(50-100)			15(0-60)	

APPENDIX 17 (continued)

* Percent cover by each class: A, 1-5; B, 6-10; C, 11-20; D, 21-50; E, 51+

**Botanical name[1] represented by each species symbol:

	Symbol	Botanical Name
1	Af	*Athyrium filix-femina* (L.) Roth.
2	At	*Achlys triphylla* (D.C.)
3	Cc	*Cornus canadensis* L.
4	Gs	*Gaultheria shallon* Pursh
5	Mn	*Mahonia nervosa* (Pursh.) Nutt.
6	Pa	*Pteris aquilina* L.
7	Pm	*Polystichum munitum* (Kaulf.) Presl.
8	Rp	*Rubus parviflorus* Nutt.
9	Ss	*Struthiopteris spicant* (L.) Weis

***Average total cover and range (in brackets) of samples within each mature forest plot

1 Common name can be found at the end of Appendix 14.