Range and Wilelife Productivity.

E.W. Muiruri M.Sc. (Geography)

RANGE AND WILDLIFE PRODUCTIVITY: THE CASE OF THE BLACK-TAILED DEER ON VANCOUVER ISLAND, B.C.

by

Esther Wanjiku Muiruri

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Geography Department
McGill University
Montreal

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ABSTRACT

The objective of this thesis is an examination of the factors that affect the productivity of black-tailed deer, Odocoileus hemionus columbianus (Richardson), and of their habitat on Vancouver Island, B.C. Food is the major control of deer populations in this area. However, the use of the classical concepts of natural plant successions as a basis for classifying deer food types and determining deer ranges should be reconsidered. Seasonal changes of forage quality and quantity are considered as the most significant influences of carrying capacity, as opposed to long-term vegetative changes. The size of the annual deer harvests is seen to be well below the expected level. It is suggested that a greater liberalization of both the open and anterless seasons might result in a greater harvest. In this respect, the attitude of the hunters towards sport hunting is regarded as an important factor influencing deer management. Finally, it is suggested that in view of an inadequate system of cropping deer yields, and due to the natural forces of mortality, it is difficult to conceive of a natural surplus of the deer population, and consequently, it is erroneous to rationalize deer management on the basis of a "hypothetical surplus".

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CHAPTER ONE: INTRODUCTION

Certain conditions govern the size and reproductive rates of wild populations, as well as the level of carrying capacities of their habitats. The productivity of big game animals can generally be said to be largely determined by varied aspects of factors such as the carrying capacity of the ranges, and the population characteristics of the animals. In addition, poorly conducted censuses and inventories may distort the productivity of the animal populations.

In North America, deer management apparently revolves around the concept of obtaining a surplus that just balances productivity. In this respect, some of the basic problems of wildlife management, and of deer management in particular, seem to stem from a fundamental lack of knowledge of the ways in which some of the ecological factors pertaining to food affect the size of the populations, their structure and composition, and the size of the surplus.

It is against this background that the productivity of the black-tailed deer, *Odocoileus hemionus columbianus* (Richardson), and of the range it inhabits on Vancouver Island, British Columbia is examined. The investigation was based on Vancouver Island for a number of reasons. The Island is a highly varied habitat with an abundance of edge; there is great variability of factors such as range composition and the production and availability of deer food. Also, the deer resource of the area is extensive, while its value and management is well documented. Black-tailed deer occupy much of the forest land of Vancouver Island and are the most important game animal in terms of their abundance, distribution and harvest. In this management unit, there probably exists a unique combination of range and wildlife productivity possibly at its nearest full potential, with regard to these animals.

All the data on which this analysis is based were obtained from published literature based on studies of black-tailed deer on Vancouver Island, and also from records of general inventorying in the area, and elsewhere in North America. In addition, some useful information and data were obtained from personal communications with certain wildlife biologists of the B.C. Fish and Wildlife Branch in Victoria. Most of the data were used on a comparative basis, and some of the conclusions arrived at were based on these comparisons. The concepts of wildlife management discussed in this thesis were first examined as they have been developed in the literature. The ways in which these concepts apply to the black-tailed deer management experience on Vancouver Island were then examined.

A range is a basic production factor for big game populations. It is generally defined as any unit of land capable of supporting some level of population of browsing and grazing animals, for all or for part of every year. The carrying capacity of a deer range is believed to be largely determined by the factor of food. Thus, food is seen as the major limiting factor of deer populations, especially in winter. On this basis therefore, it should be possible, ideally, to determine deer range carrying capacities by an assessment of the food potential of the range under consideration. One of the methods that exist of measuring range capacities consists of a delineation of key deer areas, that is those parts of the range in which deer feed normally and cause no permanent damage; and also by a determination of the key species, or those forage species most preferred by deer, their platability and availability. Thus a range can be defined on the basis of these key deer areas, and the distribution and availability of the key species within them. However, such a definition appears to be unduly loose.

It is apparently an accepted procedure amongst most workers to classify or to determine key forage species on the basis of "plant successions", by upholding that the availability of deer food, its quantity and quality, is determined by regeneration and successional stages. It is suggested in this thesis, however, that unless it is fully established that such sequential vegetation changes occur, for instance after logging, the use of this concept to determine deer food types, or to define deer ranges may be questionable.

Although the critical requirement on any deer range is primary production, this can, and is known, to differ in form, ranging from forested grassland, shrub and herbaceous cover, to disturbed forest or alpine areas. The plant form is really not important; rather it is the adequacy of the vegetative cover in meeting the nutritional requirements of deer that should be considered critical. It is concluded, therefore, that a determination of range carrying capacities for deer should probably not be based upon the "successional stages" of the plant species, but rather upon general population levels of deer. Ultimately, it is the condition of the animal that offers the most reliable measure of the adequacy of the range to support it. The relationships between the animal's well-being, the plant community, the stage of plant growth, the soil nutrients and climate, is so complex that only the animal itself probably offers a reliable index of life conditions on the range. On the other hand, certain basic aspects of the range should be considered, for instance, the seasonal pattern of occurrence of the principal forage plants.

The black-tailed deer population of Vancouver Island is seen to be largely a by-product of the temporary conditions of the environment that largely result from forest logging activities. Its numbers are, therefore, constantly fluctuating in time with the "boom and burst" rhythm of the carrying capacity of food. Smith (1968), p. 89) states that,

> "....black-tailed deer have apparently evolved in such a way that populations can take advantage of short-lived seral changes, and as long as man continues to manipulate the environment by accident or design, such fluctuations may be expected."

Consequently, the size of the black-tailed deer population on the island can be said to be determined by the "current" carrying capacity of the particular time being considered.

Food is believed to be the major limiting factor of the Island-wide deer population, and is manifested by deer losses through winter mortality. Thus the most critical conditions for black-tailed deer in this region occur at intervals, usually every winter, with respect to food requirements and their productivity. Deer productivity apparently is intricately tied up with the severity or mildness of the winter season. The proportions of fawns and yearling deer within the total population are said to be indicative of the level of productivity of a deer population. However, the heaviest toll is exerted on these two segments of the population and this therefore ultimately influences productivity. On the other hand, it is doubted whether the classical concepts of population dynamics can be applied to the black-tailed deer population of Vancouver Island, owing to the dynamic and unpredictable nature of this habitat, and its influence on these animals.

Variation in the number of animals is one of the most important means of adaptation to the environment, and changes in numbers are some of the most important and frequently the most accessible indices of ecological conditions. Such continued changes necessitate repeated surveys and inventories in an attempt to estimate trends in population size, structure and composition. The various techniques most frequently used in censusing deer are discussed. It is suggested that for Vancouver Island, it might be possible to make use of aerial survey inventories and ground drives where the vegetation cover is not too dense. But the use of the former method would only be probably feasible by utilizing the highly advanced remote sensing technique.

Concerning the methods currently in use, classified counts are considered as the most useful for the purposes of management. It is suggested that, with a better road network system and with an increased number of personnel, classified counts should provide much more valuable data concerning all deer herds inhabiting the range.

On Vancouver Island, black-tailed deer are generally managed by hunting. Thus most management policies and regulations are based on hunter kill data. The hunter sample and the road check operations are the two main sources of data on the harvest. These two methods are analyzed and compared. It is suggested that on the whole use of information derived from hunters in management is basically inadequate. Out of these two sources, however, the road check operation data are regarded as the most reliable in as far as they are more indicative of hunting conditions in the field. With regard to hunting seasons, it is suggested that since the percentage of the animal harvest, out of the total population, is well below the desired permissible off-take, hunting regulations and hunting seasons should be more liberalized.

Aldo Leopold (1933) who is recognized as the father of game management defined it as "The art of making land produce sustained annual crops of wild game for recreational use." Within this context, deer management could therefore be termed as "the art of making" the range produce an annual surplus for hunting. It appears that by far, the greatest effort in deer management is channelled towards increasing this surplus, often through an attempt to reduce the environmental resistance. It is suggested in this thesis that such a rationale for a management policy is not sound because it is apparently not related to certain fundamental ecological phenomena.

Change is one of the prime characteristics of all living populations; a static balance-of-nature does not exist. A given habitat can be said to support a given number of animals for a certain length of time as long as conditions do not change. However, each habitat is in a dynamic state; it possesses both a past and a present, and not merely a horizontal extension. At any given time, therefore, the deer habitat may be in a condition of stress, in the process of adjustment or in relative equilibrium. It can therefore be said that deer populations have always fluctuated, constantly striving toward increase and expansion, owing to the inherent force of natural increase. This expansion is just as constantly opposed by environmental resistance. The result is, therefore, either a declining or a relatively stable population, but which is always at equilibrium with its habitat.

It is within such an ecological framework that a deer surplus must be viewed. Nothing in nature is superfluous and consequently, the success with which man can make land produce a sustained annual deer surplus through curtailing environmental resistance is most probably limited. Presumably this could only be feasible if the rate of animal harvest equalled the rate of natural mortality. Data for Vancouver Island and British Columbia seem to indicate that this is not the case in these areas. There is an inevitable limit to which man can manipulate natural ecological phenomena.

Deer productivity on Vancouver Island, if defined on the basis of the surplus available for the annual harvest, is therefore, basically greatly determined by the conditions of the range with regard to food, and is only peripherally affected by hunting activity. The attitude of the hunters towards hunting is the other main factor that indirectly affects deer productivity. It is suggested that a better knowledge of hunter psychology would contribute greatly to better deer management.

CHAPTER TWO: THE CONCEPT OF CARRYING CAPACITY

The term "carrying capacity" is well established in the literature on wildlife ecology, as well as in general ecological literature. The term is often used to describe a general concept rather than an exact idea. In this section, an attempt will be made to define the term and to assess its usefulness in wildlife management. The discussion, unless specifically noted, will not be confined to any particular group of animals, such a herbivors or ungulates, but rather it will consider carrying capacity as a general concept, within which specific conditions pertaining to particular species can be fitted.

The term is vague primarily because many authors have used "carrying capacity" as if it applied to food alone, while others use it to denote more than a limitation owing to food and include other factors. Also, carrying capacity is often considered a stable characteristic of the environment although nearly all limiting factors are known to vary constantly in their influence on population.

Past and Present Usage of the Term

Most authors, especially those working with ungulates, have assumed that carrying capacity refers only to food supply. Leopold (1948, p. 450) defined carrying capacity as "The maximum density of wild game which a particular range is capable of carrying." Speaking of ungulates, he says (p. 54) ... "There is so far no visible evidence of any density limit except the carrying capacity of food". Hadwen and Palmer (1922, p. 29) speaking of reindeer (Rangifer tarandus) state that carrying capacity is ..."the number of stock which the range will support for a definite period of grazing without injury to the range." Trippensee (1948, p. 196) also emphasizes the importance of food to deer (Odocoileus). He says, "the carrying capacity of a range measured in terms of food availability depends upon two factors; stand age and stand composition." Fowle (1950, p. 57) in reviewing factors controlling deer populations says: "The environmental factor which has received the most attention in deer studies is food. Indeed our concept of carrying capacity for deer centers around the adequacy of the food supply while our criteria of overuse have their basis in the rate of the food supply."

Some authors have held that in considering carrying capacity, the quality of the animals and the condition of the range should be considered. W. Dasmann (1945, p. 400) on carrying capacity states: ... "the maximum number of grazing animals of a given class that can be maintained in good flesh year after year on a grazing unit without injury to the range forage, growing stock or to the basic soil resource ..... is indicative of the carrying capacity." In 1948 (p. 189) he modified this definition and substituted "foraging animals" for "grazing animals" and changed "grazing unit" to "range unit". This definition restricted to grazing animals reflects the modern trend of confining the use of carrying capacity to ungulates and other herbivores. The author considers carrying capacity as a dynamic concept (p. 189) ... "Since range is dynamic, changing continually with fluctuations in precipitation, temperature, evaporation and varying use patterns, no rate of stocking can be considered final."

Allen (1954) did not specifically define carrying capacity but he used the term frequently. He states (p. 144): "Within limits a trained observer can make a fair-or-better estimate of what is likely to be a productive area for species he has worked with, but the final proof is what it is actually supporting. The biologist's term for this is 'carrying capacity'." He recognized that the carrying capacity of deer country depends upon available food on the winter range, but while acknowledging food as the main limiting factor for deer, he recognizes that other factors may determine carrying capacity for other species. Thus Allen had a very broad concept of carrying capacity.

R.F. Dasmann (1964) gives an even broader definition of the concept. According to him carrying capacity means the limitation imposed by the environment on any area, such that it can only support a limited number of animals; a population increase above this limit cannot be sustained. He considers carrying capacity to be a function of the habitat, rather than of factors intrinsic to the animal population. He distinguishes three important ways in which the term is used in wildlife literature:

(a) The number of animals of a given species that a habitat does support, determined by observation over a period of time.

(b) The upper limit of population growth (the sigmoid or logistic curve) above which no further increase can be sustained. The upper asymptote curve is defined as the carrying capacity, at which mortality equals natality. Within this context, the carrying capacity is considered to be determined by the environmental resistance of an area, which balances the biotic potential of the species at the carrying capacity level. Populations below such a carrying capacity are not secure but are subjected to mortality that increases in intensity with the population density resulting from food shortage, shelter and escape cover.

(c) The number of animals that a habitat can maintain in a healthy vigorous condition. This concept implies that a population at such a capacity has adequate food and shelter, that is, natality is not impaired, while mortality does not occur from food shortage. A population below this carrying capacity would not experience loss except from factors unrelated to food or shelter needs.

Talbot and Payne (1965) regard carrying capacity as a primary index of the productivity of lands utilized by herbivorous animals. The capacity of an area is regarded as the number of animals of a given size which can be supported for a given period of time by the vegetation growing in that area without adversely affecting the vegetation production.

The examples given illustrate the general concept of carrying capacity as it has been developed in the literature. There appears to be general agreement that any unit of the environment can only support a finite number of animals. What is, however, not clear is whether all or only some of the many factors that tend to limit animal populations should be regarded as factors that determine carrying capacity. It has also been generally recognized that within the concept is the implication that the ability of the environment to support populations varies from time to time, leading to fluctuations in populations. Thus there has been a universal recognition of the fluctuating nature of carrying capacity although some earlier authors held that it was a more or less stable attribute of the environment.

To date, the term "carrying capacity" has carried a certain stigma due to the variation in definition applied to it , but it is nevertheless an essential concept in any discussion relating to wild populations. A review of the development of the concept shows that the original ideas emphasized the role of factors such as climate and food supply in controlling populations. There has been a gradual shift of emphasis from a point of view holding that single factors are the determinants to a more comprehensive view recognizing that "The relationships of a population are with the whole ecosystem (which includes itself) rather than with the environment only," (Solomon 1949, p. 31).

Factors that influence populations are so complex that the factors that determine carrying capacity themselves change with time, place and the species involved. Edwards and Fowle (1955, p. 596) seem to favour the idea that carrying capacity is..."limited by some factors operating at a minimum, as in Liebig's Law of the minimum. This focuses attention upon more or less measurable andmanageable factors instead of complex environments regarded as entities, within the framework of local conditions and the critical factors and periods in which these conditions operate to limit populations."

Some Measures of Carrying Capacity

Most of the current concepts of carrying capacity are inadequate and ambiguous for precise management planning because they are not related directly to measurable characteristics of populations or habitats of big game ranges. The problem is one of evaluating range conditions and range carrying capacity so that, ultimately, it may be possible to predict what populations can be tolerated on any given range. The determination of range capacities is one of the most important problems that confronts the wildlife manager. The principal requisites of sustaining habitats for any class of animals are shelter, food and water. But whether the animal be herbivorous, carnivorous or or omnivorous, food is the element most difficult to supply and control on wild land.

Although ideally both the habitat and the wild animal population should be considered as integral parts of any endeavour to evaluate carrying capacities, nevertheless it is almost impossible to ascertain the exact number of game animals using a range. Consequently, carrying capacity should be interpreted from the condition and trend of the land and its vegetation and not on the numbers of animals alone. It is extremely difficult to determine carrying capacity accurately as thereis great variation in the capacities of even well defined habitat types, owing to local influences of topography, man's activities, location of water, exposure and other environmental components. Moreover, the amount of vegetation produced, and the ability of the forage species to withstand browsing pressure varies greatly between favourable and unfavourable periods. There are then no simple type factors that can be applied to any range and multiplied by the type areas to give the correct carrying capacity of that range. The objective, however, is to hold a population which the range can support in a healthy condition, without deterioration of the principal forage species. Evidence from certain food utilization factors of big game can serve as useful indices in determining the number of animals that can be safely carried on a range. These are mainly factors of palatability, key browse species and key game areas (Julander, 1937; Mitchell, 1941).

Browse species differ in palatability. Palatable browse is nutritious browse, while unpalatable browse cannot sustain deer in winter. As a herd increases, the pressure on palatable browse plants weakens them and ultimately kills them. It also prevents their reproduction or regeneration. Different workers on different game ranges have used varying numerical expressions of palatability. Cowan (1945, p. 12) reports that

> "... the one most commonly used is that standardized by the United States Forest Service (1937). In this method, palatability is expressed as the 'percent of the total current years growth, within reach of stock, to which a species is grazed when the range unit is properly utilized under the best practical range management'. The recent designation of this concept as the 'proper use factor' more nearly indicates its true nature than does 'palatability'."

Various authors (Young and Robinette, 1939; Julander, 1937; Mitchell, 1941; and Cowan, 1945) have established that numerous variables interact in influencing the degree to which a forage species is utilized. If a game population pressure is low, only the most desirable plants are extensively browsed, but when population pressure increases to overstocked levels, progressively less desirable species may be utilized to almost 100 percent. Browse plants are considered 100 percent utilized when the current leaf and twig growth within reach of the animals has been taken. Herbaceous plants are considered 100 percent utilized when all of the leaves and stems have been grazed to the ground. The degree to which any forage plant is utilized depends not only upon its abundance but particularly upon the abundance of the browsing species (Mitchell, 1941; Cowan, 1945).

Key species are those plants on a game range which provide the greater part of total diet, that is, those species that are completely utilized. On most ranges, these usually are not more than six; sometimes as few as three species may serve as the staple forage. Mitchell (1941, p. 143) reports that black-tailed deer on the summer range in Western Oregon, despite abundant herbage, browse and tree growth, were noted by Einarsen (1940) to be using only three abundant species heavily, as compared to moderate and light use of 19 others. Also that Cliff (1938) noted that 3 browse species supplied over 90 percent of mule deer diet in Northeastern Oregon, while Young and Robinette (1939) stated that only 10 species of food plants were utilized by the Rocky Mountain Elk to the extent of 30 percent. In addition, the foliage of only six out of the ten was utilized over 50 percent in Idaho. On every range then, there are a few key species that supply the greatest bulk of big game feed. If these species can be determined, it is said that the evaluation of range capacities can be based upon them, and on the basis of their utilization during the various seasonal feeding periods.

The third game utilization factor consists of the key game areas. According to Mitchell (1941) every summer herd range is usually made up of three types of areas: concentration spots, generally frequented areas, and little used areas. He states (p. 142):

> "Outside of the concentration spots are areas where the animals feed normally and cause no permanent damage. These may be large or small and are usually limited by topographic features.......but they are areas that support the bulk of the game forage.....they are the key areas upon which management of the entire range should be based. They should be used as places for judging range condition, utilization of the principal forage species, for investigation purposes, and as a basis for determining range capacity."

With regard to winter yarding areas, Mitchell (1941) states that these can be treated as key areas and that the capacity of the yearlong herd range can be based on their condition, as long as they are limited to the extent that they become the controlling factor upon game populations.

Big game carrying capacity may therefore be ultimately determined by these three factors of:

(1) key feeding areas and their ability to support game animals and provide cover;

(2) key forage species, whose designation depends on the quality and the bulk of feed that they contribute during the feeding year;

(3) the palatability of the forage species.

Although the key area-key species method is regarded by some workers as the most practical method for determining herd range utilization and carrying capacity, nevertheless it is doubted whether it can be applied as described, to most deer habitats, with some measure of reliability. It seems that there are many other factors that need to be known before the method can be used as a management technique.

With regard to key species, it is known that if the preferred plant food types are unavailable in a particular habitat, the deer will intensively browse the unpalatable, non-nutritious forage plants. It appears therefore, that in order to determine what the key species for game animals are on a range, it is essential to establish first that this particular range is in its most favorable condition for providing deer food. More precisely, it must be established that the most desired forage species for the animals, as known to exist on many other types of ranges, are represented in the particular area being considered. Failing this, it could be reasonably assumed that what may appear to be key forage species may be no more than "tidbit" plants that provide only a "buffer" diet. Such plants may be totally utilized solely because they may be the most easily available or the only ones present in a habitat. Moreover, "the proper use" factor or palatability, is itself largely determined by many variables, for example growing conditions and distribution of the forage species; also since the most favorable conditions for growth are highly seasonal, key forage species should be perennials in order to indicate their yearlong usage by the animals.

With regard to key areas, their definition appears to be nebulous. Mitchell (1941) states that they "may be large or small" and that the animals inhabiting them feed normally and cause no permanent damage. It seems important that the "normality" of feeding be established; furthermore, the degree of damage that can be tolerated as opposed to "permanent" damage should be determined. But even if these factors were known, it is doubted whether "management of the entire range" can be based upon the key feeding areas, whether of the summer or of the winter ranges. In fact winter ranges should probably not be treated as key areas at all, nor should "the capacity of the yearlong herd ranges" be based on their condition. To do this would be to ignore one basic fact, that a deer range is a highly diversified unit, with greatly varied topographic features, while in some areas, such as Vancouver Island, an intensive land policy has been superimposed upon this topographic variety.

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Moreover, conditions of the summer and winter ranges during the feeding year are so different that it is impossible and probably unrealistic to try and relate their carrying capacities. One represents the maximum best conditions for survival and productivity in terms of food and cover, while the other represents the critical minimal conditions of these two factors. Consequently, a probably more practical and realistic approach is one that treats the key areas of the summer and winter ranges as separate entities. Again, it seems unlikely that deer occupy all parts of their range and utilize them homogeneously. It is likely that these animals inhabit only parts of the range for part of the time. In the long run therefore, management of the range is probably best based on seasonal evaluations of carrying capacity for summer and winter, rather than on a yearlong basis.

On the other hand, the whole concept of a "range" probably needs to be re-examined. For example what determines the presence and extent of a deer range; is it the maximum and/or minimum number of animals inhabiting it, or is it delimited by certain features of topography and land use, or by both? Do game ranges fluctuate from time to time or are they permanent features of the landscape? In Africa, for example, and particularly in East Africa, game ranges are almost static, being determined by such factors of the environment as the presence or absence of tsetse flies, the amount and distribution of rainfall and the type of vegetation.

Should the word "range" be used to describe the area occupied by black-tailed deer on Vancouver Island, or should the term by restricted to wildlife areas less subjected to human influences of land use? The answers to such basic questions underlie the whole idea of wildlife management and until they are found, the rationale, for instance upon which deer management on Vancouver Island is based, needs to be re-evaluated.

CHAPTER THREE A: THE RANGE CARRYING CAPACITY OF BLACK-TAILED DEER ON VANCOUVER ISLAND

The Black-Tailed Deer

The case of the coastal black-tailed deer of Vancouver Island B.C. has been selected to illustrate how the applicability of certain concepts of wildlife management is affected, determined or even hindered by various activities of land use, and by the attitude of the public. Amongst all the mammals native to North America, the deer has probably played the most important role in the history of settlement of the continent. It is today the best known and the more widely prized game genus. Thirty one species and subspecies represent the genus Odocoileus in North America, the most important groups being O. virginianus, the white-tailed deer of the east; and O. hemionus, the mule or black-tailed deer of the west. Each has several subspecies, those of the black-tailed deer being O. h. Hemionus (Rafinesque), the Rocky Mountain mule deer; O. h. californicus (Caton) the Californian mule deer; and O. h. columbianus (Richardson), the Columbian black-tailed deer with which the present thesis is concerned.

The black-tailed deer inhabits the plains, foothills and mountains west of the Prairies. Its range extends southward from central Manitoba, central Alberta, and eastern British Columbia to northern Mexico; and east and west from longitude 50° west to the Pacific coast (Trippensee, 1948). In

British Columbia, the largest specimens come from mainland areas. Weights of adult males, including viscera, may vary from 110 to 250 pounds. Their total length is 56 to 66 inches, while height at shoulder varies from 27 to 36 inches.

The Habitat of the Black-Tailed Deer

Wild animals have habitat preferences and requirements which strictly limit their distribution. Preferred habitats provide the animals with optimum conditions of essential environmental factors such as food, water and cover. Therefore, knowledge of the habitat types and their distribution is an essential and basic consideration in the study of the productivity of the black-tailed deer. This animal, native to the narrow strip of terrain in the immediate Pacific slope of North America, makes productive thousands of square miles of chapparral, brushland and woodlands where otherwise no species of big game animal is found (Cowan, 1956).

The entire range of the black-tail as a species lies within a belt where annual precipitation varies from 35 inches at the south to 150 inches in the north. This habitat in general comprises the Pacific coastal mixed forest of heavy ground vegetation and dense deciduous or evergreen forests, which in turn grade into the chaparral and brushlands of California. This habitat also supports the elk (*Cervus canadensis*). The black-tailed deer apparently finds this margin of the rain forests ideal habitat, clinging stubbornly to this ecological range even when forage conditions deteriorate (Einarsen, 1946). Within this area, abundance of deer is closely associated with the early stages of forest regeneration. Before the advent of man, primitive fire removed the forest and reinitiated the regeneration so necessary to the survival of the black-tailed deer. Closing of the resulting forest canopy reduces the quantity and quality of food plants, resulting in much lower populations of deer. Studies have shown that the populations of these animals will increase 20-fold where forests are set back by fire or logging (Dasmann and Dasmann, 1963).

On Vancouver Island, the critical requirements for the species appear to be the presence of timbered stands of varying density with marginal openings. In these combinations are the two essentials for the animals welfare - protection provided by the cover, and food supplied by the clearings. Coniferous forests dominate the vegatation of Vancouver Island; Douglas fir, (Pseudotsuga taxifolia), is the characteristic species in forests about five hundred years old.

Key Deer Areas

Although the black-tailed deer is classed as a forest inhabitant, it neither prefers nor subsists well in stands of old growth timbers. It attains its greatest abundance under conditions of cover characterized by a diversity of types and age classes, which include a small representation of non-forested land and considerable areas of dense young stands and brushlands. Ideal range in Leopold's (1934) opinion contains 50 percent brushland (stands of reproduction and small saplings) and 25 percent each of woodland (all other forested area) and non-forested land. Many areas with palatable forage remain unused if they are too far from shelter; logging then provides proper interspersion of cover and forage. By this definition, the ideal habitat is composed predominantly of young age classes, and only in regions of extensive patch-logging operations of recent origin are these preferred conditions found (Trippensee, 1948). Newly cut-over or burned lands provide excellent black-tailed deer habitat; after the first growing season, burned-over areas provide both protection and food in abundance (Einarsen, 1946).

In the absence of wildfires and before the development of the logging industry at the turn of the century, the moist coniferous biome of Vancouver Island and the Pacific Northwest supported very few black-tailed deer (Cowan 1945, Leopold 1950, Dasmann and Hines 1959). Cowan (1945) estimated that the mature unlogged forest of Vancouver Island could only support from 1 to 5 deer per square mile. Gates (1968), working in the Northwest Bay logging claim of the eastern side of the island, concluded that the average deer density was 66 deer per square mile during the summer, and 49 deer per square mile during the subsequent winter in 1962. In terms of numbers then, coastal deer populations appear to undergo phenomenal increases after the destruction of the mature forest through logging.

Vancouver Island is a distinct geographical entity embracing at least three ecological units: the relatively dry east coast from Victoria to Union Bay; the remainder of the coastal area and most of the adjacent land of lower elevation, and the interior of the island containing the backbone of high mountains. In terms of deer productivity, the first is the most productive; the last unit, the high interior, has little game potential while the second unit has mixed potential (West, G.A. 1953). In the favourable habitat types, the tangle of salal (Gaultheria shallon) and vine maple (Acer circinatum) provide concealment in the forests. Here a closed canopy persists so that only filtered light reaches the forest floor, Douglas fir, hemlock and spruce predominate. It is the adjacent logged or burned areas, well covered by weeds and browse that feed the deer. Ecologically it is the ideal example of "forest edge habitat". Hatter et al, (1956) give five broad habitat types with regard to deer and elk productivity on Vancouver Island, which are reproduced below.

Table 1. A Broad Classification of Habitat on Vancouver Island in Respect to Production of Deer and Elk.

Area and Descriptive Features (Climate and Vegetation)	Deer	Elk
Victoria and Island........................ Low rainfall, even temperature, Garry oak, Douglas fir, slower open growth on logged areas. Much sunshine	High	Nil
East Coast of Vancouver Island to Qualicum. Fir, hemlock, arbutus, huckleberry, 30-40 inches rain, hotter summers and cooler winters than Victoria. Growth more luxuriant on logged areas but not rank.	High	Medium
Centre, mountanous portion of the Island... shorter summers, cold winters, much rain or snow. Conifers dominant, shrubs not as abundant as on the east coast.	Low	Medium
West Coast................................. Hemlock dominant. Conifer growth on logged land is lush, chokes out ground cover species. Mild weather, much rain, low sunshine. Ferns and salal form vegetation mats.	Low	Medium
Northern portion of Vancouver Island....... Apparently midway between east and west coast in climate and plant growth. Productivity not known but likely between extremes of east and west coast.	?	Medium

Deer: High - In excess of 15 per square mile

Medium - 5 - 15 per square mile

Low - Less than 5 per square mile

Source: Hatter et al., The 9th B.C. Natural Resources Conference 1956, p. 479.

Cowan (1945) recognized, on the other hand, only three major cover types for deer habitat on the island: new burn, second growth and mature coniferous forest. The new burn cover type is dominated by the dwarf fireweed (Epilobium minutum), and the groundsel (Senecio sylvaticus), together with an abundant and varied assemblage of new growth of annual and perennial pioneers such as sorrel and lupine. In additon, certain relic species of the pre-burn sub-climax forect community persist. According to Cowan (1945, p. 119), "The deer carrying capacity of the community is extremely low. Lack of cover renders it unattractive in mid-summer and in the cold winter weather." The second growth cover type consists of the coniferous pioneer forest community (Pseudotsuga-Gaultheria associes). Cowan states that it is the most extensive habitat type on southern Vancouver Island, and one of the most important deer habitat in coastal British Columbia. It is dominated by Douglas fir, salal and bracken (Pteris aquilina). This second growth fir community provides ample cover for summer and winter bedding grounds. Another component of the second growth cover type is the deciduous pioneer forest community (Arbutus-spirala-Gaultheria associes) prevalent at low elevations on the south-eastern end of the island, and equally important as deer habitat. It characterizes forest regeneration on the southern slopes and is rich in palatable browse species as well as cover. The coniferous subclimax forest community (Pseudotsuga consocies) is the third major cover type for deer. Douglas fir is the dominant tree species with characteristic salal and sword fern ground cover beneath the boles of these giant conifers. The dearth of palatable browse species within this community renders it unfavourable as deer habitat. "The deer carrying capacity of this community is on the average less than half that of the second growth fir community. But where it adjoins the latter it is often used as sheltered bedding ground" (Cowan 1945, p. 121). Deer require "edge-habitat"; the interspersion of early seral or regenerating, food producing areas with escape and protective habitat in the form of mature timber stands, riparian strips, and rock bluff communites, provides ideal range composition (Gates, 1968).

A delimitation of key deer areas on Vancouver Island that is based solely on major cover types is, however, still too general for management purposes. Key feed areas on this management unit must be seen within the context of logging activities and their resultant regeneration of vegetation. It is believed that these two factors are largely responsible for the varying levels of carrying capacities on various parts of the Island.

In terms of food, the carrying capacity of any given big game range in regions of highly diversified topography and temporary but intensive land use practices, such as Vancouver Island is quite uncertain. Leopold (1950) states that the carrying capacity of a deer range is primarily a function of plant successions. The two factors of stand age and stand composition mentioned earlier are particularly significant during the winter months when the volume and nature of browse are of the utmost importance. Analysis of the preferred deer foods has revealed wide differences in the food value of browse species growing under contrasting conditions, (Klein, 1965; Gates, 1968; Smith, 1968), plus a seasonal variation in their protein content. In general, browse is more abundant in young well-stocked stands, reaching its greatest volume a few years after logging and burning operations. Thereafter its value deteriorates. The effect of stand age can be demonstrated by direct measurement which has been done in a number of cases (Gates 1968, Smith 1968). Gerstell (1938) states that the supply of browse more abundant in a young stand, frequently exceeds 200 pounds per acre whereas in older stands it is not more than 25 pounds per acre. The effect of stand composition although it has been done too (Gates, 1968; Smith, 1968; Cowan, 1945), is much more difficult to evaluate because the rangeof the deer is so extensive and encompasses so many forest types and regions that any consideration of food preferences must necessarily be treated from a local point of view.

Cowan (1945) recognized 8 major plant associations in all stages of regeneration after logging or burning as being the main source of black-tailed deer food on southern Vancouver Island: -

1) Mud flat community (Juncus-Cavex-Isoetes associes)
2) Sedge meadow community (Cavex-Oenanthe associes)
3) Alder-willow community (Alnus-Salix associes)
4) Rock-bluff community (Polytrichum-Aira associes)
5) New burn community (Epilobium-Senecio associes)
6) Coniferous pioneer forest community (Pseudotsuga-Gaultheria associes)
7) Deciduous pioneer forest community (Arbutus-Spiraea-Gaultheria associes)
8) Coniferous subclimax forest community (Pseudotsuga consocies).

Gates (1968), however, recognized 4 distinct seral associations as the major sources of the coastal black-tail food in Northwest Bay. These were more or less equivalent to Cowan's 5, 6, 7 and 8. Gates states that Cowan's "rock bluff", "sedge meadow", and "alder willow" communities were too poorly represented in his study area to be regarded. Of these major food habitat types only the last four will be discussed here, because it would appear, on the basis of their distribution, that they are the most important.

The Epilobium-Senecio association is the one that develops immediately on newly logged or burn habitats. It is dominated by the dwarf fireweed, (Epilobium minutum)and the wood groundsel (Senecio sylvaticus). These two are associated with lettuce (Lactuca muralis)and the thistle (Cirsium lanceolatus and Carvense). There may be few persisting coniferous trees and shrubs of the pre-burn community, but on the whole total plant cover may be less than four percent (Gates, 1968). As regeneration progresses into the second year, shrubs and woody perennials and annuals such as salal, black raspberry and western hemlock become well established increasing the plant cover of forbs and shrubs to approximately 20 percent (Gates, 1968). This plant community has a low potential as deer habitat due to its lack of cover in mid-summer and in winter (Cowan, 1945).

A Gaultheria-Hypochaeris association develops from approximately the fourth to fourteenth year after slash-burning, and consists of a mixed salal and catsear shrub and forb community. These two species are associated with Rubus species - trailing blackberry and black-raspberry - and salmonberry (Rubus spectabilis). Willows, twinflower and oregon grape represent the shrub component of the association. Among the most important herbaceous plants are thistles (Cirsium spp. and Carduus spp.), lettuce, pearly everlasting, fireweed and vanilla leaf. The three- and four-year old logged over sites represent the earliest stages of this community with forbs and shrubs occupying about 15 percent each of the surface. Some grasses are present, while salal is the dominant shrub. The five-to-thirteen year old burned over sites represent the more advanced stages of regeneration with a 40 to 70 percent plant cover. Shrubs are dominant, six to eight times more of the surface than herbaceous plants, with salal still themost dominant (38 percent of the surface). Douglas fir and hemlock may represent the developing coniferous tree component of the regenerating community.(Gates 1968). Cowan (1945) did not recognize this regenerating association in southern Vancouver Island and this underlines what has already been stated, that stand composition is so variable that is significance can only be recognized on a local scale.

The Pseudotsuga-Gaultheria association develops approximately fourteen years after slash-burning (Gates, 1968), and is one of the most extensive community on southern Vancouver Island. It is dominated by Douglas fir with salal with an abundant supply of lichen Usnea barbata, a very important deer food, on the trunks and branches of the fir. This lichen greatly enhances the food potential of this habitat. The salal and total shrub cover are significantly reduced in this association as Douglas firs increase. The deer food potential of this community is high because of the high concentration of palatable and nutritious browse species, such as Usnea, salal, willow and alder.

Cowan's (1945) Arbutus - Spirala - Gaultheria association is the deciduous pioneer forest community counterpart to the above association. It is found on southeastern Vancouver Island at low elevations, and is dominated by salal, arbutus and tree spirea (Spiraea discolor), with catsear (Hypochaeris radicata), snowberry, (Symphoricarpos racemosa) and willow as Sub-dominants. It is rich in palatable browse species and its three dominants are among the most, sought after forage plants on the island. The flowering currant (Ribes sanguinea), broad leaf and smooth maple (Acer macrophyllum and A. glabra), and flowering dogwood are some of the important secondary species of high palatability, and they all increase the carrying capacity of this food habitat type (Cowan 1945).

The Pseudotsuga subclimax community is thepredecessor of the climax hemlock - balsam - cedar forest, and is of poor species variety (Cowan 1945). The Douglas fir - western hemlock canopy is so dense that there is little ground cover except for shade tolerant species for example salal and sword fern. The former may cover approximately 65 percent of the surface (Gates, 1968). Salal and Usnea provide the bulk of the deer food in this community and as already stated, its carrying capacity is less than half that of the secondary Pseudotsuga - Gaultheria association.

Most of the published literature on deer food studies points out the fact that deer food production in forest communities is greatly determined by site, logging and fire history, past land use and seral structure (Ehnreich and Murphy 1962, Gates 1968, Smith 1968). It is generally agreed that after the destrcution of "sub-climax" and "climax" communities, deer food production increases for varying periods of time, and as regeneration progresses, this production decreases and food nutrient value deteriorates as the plant community attains maturity (Gates 1968, Smith 1968, Einarsen 1946, Trippensee 1948). Gates (1968) noted that this appeared to be the trend at Northwest Bay as the table below indicates.

Table 2: Annual Production of Deer Food in Various Post-Fire Seral Stages, Expressed as Pounds Per Acre Wet-Weight. The Numbers in Parenthesis Express Palatable Food Production as a Percentage, of Total New-Growth Production.

Years Since Burning	4	10	12	14	Mature Timber
Forbs and Grasses	151	125	13	97	Trace
Ferns	15	69	140	166	2
Shrubs	782	847	791	744	423
Conifers	Trace	249	28	105	5
Total	948	1290	972	1114	430
	(93.5)	(93.0)	(63.9)	(79.5)	(95.5)
Percent of ground covered by palatable species	39.3	61.8	47.0	43.4	67.1

Source: Gates 1968, p. 49

For the first ten years after slash-burning, there is a rapid increase in total food production, followed by a slight decrease within the next four years. Four years after burning, forbs and grasses are produced in greatest quantities (151 pounds per acre).

They subsequently declined in abundance as regeneration progressed. Ferns increased in abundance from the fourth to the fourteenth year (166 pounds per acre). Both forbs and grasses and ferns were poorly represented under the mature timber community. In all age classes, and especially at ten years after burning, shrubs constituted the bulk of annual production (847 pounds per acre during the tenth year), with a significant decline in the mature timber stands (Gates, 1968).

The intermediate Gaultheria-Hypochaeris association is the most important food producing habitat in terms of food weight and palatable cover. Its species variety renders it the most favourable for food during spring to late autum and early winter. The greatest bulk of evergreen winter browse comes from the mature Pseudotsuga subclimax (Gates, 1968).

On the basis of what has been stated so far, it seems that the number of black-tailed deer inhabiting any one area on Vancouver Island is determined by two main factors. The need for cover is one of these, and though important, it is not critical. The stage of regeneration reached by the vegetation after logging is, however, the most significant factor. Of particular importance is the ratio of shrubs to herbs within the plant cover because the species composition of these two cover components determines the availability of the key forage species. Carried to its final conclusion, this means that the carrying capacity of the deer range on Vancouver Island is constantly in a state of flux and change, particularly with regard to the nutritional value of the browse species. As

Gates (1968, p. 64) states, "since floral composition differs in each seral stage, over-all seasonal changes in the nutritional status [and carrying capacity] of these seral stages must also occur."

Key Plant Associations for Deer Feed

A knowledge of the major food items for the annual and seasonal diets of the black-tail is necessary in an evaluation of the carrying capacities of the ranges it inhabits. Shrubs and deciduous trees are the two major sources of black-tailed deer food on most ranges. An analysis of the plant associations that comprise deer food is probably best done by outlining the seasonal food habits of these animals. Cowan (1945) and Gates (1968) in their treatment of Vancouver Island's black-tailed deer food habits divide the feeding year into four seasons on the basis of the type of vegetation eaten and its seasonal availability.

The Spring-Summer Transitional Diet: This feeding period is short and extends from about mid April to late May, when there is lush growth with many succulent annuals and perennials. Such newly available forbs constitute the greatest bulk in rumen samples - 59 percent (Gates, 1968). Cowan (1945) noted that fir was still the most important single food item, while Gates (1968) found that it was little used. Grass, rushes and sedges consumption reaches an annual all time peak (Cowan 1945, Gates 1968). Gates (1968) found these to be the next most important food item (15 percent of the diet after new leaves and flower buds (79 percent of the diet). But Cowan (1945) found the latter to be little used in southern Vancouver Island. Usnea barbata the arboreal lichen was abundant in May samples but became less and less used as summer progressed. Cowan (1945) noted that it made up 14 percent of the diet and was highly consumed wherever available. Salal, trailing blackberry, bearberry, Douglas fir and red cedar each made up less than 6 percent of the diet but were found in most of the samples. A shift in preference was noted from browse to succulent forbs as soon as the latter became available in spring (Gates, 1968). Salal leaves and berries provide the major food item in June, July and August. Alder, willow and bracken are also characteristic of the summer diet (Cowan, 1945).

The Autumn Diet: This browse period extends from early September to late November or early December, about three months. Shrubs and deciduous vegetation replace forbs as the main food item. Salal berries form a major food item an average of 79 percent of the autumn diet while the leaves contributed 16 percent. For the autumn browse period, salal made up 56 percent by volume (Gates, 1968). Cowan (1945) found it made up 27 percent of the autumn diet. Another major food item in autumn consists of mushrooms, 13 percent (Cowan 1945); Gates (1968) arrived at a figure of 7 percent but noted that this food item was represented in 73 percent of his samples. Alder, willow leaves and fir tips are also significant (Cowan, 1945).

The Winter Diet: This is the longest browse period, four and a half months, extending from early December to mid April (Cowan 1945). There is greatly limited food choice and deer exhibit the greatest diversity in their use of the available food plants. The evergreen shrubs and trees, conifers and lichens provide the greatest bulk of winter feed. Cowan (1945) found that black-tailed deer made great use of Douglas fir as winter food, 47 percent, with the arboreal lichen *Usnea barbata* as the next most important, 36 percent, while salal showed poor consumption, only 8 percent, despite its abundance in southern Vancouver Island. On the contrary, Gates (1968) noted that "The consumption of salal from December through March was about half that of the autumn period but the species was still eaten by almost all deer and was still the key food." He also noted that Douglas fir was eaten only moderately, although it was represented in 70 percent of his samples. Red cedar, at 21 percent, was next to salal as the preferred browse species. Grasses and sedges (8 percent), trailing blackberry, catsear, mushrooms and many other plants were also utilized though in minor amounts. "Restricted availability no doubt accounts for the reduced number of species represented in the winter stomachs in comparison with the autumn stomachs" (Cowan, 1945). The table below illustrates this difference more clearly.

Table 3. List of Food Plants Taken from Stomachs of Coast Deer on Southern Vancouver Island, B.C., in Fall and Winter.

Species	Fall Stomachs (15)		Winter Stomachs (15)	
	No. of occurrence	Parts Eaten	No. of occurrence	Parts Eaten
Pseudotsuga Taxifolia	8	Needles	15	Needles
Gaultheria shallon	11	Leaves	7	Leaves
Alnus rubra	9	Leaves	0	
Salix sp.	5	Leaves and Buds	0	
Usnea barbata	5		15	
Thuja plicata	3	Leaves	5	Leaves
Mushrooms	8	Thallus	2	Thallus
Flat lichen	3		7	
Rubus parviflora	3	Leaves	0	
Pteris aquilina	2	Leaves	0	
Acer macrophyllum	3	Leaves	0	
Arbutus menziesii	1	Leaves	0	
Spiral discolor	1	Leaves	0	
Symphoricarpos racemosa	1	Leaves	0	
Berberis nervosa	1	Leaves		
Hypochaeris radicata	1	Leaves	1	Leaves
Selaginella sp.	0		1	Leaves
Rubus macropetalus	0		1	Leaves
Cavex sp.	0		1	Leaves

Source: Cowan 1945, p. 127.

The Annual Diet: The food habits of coastal black-tails on the island are best appreciated when viewed on an annual 9 month browse period. Gates (1968) has done this on the basis of Cowan's (1945) "consumption index" method. He noted that the eleven major sources of deer food at Northwest Bay accounted for approximately 92 percent of all food consumed during the nine month browse period. Table 4 indicates the seasonal use of these food items, within the nine months (Gates, 1968).

Salal accounted for one third of the total diet and was three times more important than any other species; then red cedar 11 percent, arboreal lichen 7 percent, pearly everlasting 8 percent and grasses and sedges 7 percent. These eleven key species consisted of 46 percent trees and shrubs, 11 percent herbaceous plants, 8 percent lichens, 4 percent mushrooms and 8 percent mixed vegetation (Gates 1968).

By combining data from three different sources, (Cowan 1945, Brown 1961, Gates 1968); Gates (1968) gave a 'tentative list' of the ten major deer food items on an annual basis on three coastal separate ranges.

Table 4: The Relative Importance of Food Items to Black-Tailed Deer at Northwest Bay as Indicated by Stomach Contents of 72 Animals Sampled in Three Different Seasons.

Season	Spring-Summer	Autumn	Winter	Total	
Length of Season in Months	1½	3	4½	9	
Item	Seasonal Consumption Factors[1]			Consumption Index[2] Actual	%
Salal	8.1	167.7	136.4	312.2	34.7
Red Cedar	2.9	6.9	94.0	103.8	11.5
Arboreal lichens	11.0	Trace	59.4	70.4	7.8
Pearly ever-lasting	69.0	0	0	69.0	7.7
Grasses	22.6	7.2	36.9	66.7	7.4
Trailing Blackberry	6.9	21.9	16.6	45.4	5.0
Catsear	12.2	4.5	17.6	34.3	3.8
Mushrooms	Trace	21.0	12.6	33.6	3.8
Douglas fir	3.5	11.7	18.0	33.2	3.7
Bearberry	4.1	3.3	23.0	30.4	3.4
Red alder	Trace	21.6	3.2	24.8	2.8
Other vegetation	9.8	34.2	32.4	76.4	8.4
Totals				900.2	100.0

Source: Gates 1968, p. 27

[1] Product of average volume % for each season by the number of months represented by that season.

[2] Sum of seasonal consumption Factors. See Cowan (1945).

Table 5: The Ten Dominant Items in the Annual Diets of Columbian Black-Tailed Deer Occupying Three Separate Ranges

Northwest Bay[1]	Southern Vancouver Island[2]	Western Washington[3]
Salal	Douglas fir	Tailing blackberry
Red Cedar	Salal	Salal
Trailing blackberry	Arboreal lichen	Grasses
Arboreal lichen	Red alder	Red alder
Grasses and sedges	Willow	Vine maple
Douglas fir	Mushrooms	Western hemlock
Pearly everlasting	Bracken	Douglas fir
Red alder	Grasses and sedges	Buckleberry
Willow	Thimbleberry	Fireweed
Catsear	Equisetum	Red cedar

[1] Gates (1968)

[2] Cowan (1945)

[3] Brown (1961)

Source: Gates 1968, p. 29

It appears **from Table 5** that black-tailed deer derive the greater bulk of their feed from salal, Douglas fir and grasses. On the three ranges there are significant differences in the preferred browse species. As has already been stated, this is probably a reflection of stand composition on the various study areas. For instance pearly everlasting and catsear were only eaten at Northwest Bay, while Western hemlock was important as deer browse only in Western Washington. Ultimately stand composition on a range may be said to reflect range productivity which in turn determines deer productivity.

Ideally then, through an evaluation of the key forage species and their seasonal utilization by deer, it should be possible to determine the capacity of a deer range to support these animals during any of the feeding periods, or during the whole feeding year. Such a capacity will depend upon the availability of the forage species, and also on the vegetation ability to withstand browsing pressure without dying out or failing to regenerate and reproduce. For instance if the shrub salal (Table 3 and 4) is absent from a particular habitat during the spring-summer feeding period, in autumn or in winter, then it can be reasonably predicted that the habitat will only support a few animals, or even none at all during these feeding periods. In other words, the absence of this key forage species can lower the carrying capacity of the habitat. It must be pointed out, however, that such a lowering of the range capacity refers largely to qualitative measurements of nutrient quality; where desired forage species are totally unavailable, deer are known to eat anything, and may often die with full stomachs.

Palatability of Forage Species

The various food plants for black-tailed deer on Vancouver Island can be classified on the basis of their growth structure into:

(1) trees and shrubs;

(2) herbaceous plants;

(3) grasses, sedges, rushes and ferns;

(4) lichens and mosses

Trees and shrubs by far contribute the greatest bulk of deer food on Vancouver Island; 71 percent of these constitute superior deer food, while only 8 percent are consistently ignored (Cowan, 1945). Thus black-tailed deer on most ranges depend mainly on trees and shrubs for food (Cowan, 1945; Taber and Dasmann, 1958; Brown, 1961; Gates, 1968). On the contrary herbaceous vegetation contributes little in terms of bulk; out of a total of 106 herbaceous plant species, only 21 percent of these are moderately palatable to deer, and these are only available for a short time during spring and early summer; 43 percent of herbaceous plants are rarely eaten while

36 percent were apparently not utilized at all (Cowan, 1945). Grasses, sedges, rushes and ferns are only eaten when succulent for a short time in the spring, in the autumn and early winter. The black-tailed deer on Vancouver Island is not a grazer but a browser (Cowan,1945). Significant amounts of bracken are eaten during the spring, to a lesser degree in the summer, and to a much greater extent in autumn. Gates (1968) noted that bracken and Equisetum were only moderately eaten at Northwest Bay. Of the grasses, sedges, and rushes, Cowan (1945) rated 32 percent as being palatable and 44 percent as not eaten at all. Of the lichens and mosses, the arboreal lichen Usnea barbata was noted by Cowan (1945) to be second largest single source of food for coast deer. This overhangs the trunks and branches of coniferous trees and is made available to deer when these trees are felled by strong winds, by snow and by logging (Gates, 1968). Many other species of lichens, mosses and liverworts are available to deer throughout the year. The table below, adapted from Cowan (1945) summarizes these various deer food floral types and their palatability.

Table 6: Relative Palatability of Various Groups of Plants Exclusive of Lichens, Mushrooms and Mosses

	No. of Species	% of Species in Group
Trees and Shrubs		
Highly Palatable	26	43
Moderately Palatable	17	28
Low Palatability	13	21
Not Eaten	5	8
Total No. of Species in Floral Group	61	
Herbaceous Plants		
Highly Palatable	12	11
Moderately Palatable	11	10
Low Palatability	45	43
Not Eaten	38	36
Total No. of Species in Floral Group	106	
Grasses, Sedges and Rushes		
Highly Palatable	6	15
Moderately Palatable	7	17
Low Palatability	10	24
Not Eaten	18	44
Total No. of Species in Floral Group	41	
Ferns, Equisetums and Quillworts		
Highly Palatable	1	7
Moderately Palatable	4	27
Low Palatability	6	40
Not Eaten	4	26
Total No. of Species in Floral Group	15	

Source: Cowan 1945, p. 137

It has already been stated that the intensity with which a palatable forage plant is eaten not only depends upon the abundance of the browsing species, but also upon the abundance or density of such a browse (forage) species, as well as the other components of the plant cover. For example, Cowan (1945 p. 113) estimated a "palatability" index of 63 percent for Douglas fir in an area where individuals of this species averaged over 3,000 to the acre. But this same plant was browsed to nearly 100 percent in another area with the same abundance of deer as the first one, but where the Douglas fir individuals averaged only about 300 to the acre.

Where the range is greatly overstocked, deer have been known to eat every available leaf and twig within their reach, resulting in the appearance of the "Deer or Browse Line" - a distinct absence of foliage and twigs up to the height which the deer can reach. The presence of a deer line is regarded as indicative of starving conditions on a range, a sign that the safe degree of stocking relative to the carrying capacity of the habitat has been passed.

Ratings of the "proper-use-factor", the delimitation of key game areas and the evaluation of key forage species can only be used with reference to the areas of their occurrence, within the particular local conditions under which they prevail. They cannot be inferred to other areas where different conditions exist. A plant species under the same deer pressure may be browsed to different intensities in different habitats "depending upon the concentration of certain chemical constituents in the soil upon which the plant is growing". (Cowan 1945, p. 113).

Determination of carrying capacities using these three factors therefore has only a limited application value, and in this perhaps lies their chief disadvantage. This would seem to be particularly true of an area like Vancouver Island with its diverse topography coupled with its system of land use. Also, the black-tailed deer populations in this management unit appear to be continually adjusting their numbers to these varied changes that occur within their habitat, particularly with regard to food. However, a closer and critical examination of the treatment of the food factor for deer populations in the literature calls for a further comment.

Deer productivity is apparently always associated with the level of food availability. In this respect, nearly all workers apparently unanimously uphold the fact that destruction of pristine forest conditions results in enhanced deer productivity through the provision of secondary plant growth which is believed to be more succulent and nutritious. It also appears that most of these workers have dealt with the factor of food always from a plant ecological viewpoint. Thus deer food types are nearly always determined on the basis of "plant successions"; key forage species and their palatability are based on classical phytosociological phenomena. Often, a deer habitat is acclaimed as ideal or not ideal depending on the level of plant successions. In other words, the more "advanced" the successions, the less the food available and ultimately the fewer the animals that can be carried on the habitat under consideration. Yet in recent years, some plant ecologists have questioned whether the classical theories of plant successions as they exist represent reality; whether in fact plant "communities" may not just be mere mental abstractions on the part of plant ecologists. The implications of such a contention are important to deer studies. If indeed "plant communities" are not represented in real world phenomena then the statement that "the carrying capacity of a deer range is primarily a function of plant successions" assumes enormous significance. If such is the case, that is if an "orderly", flawless natural succession of plant species does not exist, then the whole approach to deer food studies must be changed.

Most probably, the approach should no longer be based on the total floristics of the plant cover, but rather on what plants the deer actually eat. It may be necessary therefore to treat deer food investigation solely on the basis of the feeding habits of these animals, without attempting to relate them to the little understood phenomena of plant growth and development. Probably wildlife biologists put too much meaning into the simple fact of feeding. It is the presence or absence of a plant species that should be considered critical, not its manifestations of life and death. Moreover, highly detailed and complete phytosociological surveys consume great amounts of time and effort, yet the deer are known to feed only on certain selected plants. In addition, the "plant communities" vary greatly in space, and consequently, the data obtained will have only limited usefulness.

CHAPTER THREE B: FOOD QUALITY AND PHYSIOLOGICAL EFFECTS OF DIETARY DEFICIENCIES

As stated in Chapter One, the success and reproduction rate of wild animals ultimately depend on seasonal climatic changes,as these affect the animals' source of nutrition (Talbot and Payne, 1965). Food,as a factor in determining deer productivity has been documented more than any other environmental factor. Certain ecological bases related to food, such as plant regeneration, soil fertility and topography, seem to determine shifts of deer abundance in as much as they affect the food supply: its availability, quantity and particularly quality (Julander, 1937; Hellmers, 1940; Leopold, 1943; Einarsen, 1946; Trippensee, 1948; Fowle, 1950; Verme, 1963; Dietz, 1965; Klein, 1962 and 1965; Smith, 1968; and Gates, 1968).

A diminishing food supply is the most efficient check on deer populations when they begin to increase above a certain level. The more spectacular manifestation of a food shortage is outright starvation. In some winters, approximately one half or more of the fawn crops can be removed from parts of the range by insufficient food supply and severe weather conditions. On Vancouver Island fawns make up 20 to 40 percent of overall winter mortality*. The relative adequacy of the animals' nutrition, particularly in winter may be a paramount factor governing deer populations. The nutritive value of the

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* The Victoria Observer, June 1st, 1966.

food during this time is the most critical factor. In Pennsylvania, nutrient content of deer food was found to be lower in winter (Hellmers, 1940). Protein content of the twigs of most of the browse species declined in winter, and digestibility and nutritional value of deer feeds apparently varied directly with the crude fiber content. Crude fiber content rose through the winter months, while the more digestible carbohydrates decreased through the winter season, thereby indicating a reduction in nutritional value. Losses and variations in size in black-tailed deer populations in Oregon have been attributed to variations in protein content in preferred deer foods (Einarsen, 1946). Other workers have investigated the correlation between deer productivity and range quality on different deer ranges. Chaetum and Severinghaus (1950) found that considerable regional variability, in the fertility of white-tailed deer corresponded broadly with the evaluations of range quality in New York. Taber, (1956) and Dasmann (1956), working with Columbian black-tailed deer in California, also found that high deer density, productivity and general well-being were characteristic of the better shrubland habitat while opposite conditions prevailed on the less favourable chapparral. In addition, protein quality in all chaparral shrubs fluctuates seasonally from a high in spring to a low in late fall. Dasmann (1956) noted that the pattern of deer mortality followed these protein fluctuations to a considerable degree.

When protein levels in deer food fall below seven, six or five percent, deer productivity is greatly impaired. Deer foods produced under conditions which result in a minimum protein content during the summer as growth matures are almost valueless in midwinter. The amount of browse eaten need not alter in bulk; but it is when the protein value is greatly reduced that the deer receive little nourishment. Malnutrition is marked where environmental conditions are unfavourable. Deer losses in such areas become progressively higher until new vegetation becomes nutritionally adequate.

Game ranges are not static, but provide game animals with a constantly changing diet. Generally, the succulent forage available during late spring and early summer provides nutrients needed for growth, fawning, lactation, antler development and body tone. As plant growth matures in the late summer and early fall, fats and carbohydrates increase and the diet changes from a growing ration to a fattening one. In winter, plants are generally dormant and can only supply a maintenance ration. Thus in summer, deer have a greater quantity of forage to select from, which is also nutritionally superior feed as compared to winter stems.

On Vancouver Island, available data suggest that carrying capacity has meaning largely with reference to food availability, particularly its quality, and that the need for cover plays but a minor role. Food quality appears to decrease with advanced seral regeneration. Table 7, illustrates such nutrient level fluctuations for six important deer forage species for Northwest Bay; Douglas fir, western red cedar, salal, trailing blackberry, red alder and willow. Crude protein levels decreased from summer through to winter for all the species except the conifers, Douglas fir and western red cedar. These showed lower crude protein levels in the summer but had higher levels in winter. This goes to illustrate the seasonality of the ability.of the range to support deer. Average Free Nitrogen Extract (N.F.E.) levels were also noted to be higher in late winter than in summer, corresponding to the onset of dormany as phenology advanced (Gates, 1968) thus providing the animals with adequate winter nutrition. Similarly, the crude fibre content levels rose during the winter but were low in the summer. Moisture percentage levels for the six species followed a similar pattern, being highest during the summer and lowest in late winter (Gates, 1968).

Deer have been noted to adjust their feeding habits to such changes of forage quality, choosing "browse containing the highest amounts of important nutrients during each season, especially in the case of protein" (Dietz et al. 1958). Gates (1968 p. 63) reports a similar adjustment by Northwest Bay black-tailed deer: -

Table 7: The Average Seasonal Composition of Some Important Deer Forage Species at Northwest Bay, Vancouver Island.

Browse Species		% Moisture	Percent of Dry Weight: Crude Protein	Ether Extract	Ash	Fibre	N.F.E.
Douglas Fir	July	63.5	6.32	16.43	2.36	20.20	54.67
	Dec.	59.6	10.17	12.69	3.97	20.31	52.84
	Mar.	53.9	7.63	13.76	2.60	18.96	57.03
Western Red Cedar	July	61.0	4.68	18.04	4.22	25.34	47.71
	Dec.	58.5	7.38	18.02	4.48	27.02	43.09
	Mar.	51.6	4.75	9.65	3.40	21.10	61.10
Salal	June	78.4	9.68	14.16	3.83	18.26	54.07
	July	71.4	7.97	13.63	4.46	22.93	51.56
	Aug.	57.6	3.70	7.20	3.85	26.05	59.10
	Dec.	58.5	6.40	10.42	5.23	24.48	53.45
	Mar.	55.9	5.03	10.20	4.66	19.60	60.50
Trailing Black-berry	July	66.3	15.04	12.64	6.22	13.13	52.96
	Aug.	61.2	9.30	8.10	5.60	15.40	61.60
	Dec.	63.0	13.23	12.70	6.57	13.92	53.56
	Mar.	57.4	8.55	8.00	5.40	11.40	66.20
Red Alder	July	56.5	17.47	13.66	4.14	11.41	53.32
	Aug.	59.4	13.70	10.60	3.30	16.50	55.90
	Dec.	46.5	11.16	14.16	3.00	23.47	47.47
	Mar.	53.6	7.90	17.17	2.50	21.17	51.23
Willow	June	69.1	14.46	12.69	6.30	15.78	50.77
	July	62.9	12.35	14.27	6.46	16.26	50.63
	Aug.	----	5.40	4.60	5.70	22.90	61.40
	Dec.	50.4	9.46	8.30	3.92	29.54	48.76
	Mar.	50.5	6.25	10.50	3.40	24.00	56.10

Source: Gates, 1968, p. 58

> "....June samples of bracken fern shoots, typically the portion eaten by deer averaged 33.2 percent crude protein......One month later, when almost all plants reached the open froud stage and were rarely browsed, average protein had decreased by almost two thirds to 11.9 percent.....Moisture and ash content were also higher, and crude fibre lower in the preferred new shoots than in the mature frouds".

The animals also adjusted their preferences with regard to the evergreen species; Douglas fir, western red cedar, salal, trailing blackberry and others. The correlation between the change in forage preferences by the deer, and the fluctuation in the nutrient quality of the feed is a good example of how seasonal changes in carrying capacities on the ranges necessitate deer seasonal adjustments to these fluctuations. In the long run therefore, the extent of the interaction of deer and range productivity can only be evaluated from the performance of the animals themselves. The quality of forage affects deer in various ways.

Physiological Bases for Decline in Deer Condition

Decline in Deer Quality: This is first reflected in the physical condition of the animals. Such deer have little or no fat reserves, their coats lack lustre and in extreme cases, the bone structure may be seen through the skin. Such deer are not wild and alert and may show no fear of man. All deer are subjected to some external and internal parasites and diseases, but heavily infested animals are usually suffering from malnutrition. The parasite threat is a culmination of progressive deer deterioration: deer weakened by malnutrition are unable to resist the internal parasites and become disinterested in the grooming required to remain relatively free of external parasites. In addition, depleted ranges make grazing close to the ground inevitable and the chances of picking up the parasites are increased.

Einarsen (1946a) working with Sitka black-tailed deer in Alaska found that amongst the deer that had died in late winter and early spring, although there was no evidence of an epizootic, nevertheless parasites were particularly abundant in emaciated deer from overgrazed grounds. He stated that such parasitic infections actually hastened death of the animals in critical condition. Such animals had rough pelage and generally in poor condition. Studies of Columbian black-tailed deer (Dasmann, 1956; Taber, 1956) have revealed that the general condition of the deer followed the protein level of the forage on the chaparrel and shrubland deer habitats. The protein level is high in spring and summer, but declines through late summer and fall, and reaches a low point in late winter. Deer condition is poorest in the area of dense heavy brush.

For Vancouver Island, such changes in condition were assessed by Smith (1968) for Northwest Bay deer. He used average dressed weight as the sole criterion for his assessment because various studies had established that "weight is a valid indicator of condition" (p. 16) Smith (1968) noted that deer condition of the youngest three age classes of males (.5, 1.5 and 2.5 years) deteriorated over the period of study 1954-1966, during which time there was also a gradual deterioration of the habitat. According to him, "successional patterns influence the condition of the deer." These data are further evidence that wildlife productivity will fluctuate with variations in the carrying capacity of the habitat.

Decline in Antler Development and Size: Antlers are true bone, grown during a 4 to 5 month period and represent the fastest deposition of bone tissue in the animal world. An abundance of food high in minerals is required for good antler growth. If food supplies are inadequate, body requirements take precedence over antler growth. This is most significant when most of the bucks in the herd consequently harvested by hunters, are yearlings of approximately 18 months old. These animals are growing in size while also growing antlers: both activities requiring large amounts of food, balanced to provide proper nutrition. A good sympton of overpopulation is illustrated by a deer herd containing a high percentage of spike (non-forked) bucks.

It is essential then, that the quality as well as the quantity of forage produced on various deer habitats should be understood, including the factors that affect these nutritional attributes. Big game animals have a tendency to use certain ranges and it is impossible to change these habits. Leopold (1943, pp. 7-8) states that "Most animals when crowded and hungry, disperse by their own social pressure. Deer herds, at least in winter, seem devoid of such pressure. State after state reports instances of deer stubbornly refusing to leave (or even to be driven from) a depleted winter range. Paraphrased in human terms, 'deer would starve rather than move'." Consequently, the productivity of game ranges should be considered on the basis of deer herd productivity rather than on a land basis. Each herd should be controlled separately as the conditions of food, environment and land use indicate.

CHAPTER FOUR: POPULATION DYNAMICS

Some Concepts Pertaining to Population Dynamics

Recently, it has become increasingly evident that the one discipline intimately related to game management is the relatively new field of population dynamics. Variation in the number of animals in an area is one of the most important means of adaptation to the environment, and changes in numbers, whether decreases or increases, are some of the most sensitive indices of ecological conditions.

Population dynamics refers to the process of numerical and structural change within populations resulting from births, deaths and migrations. The primary factors that interact to effect these changes are reproduction, growth rates, longevity, mortality and migration. Game management is directly concerned with interpreting or manipulating such changes in animal numbers, while the study of population dynamics develops the principles and explains the patterns according to which these numerical changes occur.

Reproduction Rate: In most populations of wild animals, the rate and success of reproduction is linked with the level of the population relative to the carrying capacity of the environment. In other words, the timing and success of breeding is largely determined by nutrition. For instance, fecundity appears to be primarily determined by the plane of nutrition of the animals before and during the rut.

Ideally, then, a population with numbers below the carrying capacity of the environment may almost achieve its physiological maximum reproduction rate, while one with numbers in excess of the carrying capacity may have a much lower rate of reproduction. Annual fluctuations in numbers of even apparently stable populations, are the rule rather than the exception, and result from the imbalance between the population level and the carrying capacity of the environment. Consequently, over a long period of time, the breeding periods of wild populations will become correlated with seasonal weather patterns as these affect the animal's source of nutrition, that is, the vegetation (Talbot and Payne, 1965). The periods of rut and production of young will occur at the time of year when optimum nutrition is likely to be available. Carried further, this means that range quality can affect the reproduction rate of wild populations. On a good range, fawn survival is good and consequently, production is high. There may also be increased conception and parturation rates. On a poor range, there may be a resultant low rate of conception because of the poor physiological state of the animals, while mortality may increase. Such heavy mortality gives rise eventually to a dominance of older deer, and a reduced proportion of young deer in the population. Consequently, the rate of reproduction or the forces of natalily are of much greater significance in the dynamics of a population than mortality.' In dying, an individual animal can subtract from the population only once, but it can add many times by reproducing. In other words, "The reproductive capacities of animals generally extend over considerable fractions of their individual lifetimes, while each living thing dies only once." (Pearl 1939, p. 14).

Population Growth Rate. It is in the nature of living things to multiply their numbers. Populations, however, cannot increase indefinately. Growth in any population is determined by the interplay of two main forces;one, the organism, seeks to expand its reproduction exponentially, while the other, the environment, inexorably curtails growth. Chapman (1928) described this phenomenon as the conflict of "biotic potential" versus envionmental resistance which is expressed graphically as the "logistic" or "sigmoid curve" of population growth. This concept has become a cornerstone of game management.

Biological literature abounds with numerous concepts and theories all purpoting to explain the major factors of population control. Elton (1946) supports the thesis that competition is basic to the control of animal populations. According to him, density-dependent factors, ("intra-specific competition for resources, space or prestige; and inter-specific competion, predators or parasites."), regulate the rate of population growth among animals. But Andrewartha and Birch (1954) hold that while competition is often a factor, in some cases it is apparently not significant. According to them, climate is the most important controlling factor among certain insect species in Australia. Errington (1951) has advanced the theory that reduced productivity, due to crowding and intolerance, is the primary factor responsible for control of populations of muskrats. He has shown that populations of these animals were generally not controlled by competition for food, predation or the effects of climate.

The importance of food as a primary controlling factor of bird populations has been emphasized by Lack (1954) in his "The Natural Regulation of Animal Numbers." Where hunting and predation are not the primary factors controlling deer populations, food supply is apparently almost always implicated, either directly or indirectly (Boone, 1938; Leopold et. al., 1947). Chitty (1955 and 1957), in his work on voles stresses the opposite view and concludes that the animals he worked with are controlled through variation in variability and irritability, associated with changes in population density. He considers food to be rarely a controlling factor in natural animal populations. "It is my belief that few species under natural conditions get anywhere near exhausting their food supplies." This introduces a different idea into the concept of carrying capacity, namely that it may be determined by factors other than food.

Thus there have been as many theories in literature on major factors of population control as there are factors that have been identified. It is highly improbable that any one factor is the most significant for all populations, in view of the fact that the theories so far advanced have been based on widely varied studies, of widely different animals under variable conditions.

In terms of game management, the most important population-growth concept is the "optimum yield" or harvestable surplus. Theoretically, there is only one point on the growth curve, and only one stage in the growth or density of a population, where the greatest yield in terms of numbers produced per unit time may be realized. In this sense, yield is strictly in terms of the number of individual animals produced. Theoretically then, it is possible to stabilize production at any point along the sigmoid curve, providing the harvest balances the increment associated with that state of growth.

A systematic analysis of the growth pattern of natural populations is difficult because of lack of detailed records, especially in game management. The habits of the animals, coupled with the inadequacy of the sampling methods used are among the chief stumbling blocks.

The rate of increase of any population is chiefly a function of the relationship between the natality and mortality characteristics of that population, subject to the existing environmental conditions. Any change in fertility and mortality rates will produce a corresponding change in the growth rate.

But any growth is actually a function of the physically reproducing units in a population, i.e. the females. Consequently, sexually differentiated mortality is an important factor in population dynamics.

Mortality. Knowledge of mortality as a population-regulating factor is essential in any study of animal populations. The major causes of mortality are: natural mortality resulting from winter stress (starvation and malnutrition); mortality from diseases and parasites; mortality through predation and among big game animals, mortality through hunting.

The major factors that control populations, whether of competition, climate, food, living space or predation are manifested by mortality characteristics. Therefore, mortality can be said to be the most sensitive index of the balance between a population and its habitat. Differential sex mortality greatly determines the structure of any population. Taber and Dasmann (1954), working with Columbian black-tailed deer have shown that there is significant differential mortality among these animals in favour of the does. They have found that this is particularly true under poor range conditions and that on a good range the buck-doe sex ratio tends to be about equal. This emphasizes the importance of food as a controlling factor amongst deer populations.

The classical concepts of population growth are rarely manifested in their simple form in nature, and because of this some workers, for example Errington (1951), have tended to minimize the applicability of mathematical growth patterns to wild populations. Most of the fundamental principles and concepts of population dynamics have been developed from higher mathematics or from experimental biology, and so far they have been of little practical value in wildlife management. There appears to be a conceptual gap: while wildlife management isolates mechanisms responsible for changes in individual animals, populations or environments, experimental biology isolates principles by recording patterns and effects, and expressing them mathematically. Nevertheless many of the concepts of population dynamics have become basic to wildlife management and as A.S. Leopold et. al. (1953) have pointed out, ..."in the long run, it is the principles rather than the details which will form a sound foundation for management."

The Deer Population of Vancouver Island

Deer are the most important game animal on Vancouver Island because of their abundance, distribution and harvest. The magnitude and extent of the deer resource on the Island has been considered in terms of gross estimates of total numbers, the extent of the land area involved, the population structure of the stock and the trends in annual yield. Although the game populations of British Columbia have never been threatened by over-hunting, except in certain small and isolated areas, nevertheless, the continent-wide conservation movement reached on and game protection was established in the Province long before the game stocks could become depleted. Consequently, the game populations of this area, particularly deer population, have followed a natural and virtually unaffected pattern of population fluctuation and irruption within the environmental restrictions set by habitat, climate and land use practices. Man has increased and improved great areas of deer habitat, especially on Vancouver Island, conducive to irruptions of deer but he has not been an important factor in the control of their numbers. Deer populations are still being limited primarily by natural controls. Table 8 gives an estimate of the total provincial deer population:

Table 8: Estimated Numbers of Deer in the Province of British Columbia, 1961.

Deer	Numbers
Mule deer	400,000
Sitka black-tailed deer	250,000
Columbian black-tailed deer	350,000
White tailed deer	75,000
TOTAL	1,075,000

Source: The 15th B.C. Natural Resources Conference, 1964, p. 564

Size: There is a definite limit to the number of animals that any specified area can support, and it is pointless to try to promote populations above these limits. On the other hand, there is also a limit to the number of animals in excess of needed breeding stock that a population can produce. Carrying capacities, and consequently the productivity of big game populations, are limited, depending on the type of range and the species in question. In the past, as it has already been stated, the widely accepted view was that animal populations and their productivity were limited by a combination of many factors such as food, shelter, predation, hunting and disease. But this theory has been discarded in favor of the view that, at a given time, a population will be limited by a single limiting factor. On Vancouver Island food availability during the critical winter months has been documented as being the single most important limiting factor for deer populations (Smith, 1968; Gates, 1968). This conforms with results of investigations on other deer ranges (Klein, 1965). Food is in turn limited by such factors as logging, fire and snow. Logging and fire generally produce more food but snow limits its availability. Presence or absence of shelter further complicates the issue, and may in itself act as a significant determinant of presence of absence of deer populations on certain parts of the range (Cowan, 1945). Thus on Vancouver Island, the size of the deer population depends to a large extent on the logging practices. While these induce food availability, quality and quantity, if loggers destroy too much winter range consisting of the mature low elevation forest with the proper exposure, then shelter, rather than food becomes the critical limiting factor.

Thus under certain circumstances, the ability of various parts of the range to support deer on the Island, may be influenced by factors other than food. Implicitly then, no generalizations can be made regarding the factors that limit deer numbers, even for a fairly small management unit like Vancouver Island. Carrying capacity here is so tied up with main's activities of land use that there reaches a point at which it depends only partly upon original ecological processes within the habitat.

Density: The fauna of any given area is a product of the environment, both in terms of the variety of the species, and the density of each species. A complex of environmental factors determines the density of each animal population and within a given species, the density or abundance may vary widely from area to area. Although the coastal black-tailed deer on the Island range through a variety of plant associations, nowhere along thecoast are the deer as abundant as on the slashes of the eastern half of the Island. Thus it is important to note that although deer populations on the Island are managed in terms of their overall numbers and trends, their abundance greatly varies locally. On some of the best sites, densities ranging from 50 to 150 deer per square mile have been recorded, while inventories have revealed a deer population on the southern 130 square miles of the Sayward Forest approaching 5,800 individuals (9th B.C. Natural Resources Conference, 1956, p. 172). Smith (1968, p. 29), arrived at an estimate of between 31 and 58 deer per square mile for the Northwest Bay Study area. Generally, average deer densities on the island are in the order of 20 to 30 deer per square mile.

Black-tailed deer on the Vancouver Island Management Unit are largely by-products of temporary conditions of the environment resulting from forest land use practices. Their density and distribution is therefore not static but dynamic and this complicates the task of management. While certain areas are returning to non-productive states, (mature timber stands with closed canopies), others are constantly becoming highly productive deer habitat, created through sustained yield exploitation of forest products. Consequently, inventories must be carried out constantly to evaluate the resource. Such a continuous change within the habitat means that inevitably carrying capacity will be constantly changing. Because of this, it is difficult and unrealistic to attempt to correlate deer densities to the state of the habitat except for short periods of time. Even then, such a correlation can only be meaningful within localized sections of the range.

Population Structure. Since deer populations in densely forested habitats such as Vancouver Island, cannot be accurately counted, the regulation of the harvest, and general management principles can only be based on a knowledge of the age and sex structure of the annual deer harvest. This information is obtained at checking stations by recording the sex composition of the kill. Age of the deer is determined by an examination of tooth replacement on the jaw, after the permanent dentition is formed.

Sex Ratio. It has generally been established that despite greatly varying environmental conditions, neither composition, nor the total size of the island - wide deer population vary much from year to year. It can therefore be assumed that the sources consulted and the data derived from them are, within inevitable local restrictions, fairly representative of the deer population in general, over most of the Island. The pre-hunting classified counts have revealed that the deer herd is fairly constant in its composition. The sex ratio at birth for deer is believed to be 50:50. The pre-hunting doe to fawn ratios apparently always oscillate between .56 and .76 fawns per doe, (see Table 7), while the sex ratios oscillate between .31 and .48 bucks to does. Prior to the hunting seasons, therefore, the general composition of a Vancouver Island deer herd consists of about 50 percent does, 30 percent fawns and 20 percent bucks (The Wildlife Review, March, 1969).

On the other hand, data collected from checking stations, the hunter sample analysis and information from logging companies (that is, the post-hunting season inventories) indicates that on Vancouver Island, the composition of the deer harvest is in the order of 60 percent bucks, 25 percent does and 15 percent fawns, with a sex ratio of about 67 percent male deer and 33 percent female deer. Table 9 below shows the age classes of male and female deer of the Island harvest. Although the harvest has greatly increased in recent years, (see Table 20), the age structure has remained relatively unchanged, thereby indicating that the present system of harvesting has not affected the population structure of the herd to any notable degree. Regulation of the population structure is still influenced to a large extent by natural environmental controls.

Table 9: Age Composition of the Vancouver Island Deer Harvest

Age in Years:		1½	2½	3½	4½	5+
Percent of Total Deer:	Bucks	39	25	16	9	18
	Does	30	23	17	12	12

Source: Adapted from graph by Blood and Smith, The Wildlife Review Magazine, March 1969, p. 7.

Age Structure. Over a thirteen year period (1954 to 1966), Smith (1968) has noted that the black-tailed deer herd in the Northwest Bay area underwent significant but subtle changes in the age-class structure. He divided both male and female into the 1.5 year olds, and into those over 1.5 years old and found, that males and females have significantly different age structure; that the age-class structure (as expressed by proportion of 1.5 year olds to older deer) underwent notable changes during the study period; and that the differences between male and female age-class structure did not alter appreciably over the period of study (Table 10).

Smith (1968) has also noted that there were significant changes in the proportion of 1.5-year-olds to older animals throughout the study period. He concluded however, that there was no significant pattern of trend towards the evolution of a younger or older age-class structure.

Regarding the sex ratio, Smith (1968) found that during the study period, the proportion of males in the population fluctu[illegible] to a notable extent as evidenced by hunter kill data.

While the island-wide population of black-tailed deer supposedly does not undergo any notable changes from year to year, nevertheless such a consistency does not appear to have been fully documented in the literature consulted. This is probably a result of the widely varying methods of inventorying employed, and at different times of the year; for example, pre-

Table 10: Analysis of Age-Class Structure of Northwest Bay Black-Tailed Deer Herd Treated as Binomial Population

Total for 1.5-year-old animals

	1954	1955	1956	1957	1958	1959	1960
Females	12	24	7	14	30	18	26
Males	20	17	15	23	47	39	41
Total	32	41	22	37	77	57	67

	1961	1962	1963	1964	1965	1966	Total
Females	24	31	31	42	26	24	309
Males	27	64	53	36	32	35	449
Total	51	95	84	78	58	59	758

Total for all ages including 1.5-year-olds, but excluding fawsn

	1954	1955	1956	1957	1958	1959	1960
Females	47	81	25	42	83	54	78
Males	38	61	41	51.	88	76	110
Total	85	142	66	93	171	130	188

	1961	1962	1963	1964	1965	1966	Total
Females	83	156	110	104	80	62	1005
Males	84	139	110	93	80	82	1063
Total	177	295	220	197	160	144	2068

Source: Smith 1968, p. 31

Table 11: Comparison of Age-Class Distributions for Combined Years 1954-1959 and 1960-1966.

Age	1954-1959	1960-1966
Males		
1.5	45.3	39.8
2.5	20.6	22.1
3.5	15.2	17.3
4.5	17.6	10.9
4.5 +	11.3	9.9
	100.0%	100.0%
Females		
1.5	31.6	30.3
2.5	20.5	22.1
3.5	16.0	16.5
4.5	11.7	10.7
4.5 +	20.2	20.4
	100.0%	100.0%
Number of animals in sample		
Males	355	724
Females	332	673

Source: Smith 1968, p. 33

season classified counts conducted in the field, and the post-season population analysis from the hunter kill. In an area where management is extensive rather than intensive, and where principles are based on trends rather than on absolute populations, the desirability of having a harmonious and consistent system of inventorying cannot be overemphasized.

Certain aspects of the data presented so far on the population structure of deer populations on Vancouver Island need to be examined because they are considered as having special significance to management and to deer productivity in this area.

It has been stated that the pre-hunting sex ratio is in the order of 50 percent does to 20 percent bucks. However, the post-hunting season sex ratio as evidenced by hunter kill data is in the order of 25 percent does to 60 percent bucks. In other words, many more bucks than does are killed. In this respect, Smith (1968) noted that only the male segment of thedeer population at Northwest Bay fluctuates; (again his observations were based on hunter kill data) while the female segment does not, most probably because more males are hunted than females. At the same time, it is known that the present system of hunting does not affect the total population structure of the deer herds on Vancouver Island, but only - implicitly - a section of it, the males. Since population growth is regarded as a function of the physically reproducing units in a population (the females), the data on sex ratios suggest that deer populations on Vancouver Island are potentially capable of exhibiting irruptive behaviour, were it not for the role played by natural factors of control especially through food, and also predation.

Productivity. According to Leopold (1933, p. 22), "Productivity may be defined as the rate at which mature breeding stock, produces other mature stock or mature removable stock." The ratio of yearling deer to deer older than yearlings gives an index to productivity. On Vancouver Island, the productivity can be said to be assessed by the "carry-over" counts conducted in April. These determine winter survival, and therefore productivity, by comparing the relative numbers of yearling and adult animals present in the spring. Young deer are more vulnerable to the rigors of winter than adults and the carry-over ratio therefore changes according to the severity of the preceding winter. Table 12 gives the productivity of deer on Vancouver Island for the years 1955 to 1969 inclusive. Although two extreme ratios are recorded (.95 for 1955 and .37 for 1969), on the whole the variation is not great, and this is indicative of the relative stability of deer productivity on the Island. As already stated, the two extreme ratios probably reflect extremely mild and extremely severe winters respectively.

Another index of deer productivity is fawn production. Classified counts, carried out in August prior to the hunting season, determine this. The females usually bear their first

Table 12: Ratio of Juvenile Male Deer ($1\frac{1}{2}$) to Adult Male Deer from Vancouver Island Age Class Structures

Year	No. of Juvenile	No. of Adults	Total	Ratio
1955	80	84	164	.95
1956	50	93	143	.54
1957	52	63	115	.83
1958	190	232	422	.82
1959	164	211	375	.78
1960	240	480	720	.50
1961	186	375	561	.50
1962	333	503	836	.66
1963	512	683	1195	.75
1964	247	426	673	.58
1965	206	390	596	.53
1966	528	911	1439	.58
1967	559	765	1324	.73
1968	690	1087	1777	.63
1969	240	645	885	.37

Source: B.C. Deer Census Summary Records 1970 fawn on their second birthday or thereabouts,, but if feeding has been poor they may be a year older, although well-fed captive animals have been known to mature at eight months. The degree of over-production of young will determine the ability of the population to withstand the effects of hunting. As can be seen from Table 13, the doe-fawn ratios on Vancouver Island fluctuate between .56 and .76 fawns per does. According to Smith, 1968, p. 28, the fawn component of the population in Northwest Bay was approximately 35 percent immediately after birth, but this was revealed to have fallen to 18.87 percent by the August classified counts, supposedly because of a high summer mortality among fawns.

Table 13: The Vancouver Island Fawn Crop Production for the Years 1961 to 1969.

Years	Total Does	Total Fawns	Fawns per Doe
1961	531	341	0.64
1962	1,035	746	0.72
1963	720	546	0.76
1964	899	641	0.71
1965	753	442	0.59
1966	1,342	875=	0.65
1967	502	374	0.75
1968	1,114	654	0.58
1969	681	384	0.56

Source: B.C. Deer Census Summary Records, 1970.

Animal populations tend to increase their productivity when subjected to increased hunting pressure. On Vancouver Island, it is known that the deer resource is relatively unexploited in relation to potential yield, and that an increase in the number of hunters would result in a greater harvest rate of the deer population. Nowhere on the island have the hunters been able to harvest the annual increase in the stock. It is estimated that the actual overall harvest rates of accessible stocks of deer is approximately 5 to 10 percent, while the average annual increase exceeds 30 percent (15th B.C. Natural Resources Conference, 1964, p. 566). At this rate, a 20 to 30 percent proportion of deer should be harvested each year to balance the annual increase.

If productivity is considered in terms of what is actually removed (harvested), as Leopold (1933) probably meant by "mature removable stock", then the actual productivity for Vancouver Island deer populations is unknown because they are basically underhunted. The degree of overproduction of young is known; that is, the fawn to doe ratio, and so is the ratio of yearling deer to mature deer. But these data are not really meaningful because the herds have not been subjected to increased hunting pressure except locally. In other words, their productivity has not been "put to the test", and so far it can only be inferred.

On the other hand, it is realized that it is practically impossible to accurately determine the productivity of the island-wide deer population because of the extent of the area involved, and because of the distribution of these animals. Nevertheless it should be possible to investigate productivity on an experimental basis, as has been done in Michigan for white-tailed deer (Odocoileus virginianus) under comparatively natural conditions (Arnold and Verme 1963). A white-tailed deer herd, whose size and population structure was known, was enclosed in a natural habitat for a period of ten years, during which time it was subjected to exploitation by controlled hunting and live trapping. The investigation yielded useful information with regard to the productivity of the animals and also with regard to the effect of deer hunting on a known-size deer herd. It is believed that a similar investigation for a Vancouver Island black-tailed deer herd would provide a greater knowledge of the productivity of the deer population, as well as furnishing some insight as to the ideal or maximum possible rate of exploitation.

Mortality

Mortality is one of the factors that greatly determines productivity among deer populations. Basically there are three types of mortality: 1) Winter mortality due to starvation, malnutriton and general stress in the winter months; this is the most important cause of death among Vancouver Island deer herds; 2) mortality resulting from predation and; 3) mortality of the island-wide deer population because of the extent of the area involved, and because of the distribution of these animals. Nevertheless it should be possible to investigate productivity on an experimental basis, as has been done in Michigan for white-tailed deer (Odocoileus virginianus) under comparatively natural conditions (Arnold and Verme 1963). A white-tailed deer herd, whose size and population structure was known, was enclosed in a natural habitat for a period of ten years, during which time it was subjected to exploitation by controlled hunting and live trapping. The investigation yielded useful information with regard to the productivity of the animals and also with regard to the effect of deer hunting on a known-size deer herd. It is believed that a similar investigation for a Vancouver Island black-tailed deer herd would provide a greater knowledge of the productivity of the deer population, as well as furnishing some insight as to the ideal or maximum possible rate of exploitation.

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from hunting. Diseases and parasitic infections may also contribute considerably to natural mortality. Columbian black-tailed deer are known to exhibit significant differential mortality in favour of the does (Taber and Dasman, 1958). This is particularly the case under poor range conditions; on a good range the buck: doe ratio is about equal. Differential mortality also affects deer age-classes, for instance young deer are usually believed to suffer the greatest mortality because they represent what is essentially a "surplus" in a population which is close to the food capacity prescribed by the environment (Robinette et al., 1957; Erickson et al. 1961).

On Vancouver Island, the most common cause of deer mortality are the periodic winter die-offs through starvation. Members of the deer family generally have a tendency to expand until a severe winter occurs during which a large percentage of the population starves. On the Island, winter mortality is believed to account for about 20 to 40 percent of the general mortality rate of the deer, and annually removes about one third of the population. Major die-offs have occurred in British Columbia in the winters of 1948-1949, 1955-1956, 1964-1965 and 1968-1969. The winters of 1955-1956 and 1964-1965 are believed to have adversely affected Vancouver Island deer populations. Smith (1968) has analyzed these effects in great detail for the deer population at Northwest Bay. According to him, the 1955-1956 winter was much more severe in its effects on deer as indicated by a decline in hunter success within that period (Smith, 1968, p. 64). Such a decline, he concludes, is indicative of the previous general decline of the population during the winter. This particular winter also affected the age-class structure, sex ratios and the general condition of the deer, much more so than the 1964-1965 winter. The female fawns and the 1.5-year-olds suffered the highest mortality in comparison to the other age-classes of animals.

Table 14: Effect of the 1955-1956 Winter Upon Survival of Fawns at Northwest Bay.

	Percent 1.5	Percent Over 2.5	Number
		Males	
1955	40.5	59.5	42
1956	50.0	50.0	30
		Females	
1955	40.0	60.0	60
1956	31.8	68.2	22

Table 14b: Effect of the 1955-1956 Winter Upon Survival of 1.5-Year-Old Deer ar Northwest Bay.

	Percent 2.5	Percent 2.5	Number
		Males	
1955	43.2	56.8	44
1956	45.4	53.6	28
		Females	
1955	36.8	63.2	57
1956	16.7	83.3	18

Source: Smith 1968, p. 66.

According to Smith, 1968, p. 67, the 1964-1965 winter did not cause as great a decline in the total population of deer ar Northwest Bay as the 1955-1956 winter. His data indicated that "the female fawns may have been adversely affected, but that the 1.5-year-olds tended to survive better over the 1964-1965 winter than the previous 1963-1964 winter" but he noted no clear trends as in the 1955-1956 winter.

Table 15: Effect of the 1964-1965 Winter Upon Survival of Female Fawns and 1.5-year-olds at Northwest Bay.

		Survival of Fawns	
Year	% 1.5	% Over 1.5	Number
1964	40.4	59.6	104
1965	32.5	67.5	80
		Survival of 1.5 Year Olds	
	% 2.5	% Over 2.5	Number
1964	33.9	66.1	62
1965	42.6	57.4	54

Source: Smith, 1968, p. 67

The severity or otherwise of winter mortality upon deer populations and the extent to which it influences the population structure is determined by food availability, its quantity and quality. Thus, winter food is the most important limiting factor for deer populations on Vancouver Island.

Hunting mortality for deer on the Vancouver Island is evaluated from the hunter sample questionnaire analysis, information derived from checking station data, and for certain study areas and projects, the capture-tag-recapture method. On the Island, hunting mortality is mainly compensatory rather than extrapensatory. Smith (1968), using hunter kill data, has stated that the effect of hunting mortality on the deer herd at Northwest Bay varied considerably from year to year, depending on the rate of reduction of numbers of animals entering the winter. Long term effects of hunting on deer were probably determined by the rate of removal of varying numbers of does. He also used deer tagging as a different method of determining the various causes of mortality of deer in his study area. Table 16 below outlines the causes of mortality of deer that were recovered. Smith (1968) does,however, point out that this is not representative of the causes of mortality for the whole study population because subsequently dead tagged deer are more likely to be recovered by hunting than not. The figures are more meaningful for an evaluation of hunting mortality.

Table 16: Causes of death of all Tagged Deer from Which Tags were Recovered (84 Animals Recovered from a Total of 229 that were Tagged).

	Females	Males	Combined
Hunting	73.8	86.9	80.9
Probable Hunter Wounding	10.5	8.7	9.5
Killed for Scientific Purposes	10.5	0.0	4.7
Fawn Mortality from Tagging	2.6	0.0	1.2
Winter Death	2.6	4.4	3.6
	100.0%	100.0%	100.0%

Source: Smith 1968, p. 62

Out of a total of 229 tagged deer, 68 were recovered as hunter kill. He concluded that hunting mortality may have accounted for about 33.2% of the tagged dead animals over the period 1959-1963.

It appears that evaluation of hunting mortality of the total deer population does not reveal the normal population structure phenomena because, as has been noted already, hunting mortality is greatly in favor of the does. Moreover, utility of kill data based on the hunter sample questionnaire analysis is questionable because it is known that hunters have a tendency to give incorrect answers, particularly with regard to the sex of the animal. Nearly every hunter wants to bag a buck. This might contribute somewhat to the greater number of males reported killed. Consequently, it is perhaps advisable not to infer the results and trends of hunting mortality to the overall deer population, but rather to restrict its significance to the most frequently hunted segments of the herd, in this case the bucks and yearling bucks. This way it should be possible to avoid distortions in the mortality trends of the deer population.

The importance of predation as a cause of mortality on Vancouver Island black-tailed deer has not been documented in any great detail in the literature consulted. However, it is known that the cougar (Felis concolor) is nature's deer-culler on the Island. This management unit has the largest per acre population of cougars in North America, but there are no coyotes or wolves. The bounty system is no longer in effect in British Columbia. Bounties on coyotes were suspended in 1954, on wolves in 1955 and on cougars in 1958. There is extensive evidence to suggest that predator control is not justified in most game management in British Columbia. According to Leopold (1943) cougars and wolves are the most effective deer predators. Cougars are the chief predators of big game in the west. It is not easy to evaluate the extent to which predation controls big game populations; however, on Vancouver Island, despite the dearth of documented data on the significance of predation as a mortality factor, in view of the resident large cougar population, it can only be surmised that predation is probably one of the other chief factor, perhaps second only to winter mortality, controlling the deer herds in some of the isolated and inaccessible forested parts of the range. In North America in general, predators have been extirpated in closely settled areas. Fortunately this does not appear to have been the case on Vancouver Island. Had cougars been removed from here, it is likely that the deer population would have experienced much severe winter die-offs. Leopold (1943, p. 8) in describing "Wisconsin's Deer Problem" states:

> "We have found no record of deer irruption in North America antedating the removal of predators. Those parts of the continent which still retain the native predators have reported no irruption. This circumstantial evidence supports the surmise that removal of predators predisposes a deer herd to irruptive behavior".

Migrations. Vancouver Island black-tailed deer do not tend to make the extensive migrations characteristic of other species elsewhere in British Columbia. Generally, deer tend to establish relatively small home ranges once they are mature. Smith (1958) noted that no clearpattern emerged from his tagging program at Northwest Bay, and that a greater proportion of deer maintain hom ranges close to the original tagging site.

CHAPTER FIVE: SOME DEER CENSUS TECHNIQUES

No wildlife study techniques are of more interest and importance than those dealing with determination of animal numbers or population trends. Usually wild animals in their habitat are not easily counted. Several census techniques have been designed to overcome this difficulty with regard to deer. These fall into three broad categories:

(a) censuses by enumeration;

(b) censuses by use of ratios;

(c) censuses by indices.

(a) Censuses by Enumeration

(i) Ground Drives

Ground drives of deer have been cited as providing the most accurate counts of deer. Basically, the drive census method is a sampling technique or partial estimate system. The population on any given unit of range is computed by proportions from 100% counts on selected sample plots of known area, usually about one square mile. Populations of deer in the sample areas are determined by carefully executed deer drives. The count is made by a straight line of drivers moving across the selected area, and either forcing the deer back through the line or out between counters stationed on the boundaries.

A ground drive census is best executed in the fall, when there is little ground cover, visibility being greater then than in the summer, and therefore making the recognition of the sexes easier. Also, it is the time when local deer migrations to the winter yards occur.

The chief merit of using this method in the early fall is the provision of data on the deer population at a time when hunting regulations have to be formulated. Its high degree of accuracy enhances its value for such pre-season counts. Unfortunately, its application is greatly limited by its enormous man-power requirements: between 100 and 150 men are needed to ensure a high degree of accuracy, while only two drives can be accomplished in a day. Moreover, in mountanous and rough terrain, because of the physical difficulties involved, the combined area of all samples rarely exceeds 1% of the total. Other census methods similar to the ground drive have been devised and described, such as the cruising method (Erickson 1940) and the strip census method; but they have been used in a few areas only.

(ii) Aerial Survey Census

Wild animals often are highly mobile and their movements may result in duplication of counts and erroneous inventories. Where range conditions are suitable therefore, aerial survey counts are valuable. However, their application is very limited because they require flat terrain and a deciduous forest cover. Unlike the caribou which inhabit the open arctic tundra and can therefore be counted by aerial surveys deer inhabit thick forect understory brush, thereby eliminating aerial counts as the most accurate and quick method of censusing.

Aerial censuses have been reported to be successful in censusing white-tailed deer in certain states, where the winter range is primarily deciduous forect. Experience from western United States however, seems to indicate that deer counts by a plane are difficult , if not impossible because of the rough terrain. Also, the Western deer's main winter range is the evergreen pinon-juniper belt and such a coniferous forest effectively conceals the deer (Tripensee 1948).

(b) Censuses by Use of Ratios

(i) The Lincoln Index

Banding or tagging returns as a census method was first used in estimating waterfowl populations from banding returns by F.C. Lincoln (1930). The technique consists of introducing a known number of marked animals of the kind being inventoried into the habitat with the population. The introduced animals are marked so as to distinguish them from the rest of the population. Samples are then drawn from the population and total numbers are estimated on the basis of the ratio of marked to unmarked animals in the sample:

$$T = m\frac{n}{X}$$

$$= \frac{m}{(\frac{X}{n})}.$$

Where: X = the number of marked animals in the sample of n animals;

m = the number of animals that were originally marked;

n = total number of animals in the sample;

T = total population.

For this equation to be valid, the marked animals must suffer the same rate of natural mortality as the unmarked ones; they must retain their tags; they must be as subject to sampling as the unmarked ones; they must become randomly mixed with the unmarked ones, or the distribution of effort must be proportional to the number of animals in the different parts of the habitat being studied. But even if these conditions are met, the ratio of marked to unmarked animals in the sample will not always be the same as that in the population, and this introduces a real possibility of error. The larger the sample, however, that is the nearer it gets to the total population, the greater the accuracy of the ratio derived. The size of the sample is therefore important and this, plus the physical problems of the capture- tag-recapture procedure, would appear to be the chief drawbacks to the utility of this technique in animal censuses.

(ii) The Hunter Kill (The Hunter Sample)

The kill ratio or "kill factor" is the ratio between the game population and the kill that may be removed annually through legal hunting without decimating the herd. The size of the harvest and its structure is obtained from the hunter sample. If such a ratio is known, it can be used to determine total populations of deer herds.

(iii) Classified Counts

These are pre-hunting season counts; their main purpose is not to give absolute deer numbers in an area, but to provide basic life-history data, eg. population structure and population trends, and also to serve as a basis for comparing the daily and seasonal numbers of deer for various years. The counts are conducted within the same area every year and are based on a sample size of a hundred classified adults (i.e. whether buck, doe or yearling). Ultimately, such counts should indicate the stability of deer numbers in a herd; percent of yearlings added each year to the herd, ratio of bucks to does, fawning periods, plus other life history data.

(c) Censuses by Indices

(i) Pellet Group Counts

Deer census determination by monthly counts of pellet groups was first described by Bennett, English and McCain (1940). It is the most widely used and the most widely acclaimed of the census-by-indices methods, both for determining deer numbers and also as an indicator of range use by deer.

Pellet group counting is the process of estimating by fecal pellet group counts the actual or relative number of big game or their days of use in a given area. It is justified on the premise that the periodic accumulation of (deer) droppings bears a direct and proportional relationship to population density. Once this basic assumption is accepted, it is supposedly possible, by a careful analysis of localities of known deer concentrations, to determine the quantitative nature of this relationship. The standards thus established can then be applied to similar habitats elsewhere as an approximate measure of comparative populations.

The chief merits of this method are said to be:

1. that pellet groups are an inert kind of evidence which can be subjected to standard field plot sampling technique;

2. that the method could reveal deer movement and their utilization of different forest types and subtypes, because deer deposit a great proportion of their pellets near where they feed. This way too, the pellets could serve as a useful key to forage or habitat preferences;

3. that it is possible to correlate pellet group distribution with seasonal variation in forest type-use.

Pellet group counting has also distinct disadvantages:

1. it is very prone to observer bias due to missed groups, and to differences in interpretation of what constitutes a pellet group.

2. it is subject to the universal problem of designing, establishing, and operating sampling systems, particularly sampling intensity; size, shape and spacing of plots; and time of year.

3. on ranges where more than one pellet-forming ruminant is present, pellet group counts are not reliable indicators of a species.

4. loss or disintegration of pellets due to weather conditions would invalidate the reliability of the technique.

Everything considered, pellet group counting appears to have little value for quantitative analyses of deer populations. Its value probably can only be appreciated in qualitative terms. For instance, it can be used in an evaluation of deer habitat preferences, or in computing deer-days of use on a range.

(ii) Track-and-Bed Counts

This method consists of counting the number of individual deer tracks and beds in an area. It depends on snowfall and can therefore be carried out in winter only. It is probably the original method used by man to determine animal presence and relative abundance. It is still the chief method used by men in the field to determine the presence of most mammals. But as a method of determining definite numbers of animals in an area, it is difficult and inaccurate and has only been applied in few cases (Trippensee 1948).

The Role of a Census in Deer Management

The knowledge of the relative number of animals in an area is essential for sound wildlife management. Census surveys indicate how much game there is, where it is located and its abundance relative to previous years. Such information is used to determine the safe level of a deer population that can be carried on a range, how many deer should be harvested through hunting and how many should be preserved to produce next years's fawn crop. Supplemental life history data are also required, such as population sex- and age-structure, mortality, and natality in order to prepare long-range plans.

But the acquisition of such data is only the ideal; complete counts of mammals in their habitat are so difficult that only rarely are they actually accomplished. Consequently, particularly for deer, one has to rely upon indirect methods to obtain information on population structure, numbers or trends. On this basis alone, it is questionable if the word "census" (enumeration), is appropriate at all with regard to deer.

Evidence from literature seems to indicate a definite shift of emphasis from the belief that "complete" censuses of deer are essential to the recognition that probably determination of <u>trends</u> is equally much more feasible and of nearly equal value to management programs. Under intensive management a complete deer census may be desirable but in extensive management involving thousands of animals and covering enormous areas, population trends are far more important than a knowledge of absolute numbers.

In British Columbia, owing to the forested nature of the ranges, it is impossible to count or over-all census most big game populations. Lack of technical personnel moreover, has hindered the acquisition of accurate animal checks to show numerical trends. Consequently, only apparent trends of game populations are known and a knowledge of these is based on the reports of game wardens, guides and hunters. As a result, status of the numerous big game species and their population trend is often based on guesswork.

Despite the enormous problems encountered, the census of a game species is essential. Success depends upon the availability of manpower, the size of the census area to be covered, the particular species involved, their habits and the nature of their environment. Relative to the area they occupy, black-tailed deer on Vancouver Island are distributed widely. The forest environment they inhabit coupled with their mobility render an absolute census or inventory virtually impossible. Consequently, deer management is based on the use of population indices and trend counts by the Game Department. There is general agreement in the literature presently that total population figures are not a must for a management program. Trends are considered to be adequate, even for a sustained yield program. Although the results of such inventories are not as impressive as absolute counts, they have nevertheless a practical application value as management tools. The deer management on the Island then depends almost entirely on trend data rather than an absolute inventory.

Deer Census Methods on Vancouver Island

The data available indicate that nowhere on the Island are Ground Drives used as a method of censusing deer. Besides the great amount of labor, and time expended in this method, the forested nature of most of Vancouver Island would not be conducive to its application, as forest impedes movement. Similarly aerial survey censuses are not employed as tools of deer inventorying. The rugged nature of the terrain coupled with the dense cover of coniferous forests would effectively conceal the animals.

Smith (1968) used the Lincoln Index to estimate the size of the deer population at Northwest Bay, by utilizing a fawn-tapping program. His data indicated an approximate total of 623 fawns within a tagging area of about 20 miles. This method is probably best suited to studies that cover fairly localized areas because of the obvious difficulties inherent in the capture-tag-recapture procedure.

The "kill ratio" obtained from the hunter sample is probably the most important and the most frequently used method of evaluating the size of the deer herds and trends in their population structure. This method is discussed in greater detail under the section on "Deer Harvest Management". In as far as deer management on Vancouver Island is extensive rather than intensive, and in as far as this management is based on trend data, then the kill factor method of analyzing deer populations can be said to be the most useful, and the most practical. Nevertheless, it is beset with problems that range from an inadequate hunting activity which means that the animal concentrations are not subjected to uniform hunting pressure, to inaccurate or biased reporting on the part of the hunters. The implications of these basic shortcomings of this method are discussed in Chapter Five.

Deer census by indices are rarely used on Vancouver Island, except apparently in particular studies and projects. Both Gates (1968) and Smith (1968) used it in their studies of deer at Northwest Bay, but nowhere on the Island has a deer census based on the track- and-bed count method been reported. Gates (1968) used the accumulation of pellet group densities to evaluate the ecological potential of various levels of plant regeneration to support deer, and also to determine deer preferences of these seral stages. He based his computations on the formula:

$$X = \frac{a \times 640}{b \times c} \text{ acres}$$

where: X = number of deer per square mile

a = number of pellet groups per acre

b = the time lapse in days

c = the daily defecation rate of deer

It is felt, however, that the reliability of the pellet group counting technique is still questionnable. Its use is perhaps best restricted to isolated studies and projects that cover areas of limited extent, rather than to extensive deer habitats.

Carry-Over Counts

Prior to setting hunting seasons in early May on Vancouver Island, a series of carry-over counts are conducted. These are extensive field surveys carried out in April when deer begin to concentrate on the lush spring growth on the open south-facing slopes. As many as 100 deer have been cited as having been counted during a single pre-dusk count, while up to 2,000 have been classified either as yearling or adult in scattered sample areas in a single season. Thus in certain localized areas deer density is extremely high, but such densities are by no means widespread. The objective of carry-over counts is to determine deer productivity, or more specifically winter survival, by comparing the relative numbers of yearling and adult animals present in the spring. Young deer experience greater winter mortality, and as a result, the carry-over ratio changes according to the severity or mildness of the previous winter. Information obtained from carry-over counts is extremely important in formulating hunting regulations for the autumn hunting season*. The following two Tables give the carry-over ratios for certain years and for various parts of Vancouver Island.

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* Keith Mundy 1970 Personal Communication

Table 17: The Carry-Over Ratios for Vancouver Island 1967-1970.

Year	Adult	Yearling	U/C	Total	Percentage
1967	1,421	551	301	2,273	27.94
1968	1,352	549	321	2,222	28.9
1969	1,183	243	188	1,614	17.0
1970	1,240	351	164	1,755	19.1

Source: B.C. Deer Census Summary Records, 1970.

U/C = Unclassified

Table 18: Carry-Over Ratios for Various Parts of Vancouver Island: 1961-1970.

Area	Year									
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Northwest Bay	25.2%	32.7%	42.8%	26.8%	28.7%	27.5%	29.0%	29.4%	16.7%	27.1%
South Fork	----	42.8	22.9	18.9	25.0	29.0	24.9	21.9	20.5	31.6
Caycuse	----	----	----	27.1	27.2	16.0	22.0	22.6	----	----
Copper Canyon	----	39.8	25.0	29.8	12.7	27.3	42.3	31.0	13.5	17.6
Gordon River	----	----	21.4	25.2	25.8	20.6	23.3	22.1	12.4	20.3
Courtenay	----	36.4	54.8	39.8	44.2	49.0	39.1	44.8	36.4	----
Campbell River	36.1	21.2	39.2	12.1	13.3	21.7	25.9	28.8	18.7	----
Nimpkish Valley	----	----	----	----	----	31.6	23.5	22.9	11.6	----
South. V. Island	27.2	31.7	35.5	31.0	23.0	20.5	29.5	24.6	20.6	----
Alberni Valley	50.0	----	66.6?	----	31.1	26.7	29.2	31.4	15.2	----
Cowichan Lake						13.7				

Source: B.C. Deer Census Summary Records, 1970

Classified Counts

Prior to the hunting season, classified counts are conducted in the late summer (in August) within the logged-over areas of Vancouver Island. Deer areas are reached by car along the road network built by the private logging companies. The animals are counted and classified with the aid of binoculars into fawns, does, spike yearling bucks or mature full antlered bucks. If delineation of sex is impossible in certain cases, such animals are entered under the "Unclassified" category. Classified countes are conducted within the same area every year and at about the same time of day, dusk. The best days for the counts are said to occur after a rainy spell because deer have a tendency to emerge from dense bushes and feed in the open if the weather is damp or wet*. These surveys determine the pre-hunting size of the fawn crop, and also the ratio of males to females. They are based on a sample size of a hundred classified adults. The number of yearlings, or last year's fawns is counted and this gives an indication of the year's production which is then compared to other years**. The surveys have revealed that deer herds on the Island have a relatively stable composition and inspite of greatly varying winters, carry-over percentages have been noted to vary between 25 to 37 percent only, that is, the yearling deer segment of the population.

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* Jack Lenfesty 1970. Personal Communication

** Keith Mundy 1970, Personal Communication

Classified counts are useful to management because of their comparative value, since they are conducted over the same area every year. It is possible, apparently, to predict hunter success on the basis of these counts. Their chief disadvantage, however, probably lies in the great possibility of observer bias or inefficiency, due to inaccurate counting or in denoting the wrong sexes. Weather conditions also influence the classified count method in as far as they largely influence the presence of deer in the open; weather conditions may also affect visibility. In any event, the ultimate objective in this case is to obtain ratios randomly (fawn: doe: buck) and trends, and to assess annual fawn production; and for these purposes, classified counts can be said to suffice.

Attempts to account for the presence and abundance of a game species in an area by censuses are beset by many inherent problems. But since there is no formula that can be worked to provide a universal panacea for all wildlife management problems, repeated surveys and inventories will remain as essential tools to management, in order to provide an accurate and up-to-date information regarding the state of the deer herds, and the condition of their ranges. But research and surveys in themselves are not enough. Their main purpose should be to provide reliable knowledge upon which superior management and harvesting procedures can be based.

Most of the game species in British Columbia are distributed widely over many thousands of square miles. The forest environment they inhabit, coupled with their mobility render an absolute census or inventory virtually impossible. The impossibility of obtaining the absolute census has caused the B.C. Game Department to use population indices and trend counts. It is generally conceded today that total population figures are not essential for a management program, and that trend information is sufficient. Although the results may notbe as impressive as total working figures, nevertheless they suffice as working tools and are usually adequate for the purpose of management. In addition in British Columbia, the great variety of wildlife present, the land area involved, the size of the animal populations, and the relatively low degree of exploitation all complicate the task of population counts. Consequently, the game department relies almost wholly on trend data. Population sampling to reveal the trend in numbers is currently a major activity in the management of the most economically important game species.

On Vancouver Island, deer management revolves around what is being used (the harvest) rather than the total assets (total population). With a renewable resource such as a deer population, ignorance of total abundance can be excused. The rate of harvest can usually indicate where deer are probably excessively reduced. On the other hand, it is clear that none of the deer census methods so far described, can be said to be the most reliable or sufficient for the purposes of scientific management within existing conditions on Vancouver Island. However, certain characteristics of both the animals and the habitat they occupy on this management unit seem to meet some of the requirements of some of the census technqiues. Unlike the interior of British Columbia where more than one species of big game is found, on Vancouver Island, the black-tailed deer is the only big game animal and thus the problem of having to distinguish between different species does not exist.

Aerial survey censuses of wild game have been acclaimed in recent years as the most accurate and up to date. Aerial counts have been used for inventorying the plains game of the East African open savannahs with great success. The chief drawback of the use of this technique in these game habitats stems from the fact that most of the African ungulates are highly mobile, and undertake extensive migrations that cover thousands of square miles. This results in a real possibility of error through duplication of the counts. It is, however, known that black-tailed deer on Vancouver Island do not make such extensive movements, but tend to live close together on a prescribed small unit of the range. On this basis alone, and probably using the highly advanced system of remote sensing, it might be possible to conduct aerial censuses on the more open logged over areas, where a dense vegetation cover may not have formed. Such open areas would almost certainly be limited in extent, but the high degree of accuracy obtained from an aerial survey count might be said to justify such an undertaking.

Although the absolute census is unattainable for a fairly large area, nevertheless ideally, this is what most game management programs attempt to achieve. In this respect, and with Vancouver Island in mind, the ground drive method of deer censusing is believed to be one of the few methods that can provide an almost complete deer inventory. Although the deer population on the Island is dispersed, it is nevertheless comprised of herd clusters which should render the drive of the animals feasible. The vegetation might be the chief setback where it is too dense, but this should not create too much of a problem in the marginal openings of the deer habitat where the animals tend to feed. What would probably preclude the application of this method might be the economical considerations. The cost of the time and the labor that would have to be expended if the method is to be successful would be great. Again, like in the aerial survey technique, the ground drive would of necessity be limited to a fairly small section of the range.

If attention is directed towards some of the census methods already in use on Vancouver Island, certain suggestions may be made which might probably improve some of these methods.

Under the existing conditions of game and their habitat, the classified counts are probably the most useful for the purposes of management, since they are conducted just before the hunting season. In this respect, it is important to remember that deer are basically managed by controlled hunting; and since hunting seasons are formulated on the basis of the results or trends from classified counts, the need to improve on this aspect of inventorying cannot be overemphasized. For this purpose, the present road network system throughout the deer habitat may be extended, such that most of the sections of the range occupied by deer can be reached. With a corresponding increase in the number of personnel, it is believed that classified counts would yield much useful and more representative data upon which the formulation of hunting regulations can be based.

CHAPTER SIX: MANAGING THE DEER HARVEST ON VANCOUVER ISLAND

Records Available

Most of the information contained in the present thesis was obtained from records on deer management from the offices of the British Columbia Fish and Wildlife Branch - Headquarters in Victoria, Vancouver Island. In addition, some field reconnaissance was carried out for the purpose of gaining a general impression of conditions in the field. However, no information given here was derived directly from the field. The specific works consulted and cited are outlined in detail under the section on "Literature Cited". In addition, through the assistance of the B.C. Fish and Wildlife Branch personnel, published and unpublished materials on deer investigations in Oregon and California, U.S.A., were also obtained and consulted.

Detailed inventory and evaluation of the wildlife resource of British Columbia is well documented, both on a routine and detailed research basis. Some of the most intensive studies of black-tailed deer carried out anywhere in North America have also been conducted on Vancouver Island, primarily at Northwest Bay, near Parksville, and elsewhere in the interior of British Columbia. The results of these studies are available in various works and publications for, or sponsored by, the Fish and Wildlife Branch. The data used for the thesis are but a fraction of the variety and extent of the literature available on deer management in North America in general, and in the Province in particular. A great amount of data were obtained from such publications as "The Cache Creek Report" available for the years 1966 to 1969. Cache Creek is a checking station in the interior of British Columbia which has been in operation for over twenty years. It became a permanent checking station in 1966. The Game Harvest Questionnaire Analysis is another publication of the Fish and Wildlife Branch, for ungulates and birds. It was available for all the years, 1964 to 1969. The Wildlife Review magazine is published quarterly by the Branch since 1954; much useful information on general conservation measures and principles was derived from it. The published proceedings of B.C. Natural Resources Annual Conference and the Western Association of State Game and Fish Commissioners Annual Conference provided large amounts of useful data on the status of the wildlife resource in the Province, particularly regarding advances in scientific research on wildlife management. The B.C. Forest Service Library was another source of data, in particular, data relating to the deer-forect interactions in British Columbia.

Vancouver Island Management Unit

Vancouver Island is the largest island off the west coast of North America; it runs north westerly parallel to mainland British Columbia for nearly 300 miles. It is 282 miles long and 50 miles wide on the average. All species of game present are abundant; black bears and black-tailed deer nearly overran some parts of the island. Vancouver Island and its adjacent smaller islands make up Management Area 1 in the Province. There are other 27 Management Areas in British Columbia, all of them on the mainland. In more ways than one, the Island is a unique region in which to evaluate deer management. Besides being geographically distinct and having limited access of either game or its hunters, it is a highly productive black-tailed deer habitat, yielding about one third of the total provincial deer harvest (see Table 19). Most of the deer habitat is laced with a network of logging roads which provide accessibility to hunters, and to wildlife biologists conducting field surveys and inventories. In addition, controlled access to private logging company claims has provided a lengthy and detailed history of complete harvest figures for areas of typical black-tailed deer habitat. As has already been pointed out, some of the most intensive studies of black-tailed deer populations and their habitat have been carried out on Vancouver Island.

The Harvest

Studies of reproductive cycles of wild animals show that any relatively stable population of game every year will produce a shootable surplus of young. This shootable surplus theoretically represents the excess of game above the carrying capacity of the environment. If this excess is not taken by hunting, it will inevitably be lost, sooner or later, to other decimating agents. If taken by hunting, the loss to other agents is proportionately minimized. The harvestable surplus can be determined by censusing the population before the breeding season (Dasmann, 1964). In general, one may regard as surplus the annual increase above the safe carrying capacity of the range.

Deer management revolves around the idea of sustained annual crops of the game for recreational use (Leopold 1933). To obtain the greatest productivity and to maintain the deer population within the carrying capacity of the range, particularly winter carrying capacity, some degree of harvesting is usually said to be required. Hunting is the recognized means of keeping deer, elk, moose and other big game in balance with the available forage. A safe herd size is the greatest possible assurance of perpetuation of a favorable range and of a continuously productive herd.

Successful deer population control through hunting can be said to depend on:

(1) determining the size and composition of the harvest;

(2) accessibility to insure a balanced hunter distribution and hunter pressure to both heavily and lightly populated deer ranges;

(3) an accurate assessment of hunter kill data;

(4) increasing the frequency of the open season, and shooting both antlered and antlerless deer.

The Size and Composition of the Harvest on Vancouver Island

It has been stated that the ultimate measure of a wildlife program designed to produce animals is the number of animals that are taken each year (Cowan, 1955). Thus a knowledge of the proportion of a deer herd that can be removed each year without harming the population itself, that is, an estimate of permissible off-take is essential. This necessitates careful study of the stocks, such that the desired limit of the number of animals on a given range may be known. The magnitude of the yield depends on the rate of reproduction of the deer. On the average, North American black-tailed deer frequently produce twins. At this rate, at least 30 and perhaps 40 percent or more of the population (including all age classes of deer) should be taken annually to keep a stable herd in balance with an improved range (Dasmann and Taber, 1958).

The deer management of Vancouver Island is really "deer hunter management", although the overall effect of hunters on the deer population is really negligible*. On the Island, estimates of total deer population are not accurate but show only relative mangitudes. As a result, knowledge of the annual increments cannot be used to predict the numbers of animals that can be harvested each year. Instead, measurements of what is harvested each year are used to measure the success of the management program. Consequently, knowledge of the size and composition of the annual deer harvest is extremely important. Tables 19 and 20 give some idea of the relative size of the harvest on the Island as compared to deer harvest from other areas of mainland British Columbia in 1954 and 1962 and also the progressive increase of the Island's deer harvest from 1951 to 1962. It is interesting to consider the highest recorded annual harvest for the twelve years (Table 20), that for 1962. The total Island-wide deer population is estimated at 300,000 animals. Thus the 25,500 (to the nearest hundred) deer killed in 1962 represents roughly about 8.5 percent of the total population. Thus, as stated earlier, the deer resource on Vancouver Island is clearly under-exploited, in relation to the potential yield. Smith (1968) states that the recruitment potential of the Island's black-tailed deer far outstrips the ability of the hunters to decimate the animals. If it is estimated that at least 30 percent can be

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*Keith Mundy, Personal Communication 1970

Table 19: The Percentage of Deer Harvested by Resident Hunters from Various Portions of B.C.

Area	1954	1962
Vancouver Island	32.6	36.8
Mainland Coast	10.0	9.9
Interior	34.5	44.2
Kootenays	22.9	9.1

Source: 15th B.C. Natural Resources Conference, 1964, p. 566.

Table 20: The Annual Deer Harvest by Resident Hunters on Vancouver Island Estimated by the Hunter Sample.

Year	1951	1952	1953	1954	1955	1956
No. of deer	6,160	6,517	11,431	11,738	14,943	12,325
Year	1957	1958	1959	1960	1961	1962
No. of deer	14,934	17,007	17,211	19,590	20,077	25,579

Source: 15th B.C. Natural Resources Conference, 1964, p. 572.

It is apparent that Vancouver Island and the Interior supplied 81 percent of the harvested deer in 1962 as compared to 67.1 percent in 1954. This is attributed to better accessibility on Vancouver Island.

safely removed, then an 8.5 percent harvest is really negligible. However, the harvest recorded for 1962 was that taken by resident hunters, and the harvest by non-resident hunters is excluded. Moreover, the total deer population for the Island in 1962 may have been less than the currently estimated 300,000. Consequently, it might be safe to assume that if these two factors are considered, the annual harvest for 1962 may have been a little more. The deer harvest by resident hunters is estimated through the hunter sample questionnaire analysis. The number of deer taken by non-resident hunters is derived through a direct enumeration of trophy fee records.

The general age composition of the harvest is shown on Table 19. On the whole bucks make up the majority of the harvest on Vancouver Island, in the order of between 50 to 60 percent of the total harvest. Does constitute about 25 percent and fawns 15 percent. The sex ratio is of the order of about 67 percent male deer and 33 percent females. Out of the buck percentage, yearling bucks make up a substantial portion of the kill. The early season hunting, mainly in September, is exerted on this yearling segment of the population. This segment accounts for 30 percent of the total deer harvest on Vancouver Island. In 1969, following the severe 1968-69 winter, yearling animals, both male and female were virtually eliminated, and were thus unavailable for harvesting in the fall of 1969. Thus, inspite of a reduced antlerless season during which more bucks are shot and more females produced, the 1969 deer harvest was only between 18 and 19 thousand deer*.

With a total deer population of about 300,000, then this means that during the fall hunting season of 1969, the percentage of the deer harvest out of the total population was only between 6 to 6.25 percent. If, ideally, at least 30% of the total population should be harvested, then between 24 to 23.75 percent of the potential yield was lost to the severe winter. An analysis of the surplus at the provincial level does not appear to be any different, even for "normal" years. The total provincial deer population (all species) was estimated at 1,075,000 (see Table 18) for 1961. Table 22 gives the annual total provincial deer harvest for the years 1952-1965, as estimated by the hunter sample questionnaire analysis. If these annual harvests are considered by percentages for the years 1961-1965, then out of the estimated one million and over deer, the following annual percentages are derived:

1961 .... 6.25%
1962 .... 6.6 %
1963 .... 6.6 %
1964 .... 8.3 %
1965 .... 5.2 %

(The annual harvest is considered to the nearest 1000).
Thus throughout the province, the annual harvest percentages for 1961-1965 averaged only about 6 percent of the total population. In view of the ideal 30 percent harvest level, these

*Keith Mundy, 1970. Personal Communication annual surpluses are really negligible. The low percent harvest for 1965 (5.2) is probably a reflection of the severe 1964 winter documented by Smith (1968). The role of hunting in controlling the deer populations in British Columbia can therefore be described as almost insignificant, and if a surplus is defined on the basis of what is actually removed, then the deer surplus in the area is extremely small.

Accessibility. It is not merely the greater abundance of deer present on the Island and their proximity to population centres that permits the present harvest, but most important, the better means of access. Districts supplied poorly with side roads or those closed to the public seldom yield the harvest which the indigenous deer populations are capable of supplying. So important is access in determining the game harvest that it may be said that the value of any game unit varies in direct proportion to its accessibility. At least 95 percent of resident hunters in British Columbia are confined to the use of roads, and roads are therefore important to deer harvesting. Vancouver Island offers good access over part of its area but much is still unavailable to the majority of hunters. The great network of roads built for the exploitation of the sustained forest yield is currently inaccessible because it has not been linked to the major public highways. Most of the roads of the eastern end of the Island are connected to the main highways; but the situation is different in the vast deer management areas of the north and west. These areas are too isolated to be hunted unless hunters gain access by boat or by air. Accessibility to these areas will depend on the expansion of the logging industry.

In 1956, the east coast of Vancouver Island had 1,000,000 acres of land that were covered by road networks. However, roads built during the days of large-scale logging soon deteriorated as their use, and therefore their maintenance, declined. It has been suggested that better accessibility might be provided by the construction of a road network for the exploitation of forest products on a sustained basis. Such roads would presumably be in constant use, and provided the hunters can gain access to the logged over-areas, formerly isolated deer populations can be harvested. At the same time, most portions of a sustained yield operation would be within 1000 yards of a roadway. This once more emphasizes the basic feature of deer management of Vancouver Island, that the resource is apparently inextricably tied to land use activities.

Although its ultimate results are unknown, the development of forest management areas on the west coast and in the northern areas of the Island are said to be creating deer range. It has also been suggested that logging should improve the deer range and added harvests may be taken; but that before this becomes a reality, the road network in such newly opened deer ranges will have to be linked with the population centres to the south, otherwise utilization will remain at a minimum (9th B.C. Natural Resources Conference 1956). Even today the same arguments are made, to the effect that newer deer ranges should be opened up. However, as conditions presently stand, it is felt that there are enough deer on this management unit, and consequently, the creation of new deer range will only compound the current problems of hunter management. The abundance of deer over most of the Island today is, in a way incidental, being determined for the most part by the favorable range conditions brought about by logging.

By extension, it could therefore be argued that deer management is in itself an incidental activity also. It is repeatedly asserted that as regeneration progresses and the forest canopy closes such that sun's rays cannot penetrate to the ground level, there is a progressive decrease of the capacity of the habitat to support deer owing to lack of understory vegetation made up of succulent forbs and herbs. Ultimately then, if logging activities were to cease, and if the forest cover subsequently assumed its near pristine state, then the range could no longer support a large deer population, in which case there would be no deer management. This may be too simple a conclusion, however. Natural phenomena rarely follow a simple cause and effect pattern. After all, the presence of deer in this coniferous forest habitat was documented before extensive logging operations began. The question arises, therefore, as to why deer numbers should be deliberately increased 20-fold through fire and logging (Dasmann and Dasmann 1963) if man is not going to make use of the created surpluses by hunting. In other words, there appears to be no justification of creating new deer range in view of the many remaining unknowns regarding the most effective methods of harvesting all stocks available now. In actual reality, as conditions presently stand, and in view of available evidence, black-tailed deer management on Vancouver Island may be described as superfluous.

Hunter Distribution and Hunter Pressure.

Ideally, hunter distribution should be such that hunting effort is more equally distributed over all parts of the range more equally during the hunting seasons, in order to prevent undue concentration of hunters in certain areas. Excessive hunter pressure may be created in certain parts of the range because of the tendency of most hunters to head for areas of dense game concentration, or to those game areas nearest to where they (the hunters) live. All this is seen as an attempt, on the part of the hunters, to minimize the physical discomforts that go with hunting. Besides this factor of hunter preference, the problem of hunter distribution on Vancouver Island has another dimension to it. The area has mostly a logging economy, and many of the factors that give rise to unequal distribution of hunters stem directly from this system of land use, because public access to, and harvest of deer, conflicts with the policies of the logging companies. The southern half of the Island is privately owned and the companies control access into their areas*. But it is in these same areas where the heaviest concentrations of deer are found. Moreover, it is also in these same areas of active logging where natural predators are lacking. Often in these areas deer tend soon to multiply up to and beyond the carrying capacity of the range. As a result, there may be a tendency for hunting effort to be concentrated onto the open, easily reached areas, which could lead to locally overhunted herds.

A much better policy would be one whereby the hunters are given the choice of where to hunt, such that all deer herds would, ideally, stand the same chance of being hunted. It is said that the annual crops of male deer from heavily hunted areas are composed of a high percentage of yearling bucks and those in early maturity, with only a few really mature males, with mature body and antler size. On such heavily hunted areas the rate of male deer recruitment in the herd is greatly reduced and only a few males grow to mature ages of even 5 to 6 years (Trippensee 1948). It is after such conditions have been set in motion that complaints are often heard from the public, to the effect that there are "no more deer to hunt" with widespread demands for "closed seasons", - and the viscious circle is complete.

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*Keith Mundy 1970. Personal Communication.

It has been said for Vancouver Island that a better liason between the Forest Service, the Game Department, the logging companies and the hunters would greatly improve hunting conditions. However, even if all of Vancouver Island deer range was open to hunters, it is doubted whether this would inevitably lead to a better hunter distribution than exists now. The problem appears not to be so much related to the policy of property rights and ownership, but more to the attitude of the hunters towards hunting as a sport.

Sources of Management Data

Scientifically conducted surveys and inventories are relatively new to British Columbia. They have been in operation for just over ten years. Inventories and surveys need not necessarily provide information leading to an increase in animals. Besides, available evidence seems to indicate that at present such an increase is not necessary for Vancouver Island. It is only necessary, however, that such inventories be reliable so that any management techniques deemed necessary can be based on them; for instance the formulation of hunting seasons. Despite great technical advances in wildlife management, the game manager's biggest source of information is still the hunter himself. On Vancouver Island, data regarding the population structure of the deer herds have been collected from hunters for almost twenty years.

Hunter Kill Data. Since the true measure of hunting success, or the lack of it, is measured in terms of the average take per hunter, information on hunter kill is extremely valuable. Accurate kill figures are among the most important statistics essential to scientific game management, because they provide direct evidence of the animals' productivity.

A Game Harvest Analysis has been in operation every year since 1964 for all the Management Areas in British Columbia. The analysis is geared towards obtaining greater information on the movements of the hunters, as well as a better measure of hunting pressure. It is based on the "Hunter Sample" which consists of questionnaires, mailed to a ten percent random sample of hunters shortly after the close of the hunting season. Since 1967, the sampling levels have been increased threefold in order to furnish statistical reliability. The questionnaires are designed in such a way that their completion is simple and fast. Information sought from the hunter pertains to:

1. whether the hunter hunted that particular year;
2. where he hunted;
3. whether he killed any deer that season;
4. whether he killed, one, two or three deer;
5. whether his first, second, or third deer was a buck, a doe or a fawn;
6. where he killed the deer, that is, in what Management Area;
7. the nearest post office and watershed.

The most important aspect of the Hunter Sample is the rate of return of the mailed questionnaires because it is on these that the analysis is based.

Table 21 outlines the deer licence sale and questionnaire return for British Columbia for 1968. Table 21 brings out certain interesting aspects of the 1968 Hunter Sample questionnaire analysis. For instance, Vancouver Island had the second highest number of licence sales, 25512; of questionnaires mailed, 8143; and of the questionnaires returned, 2570. However, although this management unit had the highest number of hunters from whom there was no response, nevertheless, it had the second highest percent return of the questionnaires mailed to management areas in British Columbia (31.56). However, it had the second highest percent sample size, 10.07, (the lowest being 7.46 percent for Peace River), so perhaps this was partly responsible for the high percent return rate, despite the lack of response from 356 purchasers of deer hunting licences.

On the whole, hunter response to the mailed questionnaires appears poor. The implications of this, to a management program that is based on trends obtained mainly from hunter kill data cannot be underrated. On this basis, it is doubted whether information on hunter kill data obtained from the hunter sample questionnaire analysis can be relied upon for the formulation of management ligislation. This method

Table 2.1: Licence Sale and Questionnaire Return. Deer Harvest 1968.

RESIDENT AREA	LICENCE SALES	QUESTION-NAIRES MAILED	QUESTION-NAIRES RETURNED	NON CONTACT	PERCENT RETURN	PERCENT SAMPLE SIZE
Vancouver Island	25,512	8,143	2,570	356	31.56	10.07
Lower Mainland	44,082	12,469	3,456	431	27.72	7.84
Okaganagan	12,890	4,035	971	174	24.06	7.53
Kamloops	12,693	3,801	1,061	124	27.91	8.36
Cariboo-Chilcotin	6,449	2,077	576	78	27.73	8.93
Northern B.C.	14,467	4,087	1,200	331	29.36	8.09
Peace River	7,589	1,875	566	83	30.19	7.46
Kootenays	14,004	4,346	1,431	202	32.93	10.22
Upper Mainland Coast	7,366	2,205	628	163	28.48	8.53
TOTAL	145,052	43,038	12,459	1,942	28.95	8.59

of gathering management data is probably better used as a comparative basis with another method, preferably the road check operation method. The unreliability of the hunter kill ratio obtained from the hunter sample is seen to stem not only from the poor, and therefore unrepresentative response from the hunters, but also from the fact that the information yielded by the hunters may be incorrect and is therefore likely to give a distorted view of hunting conditions in the field. In other words, this method should not be used alone in predicting the size of the crop that may be taken, or to indicate trends in the population, but should be used in conjunction with data from the road check operations.

Road Check Operations. Useful indices to population trends are obtained from road check operations during the hunting seasons. Road checks are operated in about seven different localities on theisland, primarily to evaluate hunting pressure, hunter distribution and hunter success, as well as the composition and age structure of the harvest. During the first two weeks of the hunting season, this information is collected from these check points. Similar road checks are made during the concluding weekends of the deer hunting season, and at varying intervals throughout the season on points of access to the major ranges. Results of such information, statistically analyzed and compared from year to year should, ideally, provide much useful information on the status of the deer population, and also indicate relative hunting pressures. In recent years on Vancouver Island, over 15,000 hunters and 3,000 deer have been tallied per season at these road check operations, while 2000 jaw bones have been obtained for the purpose of determining the ages of the deer killed.

The road check system of gathering hunter kill data appears to have a number of advantages over the hunter sample questionnaire analysis, and consequently, may have a higher level of dependability. Firstly, the data are actually gathered directly from the field when hunting is taking place. Secondly, data are collected at different intervals during the hunting season. In contrast, the questionnaires are mailed to the hunters only after the close of the hunting season. Presumably therefore, the time lag between the periods when data are obtained by these two methods may influence the type and accuracy of the information yielded. It is likely that the hunter's enthusiasm in hunting may have died by the time he receives the questionnaire and he may not therefore give as much consideration or thought to the questions, as he most probably would when confronted by the road check operators out in the field. Moreover, at the checking stations, the hunter actually has the animal(s) he has bagged with him and this further minimizes his chances of giving the wrong answers, while at the same time, the operators can examine the kill.

However, although these two sources of management data can, if used in conjunction, provide much useful information regarding the deer populations and their trends, it is doubted whether they can be widely relied upon for serious and scientific deer management. The use of the hunter as a source of management data is highly questionable.

There are certain basic aspects of hunting activity which are as yet unknown, and which may greatly affect or even distort hunter kill data received from hunters. Factors affecting hunting distribution, hunting pressure and hunter success do not wholly emanate from conflicts of land use (accessibility) or deer distribution. Undoubtedly, most of them are seen as a direct result of the attitude of the hunters themselves. Certain aspects of hunting as a recreation have, as yet, not been understood or evaluated. It is believed that these aspects are in part related to hunter psychology. Johnson, (1943 p. 349) has summarized this very well:

> ...."hunter psychology is one of the most important factors in hunter distribution. A good many of our big game hunters are inexperienced. They appear to be in a hurry. Something seems to have happened to the minds of our people since the advent of automotive transportation. Hunting like other forms of recreation should not be hurried. The early rush and desire to kill a buck and get out is affecting the quality of both the sport and our deer herds.
>
> Hunters naturally tend toward areas of game range which have the heavier game populations, where there is a good chance to take game and especially where the areas are most easily reached by car and covered afoot."

Such an observation raises a number of questions and the answers to these may reveal that information from hunters, designed to indicate population data and trends, may leave alot to be desired. For instance, do hunters derive maximum enjoyment from sport hunting as a recreation, or are they only motivated by a "tremendous early season urge to go 'buck' hunting" and get out fast with the least degree of physical inconvenience? If this is so, then, as has been pointed out, they will restrict their hunting activity to areas with the greatest deer density. Consequently, any information they yield at the checking stations, or on the questionnaires, will only reflect on a relatively small proportion of the total deer population. Moreover, hunters have been known to give the wrong information deliberately, particularly with regard to the sex of the animals bagged. Everybody wants to bag a buck, while others, for some unknown reason, state that they bagged a doe while infact they may have downed a full-antlered buck.

Until such aspects regarding the attitude of the hunting public are fully understood, the extent to which hunter kill data can be used as a basis for management will be limited. If, as was stated earlier, deer management on Vancouver Island can be defined as "deer hunter management", then the whole issue of deer management takes on a different outlook. It can therefore be said that deer will only be truly managed if what the hunters really want is understood first.

Management Tools

Successful wildlife management depends on many varied aspects, most of them pertaining to legislation. Range and forest use, habitat manipulation, harvesting of the surplus, setting of the seasons and control of predators are but few of the tools that are employed in the management of big game populations. On Vancouver Island, deer harvest management tools revolve around restrictive legislation such as the setting of hunting seasons, season dates, season lengths, bag limits and hunting methods.

Hunting Seasons. The setting of hunting seasons is one of the most important prerequisites in deer harvest management because of its role in controlling deer populations. It is also one of the activities of game departments that is most frequently criticized by the public.

On Vancouver Island, the 1968-69 winter is known to have been a particularly severe one for deer*. Smith (1970) states that possibly over 40 percent of the deer on coastal British Columbia died during this time. Deer losses on Vancouver Island were in the order of over 100,000 animals. Hunting regulations are directed at off-setting such enormous die-offs through natural causes. In the summer and early fall, there is no shortage of deer food because there is plenty of abundant and high quality forage; the animals become fat and sleek and this is why hunting seasons are set in the fall**,

*Smith, Ian 1970: 1968-69 Winter Hard on Deer
**Smith, Ian 1970: 1968-68 Winter Hard on Deer

usually from about the second week in September to the last week in November. At this time also, "good" hunting weather is more likely to prevail in the form of damp days when deer flock out to feed in the open. "Bad" hunting weather conditions of pleasant and dry days is not conducive to maximum harvests.

The Open Season. In some years, deer herds increase to such large numbers that even a moderately severe winter would kill thousands of these animals, while the range and feeding grounds may become greatly impaired. At such times, open seasons are declared when hunters can shoot deer of all ages (fawns, does, yearlings and bucks) of both sexes. Since hunter distribution is one of the key problems, the open season is therefore also aimed at controlling hunter distribution in proportion to the abundance of game. The time and duration of the any-sex season greatly determined the distribution and congestion of hunters such that only the accessible areas such as those close to highways or those in easy hunting country are hunted. Sometimes, therefore, it may become necessary to introduce only a short open season, or even to declare a closure on antlerless animals, if certain areas of high hunter success are threatened by overhunting.

Since, as has been noted the hunters take only a negligible proportion of permissible off-take, and since the remainder is most likely lost through natural causes, then it seems to follow that open seasons should probably be declared more frequently. However, since it is an any sex season, the situation might arise in which a much greater proportion of a particular sex, for instance bucks, might be hunted beyond the safe level. Another possibility could be that the hunters might fail to make use of an open season as intended, by refusing to shoot all ages of all sexes (fawns and does), in which case the desired effect, that of reducing the population, would not be achieved. With a co-operative hunting public, the open season could be a valuable tool to deer management.

The Anterless Season. The antlerless season for deer is usually confined to three weeks in November. It is probably the most controversial of all hunting seasons in Vancouver Island, strongly opposed by most hunters. This season is the most liberalized of hunting regulations, designed to prevent imbalances between the carrying capacity of the game habitat and the number of animals. Data based on the hunter sample questionnaire analysis indicate that between 1950 and 1967 in British Columbia, both the number of hunters and the number of deer taken have increased steadily; but the number of deer has increased faster than the number of hunters. Therefore the increase in the deer harvest has been due to increased hunter success. This is attributed to the implementation of the antlerless season in 1953, with a subsequent bag limit of 3 deer per hunter in 1955. In 1967, four times as many deer were harvested than in 1950. Table 22 illustrates the contribution of the antlerless season to the deer harvest from 1954 to 1965.

Table 22: Contribution to the Deer Harvest Afforded by Antlerless Seasons. A Review of Estimated Kills Since 1962.

Year	Bucks	Actual Anterless	Total	Projected Bucks Only Instead of Both Sexes
1952	17,963	-	17,963	17,963
1953	29,399	-	29,399	29,399
1954	28,622	7,389	36,011	28,622
1955	36,231	14,687	50,918	30,000
1956	32,958	10,017	42,975	30,000
1957	34,663	12,755	47,418	30,000
1958	43,584	16,136	39,720	30,000
1959	44,880	16,538	61,418	30,000
1960	42,472	16,100	58,572	30,000
1961	47,907	19,118	67,025	30,000
1962	48,505	20,984	69,489	30,000
1963	47,115	24,408	71,523	30,000
1964	50,667	27,768	78,435	30,000
1965	37,880	18,997	56,877	30,000
TOTAL	542,846	204,897	747,743	405,984

Source: B.C. Wildlife Service Hunter Sample Questionnaire Analysis 1966

"The figure of 30,000 projected bucks - only, was based on the assumption that increased harvests of bucks are taken during either sex seasons. In the past, harvest of bucks during "bucks only" years has been stable at around 20,000 to 30,000. The high figure was taken" (Finegan, 1970. Hunter Sample Questionnaire Analysis). According to Finegan, the total contribution to the deer harvest by the antlerless seasons is in the order of 27.4 percent minimum of the total harvest and 45.7 percent probably of the total harvest, while the actual contribution to the deer harvest since 1954 has been 205,897. The antlerless season then is essential to management because it maintains a better sex ratio and curtails excessive winter mortalities.

However, inspite of such an overwhelming amount of data in support of the antlerless season, rarely do hunters take enough animals during a liberal season because of a misguided fear for the safety of the animals. This makes them demand unnecessary restrictive seasons.

Like the open season, the antlerless season, though potentially a useful tool, rarely achieves the full desired results on the population composition. An examination of Table 22 reveals that many more bucks are still shot than does. The antlerless season may therefore contribute to the total number of deer harvested, but whether or not it successfully maintains a better sex ratio within the deer population is open to question. Furthermore, its role in curtailing excessive winter mortalities cannot be rated as significant, because as already noted, the percentage of the annual total provincial harvest is well below the desired level.

The Closed Season and The Buck Law.

Originally, closed seasons (when no female deer are hunted) were declared in North America to protect game stocks that were threatened by hunting; but such seasons only covered the actual breeding season of the big game animals. This early policy of almost total protection of the female sex in big game herds appears to have carried over to the present time. Apparently, many people in North America are still haunted by the idea that game animals as such will ultimately disappear. Consequently, their approach to the issue of surpluses is influenced largely by emotion and only partly by reason.

The "Buck Law" in North America is a regulatory legislation, which has been adopted by certain big game departments, whose purpose is to protect does at all times. Johnson (1943 p. 395) reports that studies by the Washington Game Department have determined "that a ratio of one buck to 2.5 does may be maintained with an annual kill of one third of all antlered bucks."

On Vancouver Island, it has been estimated that it is possible to get a 30 percent increase out of a deer herd on a good range (15th B.C. Natural Resources Conference 1964, p. 566). Hatter (1966)* states that under a buck season about 10 percent of game animals, or even less are killed. A heavy harvest of bucks still takes about 10 percent of the deer population. Consequently, with the 30 percent increment rate, about two thirds of the resource is being wasted if only bucks are harvested. A deer herd is truly harvested when does are taken too because it is them that are responsible for the 30 percent increase. Leopold (1943, p. 9) states that "Laws protecting antlerless deer pre-dispose a herd to irruptive behavior to the extent that they are enforced for the killing of males in a polygamous species has, within ordinary limits, no effect on reproductive rate ..... Irruptions have been confined to buck-law states."

Many people, however, still believe that total protection of does, or sanctuary status, is the most reliable method of perpetuation of the species; they have hailed protection as the panacea to the problems of big game surpluses. To such people, there is no, nor can there ever be, a surplus. On Vancouver Island in particular, many people cannot conceive how animals could die of starvation, in the midst of plentiful forests. Morever, they usually see the deer during the summer and fall when forage is super-available and the animals are plentiful. Thus in 1970, a petition was circulated throughout most of British Columbia by Mr. Earl Carlson** urging

*The Victoria Observer, March 20, 1966.

**Earl Carlson Game Management Petition, 1970 Big Game Management Recommendations that the Province should return to bucks-only seasons for ungulates:

> "We therefore recommend the immediate closure of widespread female and antlerless hunting seasons on deer, elk, moose and caribou .... We ......urge rigid enforcement of the above mentioned, safe 'male only' harvest method, to prevent the extermination of our game in accessible hunting areas as the present 'shoot anything you see' method is obviously doing."

Yet this petition is inspite of the fact that it has been established beyond doubt that:

> ...."it is highly unlikely that British Columbia hunters are causing any declines which are occurring. What does cause deer numbers to decrease are changing vegetation conditions, such as occur when a forest begins to fill open areas or when critical wintering areas are lost."

What is probably needed is a crash program, aimed at educating the public, and making it aware of the basic ecological principles that govern wild populations and their productivity. The source of the problem appears to be associated with a fundamentally misinformed hunting public.

It appears likely that the success of the buck law in the past in building up deer herds that were nearly depleted, has created a prejudice in most people against killing female deer. Ironically, these same people would probably be the first to advocate the implementation of an artifical feeding program to overstocked, starving deer in winter. The buck law greatly affects the rate of deer population increase, after which it becomes necessary to hold a herd at a constant number, or even to reduce the numbers inorder to hold the population at the safe carrying capacity. This can rarely be achieved by the removal of males only. A buck law is only useful in building up a threatened population to the carrying capacity of the range after which can open season on all sexes is essential for good deer management.

DISCUSSION

Most of the data available seem to support the contention that an evaluation of the current or seasonal carrying capacity is more meaningful than an attempt to determine the carrying capacity for an extended period of time. In this context, seasonality refers to the main feeding periods of the black-tailed deer during the feeding year, as determined by the availability of the desired forage species. It is seen that it is the effect of the seasonal occurrence of a number of factors that largely determines the number of animals that can be carried on any unit of the deer range, and the ability of this unit to provide the animals with their basic requirements. On Vancouver Island, this aspect of seasonality is apparently further accentuated by the intensity of logging practices; the effect of this upon stocks of deer is therefore superimposed upon the dynamic ecological rhythm of the habitat.

Thus, although ultimately the deer populations are maintained by periodic recruitment of new members through immigration and/or reproduction, between such periods of recruitment, the herds show a tendency to decline in response to the seasonal factors of food availability and mortality. For any one area, the effects of these factors will most probably vary in intensity depending on the season, and the population density. Consequently, no one definition of carrying capacity exists for all populations inhabiting different ranges and at various levels of density.

The Effect of the Seasonality of Food Availability

Each environment has to provide the great variety of food, cover and water needed by the deer during the different seasons for the various activities of both sexes and all age groups that the environment supports. But the mere presence of food, water and cover on a range is not itself indicative of a suitable carrying capacity level. These basic requirements should be relatively easily available to the various animals groups. Thus on Vancouver Island during the winter, coast deer tend to frequent certain areas where they find a close association of both mature timber stands for cover, and regenerating areas that provide an abundance of food (Gates, 1969). Winter is therefore the most critical time for deer survival on the Island. During other seasons, the abundance and variety of food materials ensure a continuous supply of nutrients that adequately meets any contingency except in rare cases. In winter, however, the most unfavorable conditions prevail: There are fewer and less nutritious foods available; continued cold and constant high winds lower body temperature , thereby placing a greater strain upon metabolic processes with a consequent greater demand for more energy-producing feeds. Moreover, the animals tend to concentrate in yarding areas of limited size and carrying capacity, becoming crowded in a relatively small portion of the total range, usually at the lower elevations. Under certain conditions, there may be no acute absence of food, but the depth of the snow hinders movement. These findings seem to correspond with findings on other deer ranges (Klein and Olson, 1960).

The effects of the seasonal shortage of food on deer populations are manifested through mortality and its characteristics. According to Klein and Olson (1960), deer winter mortality is determined by many variables, chief among them being: the condition of the range; the population density with respect to the carrying capacity; and the severity of the winter season. They state that yearly and regional variations in winter mortality can frequently be attributed directly to browse abundance and availability and to the depth and duration of snowfall. It has been stated that on Vancouver Island, winter mortality accounts for about 20 to 40 percent of the general mortality rate of the deer. Smith (1968) has associated deer winter mortality at Northwest Bay to deterioration of the habitat.

By far the greatest effect of winter mortality on deer productivity is, however, indirectly due to the sex-age-class differential mortality. Taber and Dasmann (1954, p. 314) in a study of Columbian black-tailed deer have found a differential mortality in favor of the does

> "....there is differential mortality among deer under eighteen months of age, appreciably more males dying than females."

Cowan (1950) in investigating overstocked big game mountain ranges in Western Canada, (Banff, Jasper, Kootenay and the Rocky Mountain region of Alberta and British Columbia) noted that malnutrition, periodically intensified by particularly severe weather was profoundly influencing both fecundity, as measured by survival of young to yearling age, and sex ratios. It is also known that winter mortality takes a heavy toll of the fawn segment of the population. Fawns are usually the first to die when large scale deer losses occur because in winter, remaining food supplies are usually out of reach for the smaller fawns (Chaetum and Severinghause, 1950; Verme, 1963; Murphy and Coates, 1966; Klein and Olson, 1960).

It was stated earlier that it is the proportion of the yearling and fawn segments in a population that indicates productivity in a deer herd. It seems to follow, therefore, that since it is these same segments which are subjected to greatest winter losses, that productivity will fluctuate seasonally, depending on the extent of winter survival of these two groups of the deer population. Smith (1968) also noted that the effect of hunting on the deer herd at Northwest Bay varied from year to year as determined by the rate of harvesting of the numbers of animals entering the winter. Stated differently, the number of deer that are available for harvest is directly related to the number of fawns surviving from the previous year's crop.

Deer management on Vancouver Island attempts to meet the demand for hunting as a recreation by an annual assessment and regulation of the resource. Because of the continued seasonal changes to both the conditions of the range and the deer population, it appears necessary that repeated seasonal surveys and estimates of carrying capacity and of the harvest that may be removed safely should be carried out. Surveys should be geared towards providing information of a distributional nature, with a view to equalizing hunter pressure and distribution.

It has been stated that on Vancouver Island, deer management is based on general population levels, and the relative magnitude of the animal harvest, and not on the condition of the range. Moreover, data on which management policies are based are obtained from the hunter kill ratios. Some of these ratios are obtained at checking stations and road check operations during the hunting season. For the purposes of management, these checks are valuable tools. Since both the hunter and the animals he has bagged are checked through, then it can be assumed that the level of accuracy of the data obtained is fairly high. What is doubted, however, is the reliability of data received from the hunters through the hunter sample questionnaire analysis. This method is regarded as basically inadequate for a number of reasons outlined earlier.

There is however, another general problem with regard to the attitude of the general public, both hunters and non-hunters, to the deer resource. On Vancouver Island, the deer herd is public property, which is held in trust by the Province. Generally, management is designed therefore to meet the needs of the hunters. However, it has been stated already that the public at large views the issue of deer numbers and surpluses through emotion-clouded eyes. This sentiment of favoring excessive deer numbers is regarded here as being a great deterent to constructive management. It is necessary that the sportsmen learn to appreciate the use of sound ecological principles in big game management. This prevalent attitude of favoring huge deer numbers can probably be modified by public education; public awareness of biological methods of deer management would probably be the most important single advance to the management of these animals.

The Surplus

It appears that an evaluation of a wildlife management program for most parts of North America that does not consider the implications and ramifications of "the surplus" is incomplete. Available evidence from the literature seems to indicate that this is one of the least understood and the least considered of the aspects of a natural wild population. Most workers have apparently not attempted to try and understand the meaning of a surplus within the context of a natural wild big game population, or against the background of ecological phenomena. Yet wildlife management in North American revolves around the concept of a sustained annual surplus for hunting.

Every natural population of ungulates can be said to produce a surplus of animals in normal years. There is a widespread belief amongst most wildlife biologists that only by cropping this surplus annually can range damage be confined to a minimum. It is said that if this surplus is allowed to be taken by natural causes of mortality, damage to the range will be inevitable and ultimately the habitat will only be capable of supporting fewer animals in future years. This theory is upheld by many game departments and has been "tested" in many places.

However, a critical examination of ecological phenomena, and of available data points out to an apparent paradox. It is pointed out time and time again by many authors that there were only few deer in the Pacific coastal habitat prior to the coming of the white man, and that not until logging activities began did these animals achieve their present abundance. Thus, it is generally held that such land use activities have been beneficial to the status of the black-tailed deer as a wild big game animal. At the same time it is conceded that the Indians, of whom there were many more then than today, lived mainly by hunting these animals. The conclusion that can be drawn from this, therefore, is that there must have been a large deer population on the western Pacific coast of North America, that adequately supported the large populations of Indians that existed then, and whose sole means of livelihood was big game hunting and fishing.

Consequently, there must have been some natural ecological balance between such a population of black-tailed deer and its habitat. The large predators, such as cougars and coyotes, and man, most probably maintained the deer numbers to the safe level of the range carrying capacity. But then along came the white man, who killed off most of the predators (including the Indians), thereby upsetting the courgar-deer-man food relationship. In addition, he introduced a destructive system of land use that further set more habitat changes in motion. In parts of Africa too, it is known that problems of the wild ungulate populations and their carrying capacities were virtually non-existent before the advent of the white man. The killing of the large predators, such as lions and leopards as trophies, nearly eliminated the essential predator pressure over the ungulates, with subsequent overpopulations of these animals. The problem has only been rectified in recent years through protective legislation of the large carnivors.

With regard to North America, the assertion that land use activities have been beneficial to deer populations is clearly erroneous. It appears to be but the white man's attempt to justify the havoc he has caused in upsetting the ecological balance. While a balance of nature as such does not exist, nevertheless in the natural world of living things, there is inevitably some equilibrium between the organisms and the environment. Every living thing in nature can be said to have its own time and space within the ecosystem; ecologically therefore there are no "natural surpluses". This appears to be clearly illustrated by man's failure to "create" and sustain a deer surplus; excessive deer numbers, it has been noted, experience the greatest mortality through natural causes.

Because of this belief in a "shootable surplus" the North American system of deer management appears to be riddled by contradictions. For an area like Vancouver Island, it is said on the one hand that hunting exerts no significant control over the total deer population, and the data available seem to support this. On the other hand, however, people speak of the surplus that must be managed and harvested if the range is to be saved from irreparable damage caused by overstocked deer. Deer management is infact mainly justified on this basis: to manage and sustain yields that can be taken by hunters for sport, such that the hunters can derive maximum enjoyment from this recreation. Ironically, however, these same hunters apparently do not know what they want! Hence a situation arises in which "the surplus" is never taken by man, but goes the same way that it has always gone throughout its ecological years - by natural mortality from winter die-offs. This raises an important question: - Is "deer management" activity necessary?

In conclusion, two basic factors appear to greatly influence the productivity of black-tailed deer on Vancouver Island. The seasonabity of fodd availability, and implicitly of carrying capacity, is regarded as important. It is this factor of seasonal food availability that causes deer populations to adjust their numbers accordingly through winter mortality. The other basic factor pertains to the attitude of the public to hunting, and to deer management in general. It is believed that not until the hunters know and appreciate what scientific deer management is all about, and not until they subsequently know what they want, will black-tailed deer on Vancouver Island be fully managed.

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