

**An Assessment of the Nutritional Status and Habitat Quality
of a Southwestern Virginia Deer Herd**

by

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(ABSTRACT)

To determine the causes for low hunter kill and presumed poor population growth of the white-tailed deer (*Odocoileus virginianus*) herd in the High Knob (HK) area of Scott and Wise Counties, Virginia, the relative abundance and nutritional status of the deer herd and the habitat quality of the HK area were studied relative to a deer herd and an area in the Stony Creek (SC) section of Giles County, Virginia, known to produce deer of good physical size and antler development and sustained high hunter harvests. Pellet-group surveys, deer collections in September and March, check station data on hunter-killed deer, soil sampling, and quantitative and qualitative forage analyses were used in assessing the HK deer herd and area. The extent to which poaching, free-roaming dogs, and winter weather might be affecting the HK deer herd also was investigated. Pellet group density was significantly lower ($P = 0.004$) at HK relative to SC and was believed to be indicative of a somewhat lower herd density at HK. In September, the condition of the HK deer herd was similar to that of the SC deer herd. However, the average number of parasites in the abomasums of HK deer was significantly greater ($P = 0.0002$) than in the abomasums of SC deer. Yearling bucks killed by hunters at HK had significantly lower eviscerated body weights ($P = 0.0001$), while all bucks killed by hunters at HK had smaller antler beam diameters ($P = 0.006$) and fewer antler points ($P = 0.0001$) relative to hunter-killed deer at SC. Because of an abnormally abundant acorn crop at SC in the fall of 1985 and an abnormally mild winter at HK and an abnormally severe winter at SC in 1986-87, the nutritional condition of the HK deer herd relative to the SC deer herd in March in a "normal" year was difficult to ascertain. However, it was inferred that in a "normal" year the HK deer herd would be in worse physical condition in March relative to the SC deer herd. Soil pH, organic matter, and mineral levels were significantly lower ($P < 0.1$)

at HK than at SC. The HK area had significantly greater ($P < 0.1$) quantities of various vegetation categories than did the SC area in September, 1986. Quantities of common forages consumed by deer in winter were believed to be similar or slightly lower at HK than at SC. However, the average yearly biomass of acorns was believed to be substantially lower at HK than SC due to the greater percentage of the HK area comprised of yellow poplar dominated forest stands. No clear patterns between areas were evident among the forages analyzed for nutritional components. Poaching and harassment by free-roaming dogs were not believed to be substantially different between areas. However, winter weather severity was much greater at HK than at SC. Based on a 10-year average, snowfall is normally over 3X greater at HK relative to SC. Thus, it was concluded that the HK area has a reduced capacity to support highly dense deer herds due to a lack of quality forages in late fall through late winter and greater winter severity relative to SC.

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Introduction

As the science of wildlife management has progressed, professionals within this field have learned many new and important facts about many different species. Of these species, the white-tailed deer (*Odocoileus virginianus*) has probably been the most studied big-game animal in North America. Ironically, while so much has been learned about its physiology, behavior, movements, and habitat requirements, many state wildlife biologists often find that certain deer herds in their state exhibit traits uncharacteristic of the rest of the state's herds. Problems often cited include lower than average body weights, inferior antler development, low reproductive rates, and more often, low herd densities or incomplete expansion into apparently suitable habitat. Most attempts to remedy these situations include manipulating a harvest regime, often with successful results. Occasionally, however, results are not acceptable and delving into the deer herd's biology and ecology is mandated. One such deer herd is located in an area known as High Knob (HK, parts of Wise and Scott counties) in far southwestern Virginia.

At the turn of the century, deer numbers in the mountains of Virginia were nearing depletion (Peery and Coggin 1978:9). The HK area was no exception. In 1916, professional management of Virginia's whitetails was started with emphasis on repopulating areas west of the Blue Ridge Mountains that had been depleted of deer. Deer were imported from several states including

Pennsylvania, North Carolina, Michigan, Wisconsin, and Alabama. Deer also were translocated from the Radford Army Ammunition Plant in Virginia (Peery and Coggin 1978:15-16). Over a 44-year period (1931-75), 316 deer were released in Wise County on 8 occasions and 157 deer were released in Scott County on 5 occasions (Peery and Coggin 1978). These efforts were apparently successful in establishing a concentration of deer in a part of the HK area known as the Glades (Davey 1955).

Concurrent with this restocking effort a bucks-only harvest regime was implemented in 1947 in Scott and Wise counties (Peery and Coggin 1978:21). Harvest records also were started at this time and reveal interesting trends (Figures 1 and 2). In 1958 the number of legally harvested antlered bucks reached a peak in Wise County (136). In the following 8 seasons (1958-66), either sex hunting was permitted in some fashion. At the end of this 8-season period, the legal antlered buck harvest in Wise County had dropped to a mere 21 animals. In 1967, a bucks-only harvest regime was once again invoked. Scott County harvest records track the Wise County scenario, but with a 1-year time lag. Both counties bottomed out in 1968 with Wise County recording only 9 legally harvested antlered bucks and Scott County recording 52. Although the harvest of antlered bucks has increased since then in both counties, the rate of increase is slow compared to other counties (Smyth and Wythe) under similar management regimes (Peery and Coggin 1978:143,156).

Poaching was thought to have been limiting the population growth of the HK deer herd for many years; however, evidence to suggest otherwise was obtained by the Virginia Department of Game and Inland Fisheries (VDGIF) previous to the present study. Specifically, the results of a preliminary abomasal parasite count study (Eve and Kellogg 1977) conducted by the VDGIF revealed that deer at HK had heavily parasitized abomasums. Of 5 deer collected, an average of 2100 parasites were found per abomasum. These results implied that other factors, possibly nutritional, also might be involved.

Thus, the objectives of this study were to (1) determine if the abundance of white-tailed deer at HK differed relative to a reference deer herd with a sustained high harvest, (2) assess the nutri-

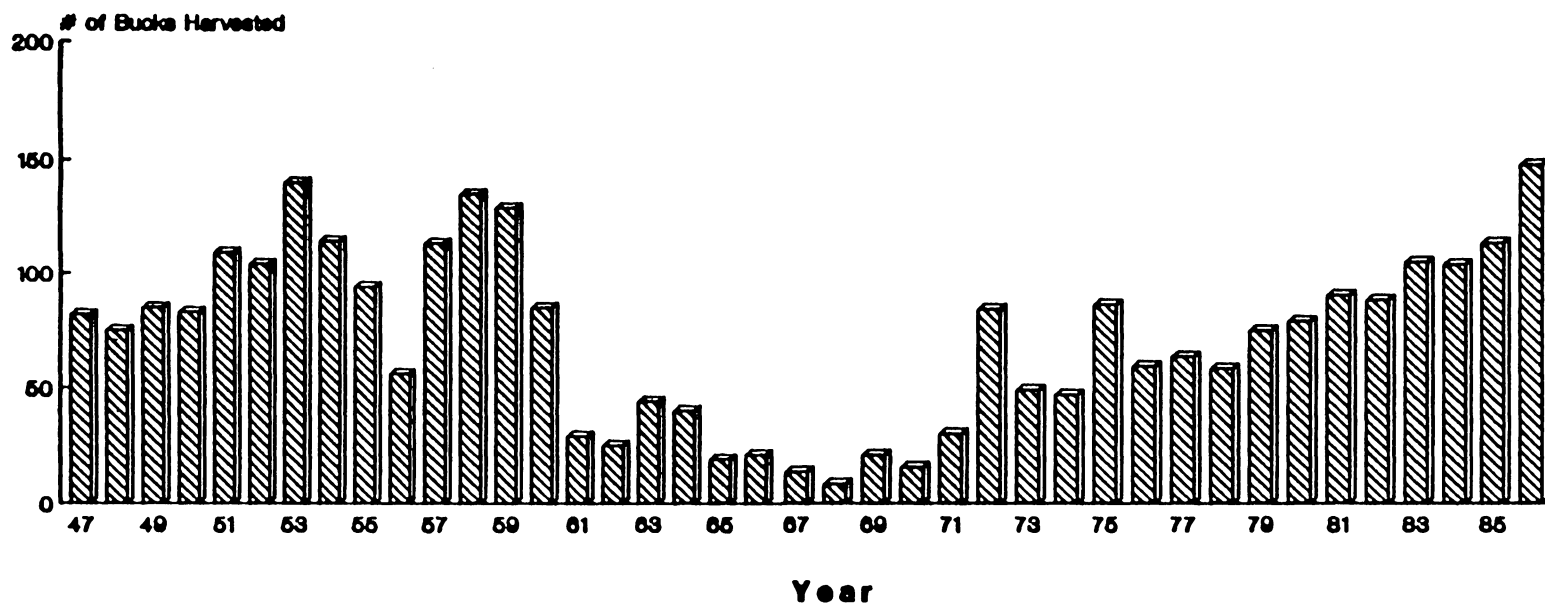


Figure 1. The number of legally harvested antlered bucks in Wise County, Virginia, from 1947-86.

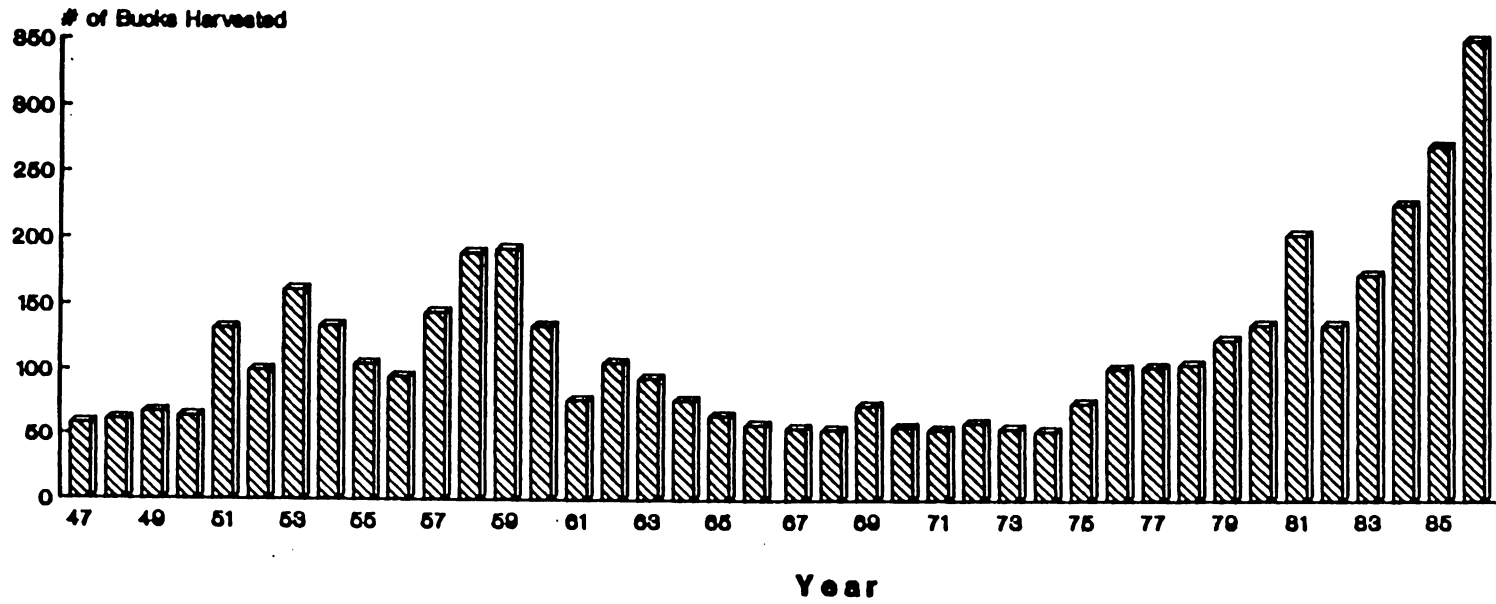


Figure 2. The number of legally harvested antlered bucks in Scott County, Virginia, from 1947-86.

tional status of the HK deer herd relative to a reference deer herd, and (3) investigate the extent to which habitat characteristics, poaching, harassment by dogs, and weather are responsible for the poor population growth of the HK deer herd relative to a reference deer herd.

Literature Review

Though a comprehensive approach is utilized in this study, much of what is investigated relates to the potential effects of nutrition on white-tailed deer. Whitetails have a remarkable ability to survive under the most adverse and broad-ranging conditions. This fact is well attested to by their broad geographical distribution. Deer are seldom limited by inadequate cover, predators (excluding humans), or water; instead, food (nutrition) is the major driving factor in the welfare of deer populations. To substantiate this importance, a review of the literature on key aspects of deer physiology in relation to nutrition will follow along with a review of studies designed to assess deer herds and their habitat via nutritional indices.

Nutritional Effects on Key Aspects of Deer Physiology

As with all species, there are certain physiological responses to nutrition that are of prime importance to the well-being of white-tailed deer. Though the list of such responses is long, only the following 6 aspects will be reviewed: productivity (fecundity), prenatal development, postnatal mortality, fawn growth, attainment of puberty, and antler development.

Productivity (Fecundity)

Given adequate nutrition, does usually reach maximum potential productivity from 2.5 years of age through 6.5 years of age, after which time a gradual decline occurs (Verme and Ullrey 1984). Nutrition has a greater effect on productivity prior to 2.5 years of age. Verme (1967) showed a strong relationship between autumn nutritional plane and doe productivity. In that study, yearling, 2-year old, and 3-year old and older does were maintained on 3 nutritional planes (low, moderate, and high) during autumn. Yearlings on the low plane almost did not breed (0.05 fawns/doe) while yearlings on the high plane produced 1.2 fawns per doe. Though not as dramatic, 2-year old does exhibited a similar response with extremes ranging from 0.5 fawns per doe (low plane) to 1.5 fawns per doe (high plane). Older does were affected by the low nutritional plane, but less severely (low plane 1.3 fawns/doe vs. high plane 1.8 fawns/doe). Ransom (1967) also documented a difference in the number of fetuses per doe between areas of differing habitat quality. In mule deer (*Odocoileus hemionus*), Julander et al. (1961) and Robinette et al. (1973) reported similar results. Thus, it is evident that the nutritional status of the doe prior to the onset of estrus is critical to the productivity of this species, especially in younger females.

It is important to note that this effect is due primarily to a shortage of energy (most likely digestible energy) and not protein (Kirkpatrick 1975). This is substantiated by a study by Murphy and Coates (1966) on captive whitetails. Does maintained on a constant energy, but varying level of protein intake exhibited almost no difference in the number of fawns born.

Prenatal Development

Prenatal mortality is quite low or almost nonexistent in white-tailed deer once the fetus is conceived (Kirkpatrick 1975). However, there is evidence that nutrition of the pregnant doe does have a substantial effect on fetal development. Pregnancy is highly energy demanding (more so

during the last trimester) on the doe and occurs during a time when forage quality and quantity are diminishing. Ullrey et al. (1969, 1970) concluded that the maintenance requirements of a pregnant adult doe were greater than could be met by consumption of the most nutritious winter forages in northern Michigan. When dietary energy supplies do not meet energy demands, fat deposits are catabolized; however, once this source of energy is depleted, bone and body tissue is sacrificed by the pregnant doe to nourish the fetus. Should this drain of body resources be prolonged, fetal growth slows appreciably (Verme and Ullrey 1984).

Verme (1977) reported a 30% difference between mean weights of fawns born in the mildest and severest winters in upper Michigan. In another study, Verme (1979) concluded that a severe winter was detrimental to fetal development, including the size of endocrine glands. Verme (1963) had earlier found that fawns born to does fed adequate diets weighed 3.5 kg, while those born to does fed grossly inadequate diets weighed 1.9 kg.

The implications of these results are far-reaching. Should an estimate of fetal age, conception date, and/or fawning date be of interest, the likely prospect for stunted development in a malnourished fetus would preclude anyone accurately determining these three characteristics by external morphology or physical measurement (Verme and Ullrey 1984).

Postnatal Mortality

Postnatal survival is closely related to maternal nutrition, both prior to and after parturition. Verme (1962, 1963) reported that does fed the highest rations over winter and spring averaged only a 7% fawning loss, while does on lowest nutritional plane exhibited a 93% fawning loss. Also, skeletal development as depicted by hindfoot measurements was roughly 19% less for the low diet group fawns.

Murphy and Coates (1966), in the study mentioned previously, found similar results among varying levels of protein rationing. They reported a 42%, 27%, and 0% loss of fawns among does being fed a 7%, 10%, and 13% protein diet, respectively. They concluded that the apparent cause of postpartum death was starvation due to absent or delayed milk production and subsequent letdown. Other causes of postpartum mortality often cited as a result of malnourished pregnant does include too weak to stand, too small to reach the teats, abandonment, failure of doe to groom its young at birth, fear or aggression toward their young, and refusal to nurse (Langenau and Lerg 1976, Verme 1977).

Fawn Growth

Rapid weight gain each the newborn fawn is essential to its ability to survive the upcoming winter. If born late in the season or a sibling of a twin, its ability to attain an adequate physiological state prior to the onset of winter will be lessened; hence, its chances of survival are also lessened. It is imperative, therefore, that sufficient quantities of milk and, eventually, highly energy-rich, succulent forages be available to the fawn until winter.

When marginal or inadequate nutrition was offered to fawns in autumn, Verme and Ozoga (1980) documented a dramatic slowing of or halted growth. Upon examining these animals, however, fairly good fat deposits were found, thus indicating that even if food consumption is insufficient for growth some nutrients apparently are utilized for lipogenesis--an excellent winter adaptation.

Ullrey et al. (1967) showed that doe and buck fawns receiving 13% and 20% crude protein, respectively, gained more weight in autumn than fawns receiving 8% and 12% crude protein, respectively. Verme and Ozoga (1980) documented that as little as a 10% reduction in caloric intake stunted fawn growth. They concluded that gross energy consumption was more important than

dietary protein in supporting growth and lipogenesis of fawns in autumn. Verme and Ullrey (1984) pointed out, however, that fawns generally are malnourished in winter (in the northern climates) and serious body weight loss may occur, resulting in an increased susceptibility to mortality.

Attainment of Puberty

Though some researchers have attempted to specify the size at which puberty is reached (Moen 1973), this phenomenon is a relative physiological state that usually determines when a whitetail is able to produce viable gametes. Because it is well known that deer reach puberty at different ages in different regions containing different habitats, it is believed that these differences in breeding ages are attributable to differences in nutritional intake or habitat quality (Kirkpatrick 1983). Morton and Cheatum (1946), Haugen and Trauger (1962), and Ransom (1967) all have shown that the percentage of fawns breeding varied in different regions of their study areas or over time. These studies, however, did not implicate specific nutritional factors.

Robinette et al. (1973) compared the reproductive performance of captive mule deer fawns fed high levels of concentrates over a 2-year period (1969-71) to fawns fed lesser amounts of concentrates over a 4-year period (1963-67) and found that fawn breeding increased from 0% to 30% with improved nutrition.

Abler et al. (1976) utilized a 2 x 2 factorial experimental design to determine the relative importance of energy and protein on attainment of puberty. They found that 82% of fawns on high energy diets reached puberty (had ovulated), while none of 8 fawns on the low energy diet had ovulated. The investigators used a plasma progesterone level of 1.0 ng as indication of ovulation. Protein intake, however, was not found to have any significant affect on the attainment of puberty, further reinforcing the importance of digestible energy over protein.

Antler Development

Proper antler formation can be essential to the successful courtship and social ranking of a buck (Verme and Ullrey 1984). Antler measurements have been used extensively by researchers and wildlife biologists to assess herd condition (to be discussed later) and are believed to reflect nutritional deficiencies.

Using unpublished data provided by the Michigan Department of Natural Resources, Ullrey (1983) showed a strong correlation between antler beam diameters of 1.5-year-old bucks killed during autumn and spring mandibular marrow fat levels of 1-year-old does from 3 different regions (both measurements occurring in the same calendar year). Mandibular fat concentrations and antler beam diameters tended to be highest in Region III. He surmized that because Region III was highly agricultural, deer food (presumably digestible energy) was much more available at critical times of the year.

In a controlled experiment, bucks were fed a complete diet *ad libitum* or at 80 or 60% *ad libitum* from weaning to 2.5 years of age (Ullrey 1983). Antler beam diameters were significantly smaller ($P < 0.05$) for the most severely restricted deer as compared to the other 2 groups. Sample sizes within groups were no greater than 3 individuals, however. French et al. (1955) fed bucks a complete diet *ad libitum* or 50% *ad libitum* from weaning to 1.5 years of age. The restricted bucks had significantly lower mean antler beam diameters (11.4 mm vs. 20.6 mm). It is apparent from the preceding that energy restrictions can have detrimental effects on antler development.

In an attempt to determine the effects of dietary crude protein levels on antlerogenesis, French et al. (1955) fed buck fawns diets containing 4.5, 9.5, and 16% crude protein from weaning to 1.5 years of age. Deer on the lower rations had average antler beam diameters and main beam lengths of 10.2 mm and 2.5 cm, respectively, compared to deer fed the highest ration with antler beam diameters and main beam lengths ranging from 17.8-22.9 mm and 33.0-38.1 cm, respectively. Sim-

ulating the timing of spring green-up, Ullrey (1983) subjected buck fawns to a low protein diet (7%) from late October to late March (early green-up) or late October to late April (late green-up) followed by a 16% crude protein diet until removal of antlers at 1.5 years of age. Only the number of antler points were statistically significant (early 5.6 vs. late 2.5). He did believe, however, that the trends in the data suggested that the timing of protein and most likely digestible energy availability (the earlier the better) in relation to antlerogenesis may be important for normal antler development.

Deer Herd and Habitat Assessment Studies

Assessing the condition of wild animal populations has long been the concern of federal and state agencies in charge of monitoring and managing populations of game and nongame species. Indices reflecting the nutritional status of individuals or groups of animals or the quality of their habitat have been commonly and successfully used. To assess the nutritional condition of white-tailed deer and the quality of their habitat, body and antler measurements, fat stores, blood parameters, reproductive indices, and soil measurements have been used by researchers and will be reviewed herein.

Body and Antler Characteristics

In an attempt to assess the physical condition of different deer herds in New York, Hesselton and Sauer (1973) collected data on hunter-killed deer in January 1965, 1966, and 1967 at 4 locations spread throughout the state. They found significant differences in whole and dressed body weights between areas among fawns and yearlings, suggesting differences in habitat quality between areas. Severinghaus (1979) summarized dressed body weights of yearling bucks from 5 regions of New York collected from 1945 to 1958. He found significant differences between regions with average

dressed body weights ranging from 41.3-53.8 kg. In Mississippi, Jacobson et al. (1981) summarized hunter-harvest data (1976-1981) collected from 9 areas throughout the state and documented significant differences between areas in dressed body weights among age classes and sexes. Stoll and Parker (1986) reported significantly ($P < 0.05$) heavier dressed body weights of does collected from the farmland region of Ohio as compared to the hill country of Ohio, indicative of better nutrition associated with increased quantity and/or quality of forages found in farmland habitat.

Hesselton and Sauer (1973) also used hind foot length in their assessment of the 4 deer herds. Although they found significant differences in hind foot length between areas among age classes, the index did not rank the deer herds the same as did whole and dressed body weights. They believed that because of inconsistencies not controllable, hindfoot length was not a good indicator of physical condition of deer or range condition. Klein (1964), however, successfully used a ratio of femur length to hind foot length to compare nutritional status of 2 populations of Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) in Alaska. A low femur/hind foot ratio was indicative of poor nutrition, while a high ratio reflected a good level of nutrition. McEwan and Wood (1966) used a body weight/hind foot ratio as an index of growth rate and long-term nutritional status in captive and wild-reared Barren ground caribou (*Rangifer arcticus*).

Using antler beam diameters of yearling bucks, Severinghaus et al. (1950) attempted to assess regional deer herd condition in New York. In their study, variations in antler beam diameter between 5 regions were evident and correlated with range quality. Hesselton and Sauer (1973) also used this measurement in their assessment efforts and found that antler beam diameters of yearling bucks ranked the 4 areas in the same order as dressed weights. Jacobson et al. (1981) reported significant differences in the number of antler points, antler beam circumference, and antler beam length for yearling and 2.5+ -year-old bucks between areas in Mississippi. Severinghaus and Moen (1983) expanded the data set of Severinghaus et al. (1950) to include antler beam diameters of yearling bucks collected from 1950 to 1979. They found significant differences among regions with values ranging from 15.0-18.7 mm. Using a different antler measurement, Scribner et al. (1984)

found significant differences in the incidence of spike bucks collected from swamp and upland habitat types on the Savannah River Plant in South Carolina. They believed that these differences were the result of density-dependent factors combined with qualitative habitat differences. Stoll and Parker (1986) reported significantly larger antler beam diameters and more antler points in yearling bucks collected from the farmland region of Ohio as compared to the hill country of Ohio.

As Kirkpatrick (1980) pointed out, antler characteristics can be affected by many nutritional factors, thus making differences among or between areas or collecting periods difficult to interpret. Antler characteristics are useful in detecting chronic habitat differences, however.

Fat Stores

Of the fat indices, femur marrow fat is the most widely used and known. This technique originally employed a visual, subjective estimation of fat content based on color and consistency (Cheatum 1949a). Though many other methods have been developed to quantify this index, ether extraction as described by Warren and Kirkpatrick (1978) is probably the most accurate. Harris (1945) and Cheatum (1949a) were the first investigators to use femur marrow fat to determine the nutritional status of dead deer found in the northern U.S. They documented low marrow fat levels and concluded that animals had succumbed to starvation, since marrow fat is the last fat store to be utilized. Riney (1955) developed his own subjective rating scheme for femur marrow fat levels and used this, along with other indices, to assess the condition of red deer (*Cervus elaphus*) in New Zealand. Finally, Stockle et al. (1978) documented a significant correlation ($P = 0.001$, $r = 0.314$) between femur marrow fat levels to a subjective overall physical condition rating in white-tailed deer collected during all seasons throughout the Southeast; however, they believed that femur marrow fat, by itself, was not a reliable indicator of physical condition.

More recently, the amount of mandibular marrow fat has been developed as an index to reflect fat stores in relation to nutritional status. Baker and Lueth (1966) collected mandibles of white-tailed deer in Alabama from February through August, 1965, and quantitatively estimated mandibular marrow fat levels. A fairly high correlation between this fat and a subjective overall physical condition rating was documented ($r=0.478$). From deer mandibles collected on wildlife management areas in Tennessee, Nichols and Pelton (1972, 1974) replicated the work of Baker and Lueth (1966). Both sets of investigators reported that mandibular marrow fat separated deer into more distinguishable condition classes than does fat from the femur marrow tissues. However, it must be reiterated that bone marrow is the last source of fat to be catabolized; thus, only chronic nutritional deficiencies are detectable.

The last index of fat stores considered was kidney fat levels. Riney (1955) developed the kidney fat index for red deer in New Zealand. The index consisted of dividing the weight of perirenal fat (that associated with the kidney) by the weight of the fat-free kidney and expressing it as a percentage by multiplying by 100. He found the index to be the most reliable of several indicators in assessing nutritional status in all seasons. Ransom (1965) used the kidney fat index in conjunction with femur marrow fat levels to assess the physical condition of female whitetails in Manitoba. He noted that when the kidney fat index fell below 30%, it was imperative also to use femur marrow fat levels. Hesselton and Sauer (1973) used the kidney fat index, along with other indices, to assess the physical condition of 4 deer herds in New York. Though they did not determine statistical significance between herds for the index, significant differences ($P < 0.05$) between herds were reported for kidney weights and kidney fat. They concluded that because the kidney fat index varied dramatically within age classes and herds, the kidney fat index was not a reliable indicator of physical condition. Stokle et al. (1978) subjectively ranked kidney fat levels in 3 categories--low, moderate, and high. They found that kidney fat rankings were significantly correlated ($P = 0.001$, $r = 0.715$) to their overall physical condition ranking and concluded that kidney fat was far superior to other indices as an indicator of condition. Finally, Finger et al. (1981) attempted to correlate the kidney fat index (using total perirenal fat instead of only perirenal fat on

the kidney) and total body fat in white-tailed deer in South Carolina. They reported a significant correlation ($P < 0.01$, $r = 0.87$) between the 2 measurements, indicative of the usefulness of kidney fat levels in reflecting physical condition of white-tailed deer. Because kidney weights fluctuate seasonally (Batcheler and Clarke 1970, Dauphine 1975), the kidney fat index should only be used to compare areas or populations within a season.

Blood Parameters

The measurement of blood chemistries in studies of captive white-tailed deer has yielded many potential indices of nutritional condition (Seal 1977). However, the application of these indices for the above purpose in field studies is virtually nonexistent in the published literature. As Seal (1977) pointed out, no single assay is adequate for assessment of condition; instead, a combination or series of assays reflecting energy and protein nutrition must be used.

Coblentz (1975) documented a downward trend in serum cholesterol levels in George Reserve deer from October 1970 through January 1971. He believed that this reflected the quantity and/or quality of the forage in the animals' diet, and may have value as an index of nutritional condition. Seal and Jones (1978) compared blood urea nitrogen and glucose levels from 2 high density populations of free-ranging deer and found that when compared to control animals, only 1 of the 2 populations was relatively deficient with respect to both dietary protein and energy nutrition. Seal et al. (1978) collected blood samples from 4 closely located deer populations in Minnesota occupying areas with vegetation of differing composition and age. They found highly significant differences between populations for 8 assays including red blood cell counts, mean corpuscular volume, mean corpuscular hemoglobin content, blood urea nitrogen, cholesterol, lactic dehydrogenase, thyroxine, and nonesterified fatty acids. They believed that the differences appeared to be nutritionally related because the indices appeared to be correlated with the quality of the habitat. For a thorough review of the effects of nutrition on blood components in captive white-tailed deer see

Warren (1979) and Card (1981). There are problems associated with the use of blood parameters as indices of nutritional condition, however. They include stress of collection, daily rhythms of blood components, seasonal fluctuations, and age and sex of the animal (Kirkpatrick 1980).

Reproductive Indices

Two of the most reliable indicators of reproduction are corpora lutea and fetal counts conducted on female reproductive tracts. Hesselton and Sauer (1973) used fetal counts in their assessment. Though not statistically determined, they reported differences in the number of fetuses per doe between herds. The most noticeable difference was among fawns with values ranging from 0.03-0.48 fetuses/doe. Jacobson et al. (1981) also did not do a statistical analysis of their data, but showed that the number of corpora lutea/doe for yearling and 2.5+ -year-old does tended to be positively related to soil fertility. Summarizing earlier work conducted in New York from 1936-54 by Cheatum and Severinghaus (1950) and Severinghaus (1954) and from 1961-68 by Hesselton and Jackson (1974), Severinghaus and Moen (1983) reported fawn reproductive rates of 5 regions ranging from 0.09-0.41 fetuses/doe. These values followed the same trend as antler beam diameters of yearling bucks and were believed to be related to range condition within each region.

Soil Measurements

Soil fertility has been readily accepted as an important factor in determining population size and condition of wild animals. Several studies involving small mammals have shown various physical and reproductive measurements to be possibly related to soil quality (Allen 1954, Steen 1955, Williams and Caskey 1965). In white-tailed deer, researchers have shown larger body size, better antler development, and greater productivity for deer collected on fertile soils than those collected on poorer soils (Sweet and Wright 1953, Wesley et al. 1969, Short 1969, Thorsland 1966, Jacobson et al. 1977, Jacobson 1981). Most of these studies have been limited to a subjective

ranking or qualitative assessment of soil fertility. The studies conducted by Jacobson et al. (1977) and Jacobson (1981), however, employed quantitative analyses of soil characteristics and warrant further review.

In an attempt to determine possible relationships between selected soil properties and body weight, antler growth, and reproductive characteristics of white-tailed deer, Jacobson et al. (1977) collected soil samples and obtained physiological data on age, dressed weight, antler characteristics, and ovarian indices of deer from 9 areas throughout Mississippi. Though use of statistical procedures were noted by the authors, statistical significance of the results were not mentioned. Of the deer characteristics measured, only dressed body weight among all sex and age classes tended to show a positive relationship with soil properties. In particular, the authors noted an apparent relationship between soil calcium and phosphate levels and dressed body weight.

Jacobson (1981) furthered the above study by testing the hypothesis that deer dressed body weights within each sex and age class and antler characteristics of yearling and 2.5+ -year-old bucks were directly related to soil nutrient levels. Using the data in the above study, he also collected soil samples and obtained dressed body weights and antler measurements from an additional 14 areas throughout Mississippi. He found significant correlations ($P < 0.05$) between all soil measurements (pH, organic matter, calcium, phosphate, magnesium, and potash) and dressed body weights in all sex and age classes. Upon employing stepwise multiple regression analysis, phosphate was the first variable to enter for all weight equations except fawn females. Yearling buck antler beam circumference and length was significantly correlated ($P < 0.05$) with some soil properties. In general, however, antler correlations were weaker than body weight correlations and inconsistent between age classes and between spike- and fork-antlered yearlings. The author concluded by pointing out that soil mineral levels, particularly phosphate levels, could be used as a "site index" to deer growth potential.

Study Areas

High Knob

Two areas were studied during this investigation--a main study site and a control or reference area. The main study site was located on the Clinch Ranger District of the Jefferson National Forest in parts of Wise and Scott counties, Virginia, (Figure 3) and is referred to as High Knob (HK). High Knob is positioned approximately 8 km southeast of Norton, Virginia and is on the edge of the Ridge and Valley and Appalachian Plateau Physiographic Provinces. Excessively steep slopes with their associated ridges and hollows dominate the topography. Elevations ranged from 530 m to 1269 m.

The soils found on the HK area are shallow to moderately deep, excessively drained, have a loamy texture, and are derived from a noncalcareous sandstone and shale mixed parent material (Perry et al. 1954). However, approximately 85% of the soils have a moderate to high productivity potential (site index 21-27 m for upland oaks at base age 50) for tree growth (USDA 1985).

The 14,500-ha area is dominated in the overstory by deciduous hardwood species. From U.S. Forest Service (USFS) forest stand data, it was estimated that yellow poplar - white oak - northern

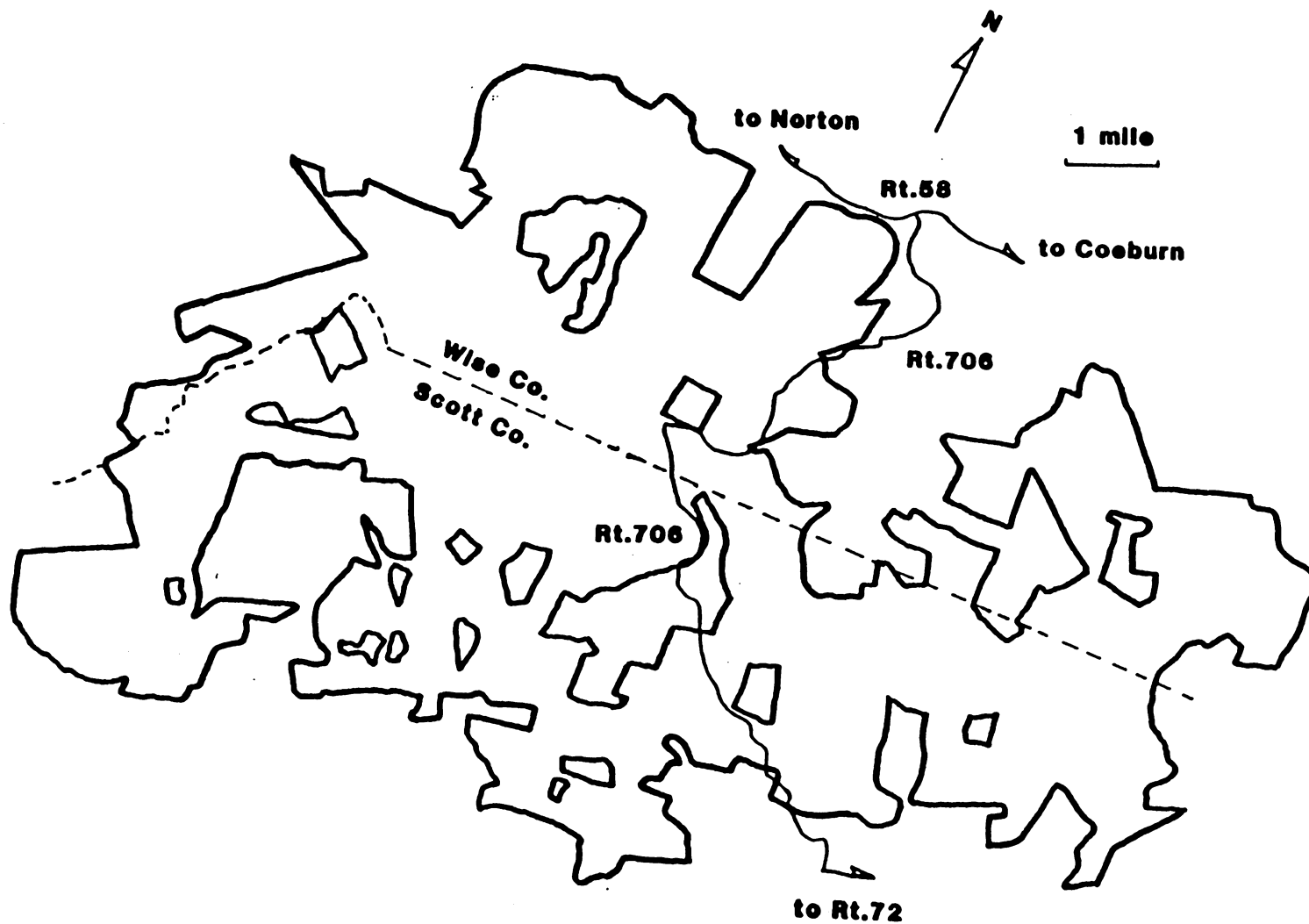


Figure 3. The location of the High Knob study area.

red oak (*Liriodendron tulipifera* - *Quercus alba* - *Q. rubra*) and white oak - northern red oak - hickory (*Carya* spp.) forest cover types composed 47.1% and 47.3% of the area, respectively. Pure stands of yellow poplar composed less than 1% of the area. From field observations, however, I believe that nearly all of the stands designated as yellow poplar - white oak - northern red oak were dominated by yellow poplar. Only 1.3% of the area is comprised of coniferous forest types, most of which is white pine (*Pinus strobus*). On harsher, more exposed, southwesterly facing slopes, chestnut oak (*Q. prinus*) and scarlet oak (*Q. coccinea*) predominated in the overstory (approximately 1.2% of area) with near-impenetrable stands of mountain laurel (*Kalmia latifolia*) in the understory. By far the most abundant plants in the understory from March to October were various ferns. Also from USFS stand data, it was determined that site indexes at HK ranged from 13-34 with an average of 25 (height [m] at base age 50 for upland oaks).

Over a 10-year period (1977-86), the harvesting of timber on the area has fluctuated markedly until 1983; at which time the harvesting of timber steadily increased to a peak in 1986 (Figure 4). An index to this trend was noted by calculating the percent of the area composed of stands 0-5 years of age (Figure 5).

From 1975-85, the mean annual maximum and minimum temperatures were 18.1 C and 6.0 C, respectively (Table 1). Average annual precipitation and snowfall were 115.5 cm and 200.2 cm, respectively. Over the duration of the present study, winter temperature extremes tended to be less severe than the norm (Table 2). Winter precipitation was somewhat lower in 1985-86 and similar in 1986-87 than the norm (Table 2). Total snowfall was similar in 1985-86 and substantially lower in 1986-87 than the norm (Table 2). The number of days with snow accumulation 2.5-15.0 cm and > 15.0 cm in depth was 23 and 8, respectively, in 1985-86 and 17 and 3, respectively, in 1986-87.

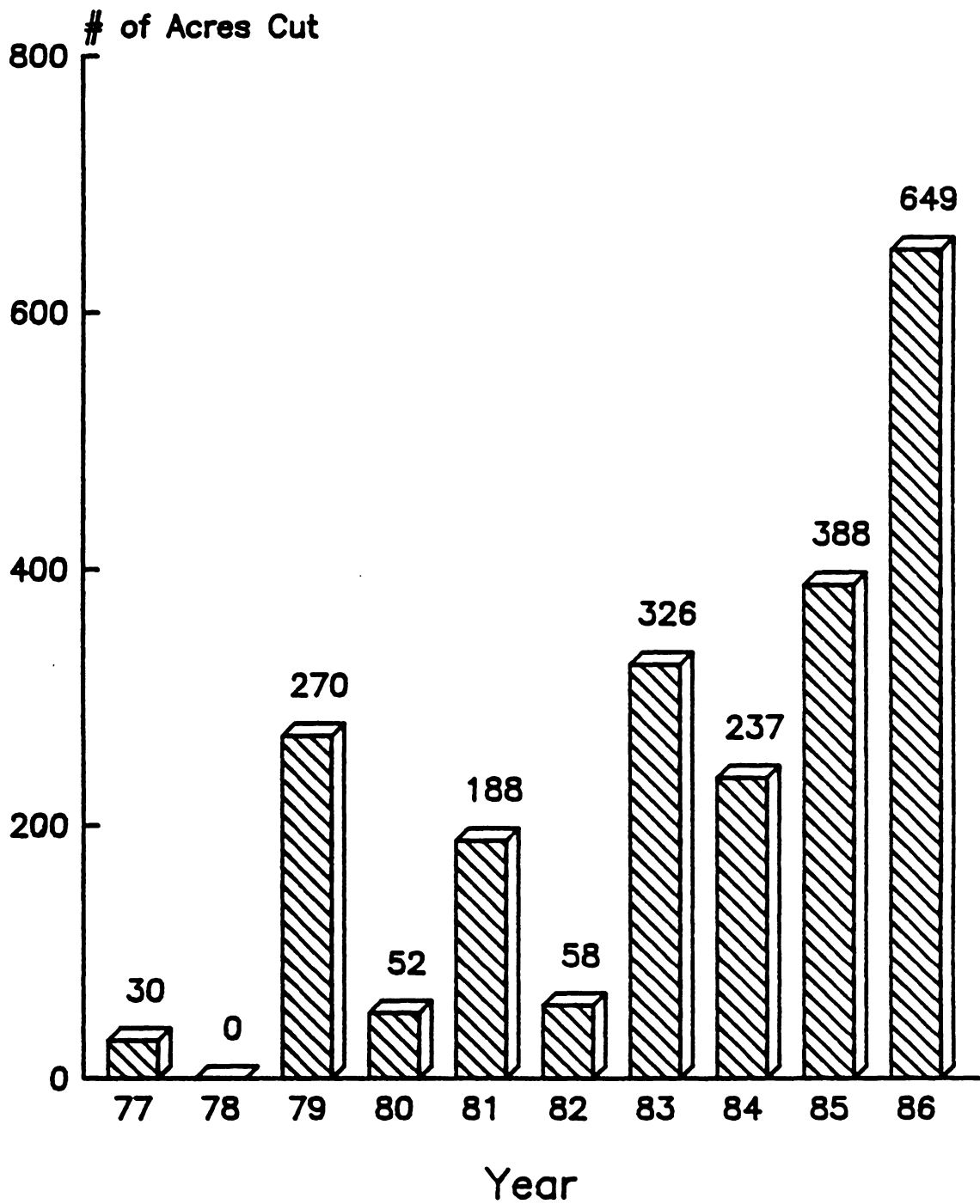


Figure 4. The number of hectares regenerated by clear-cutting within the High Knob study area from 1977-86.

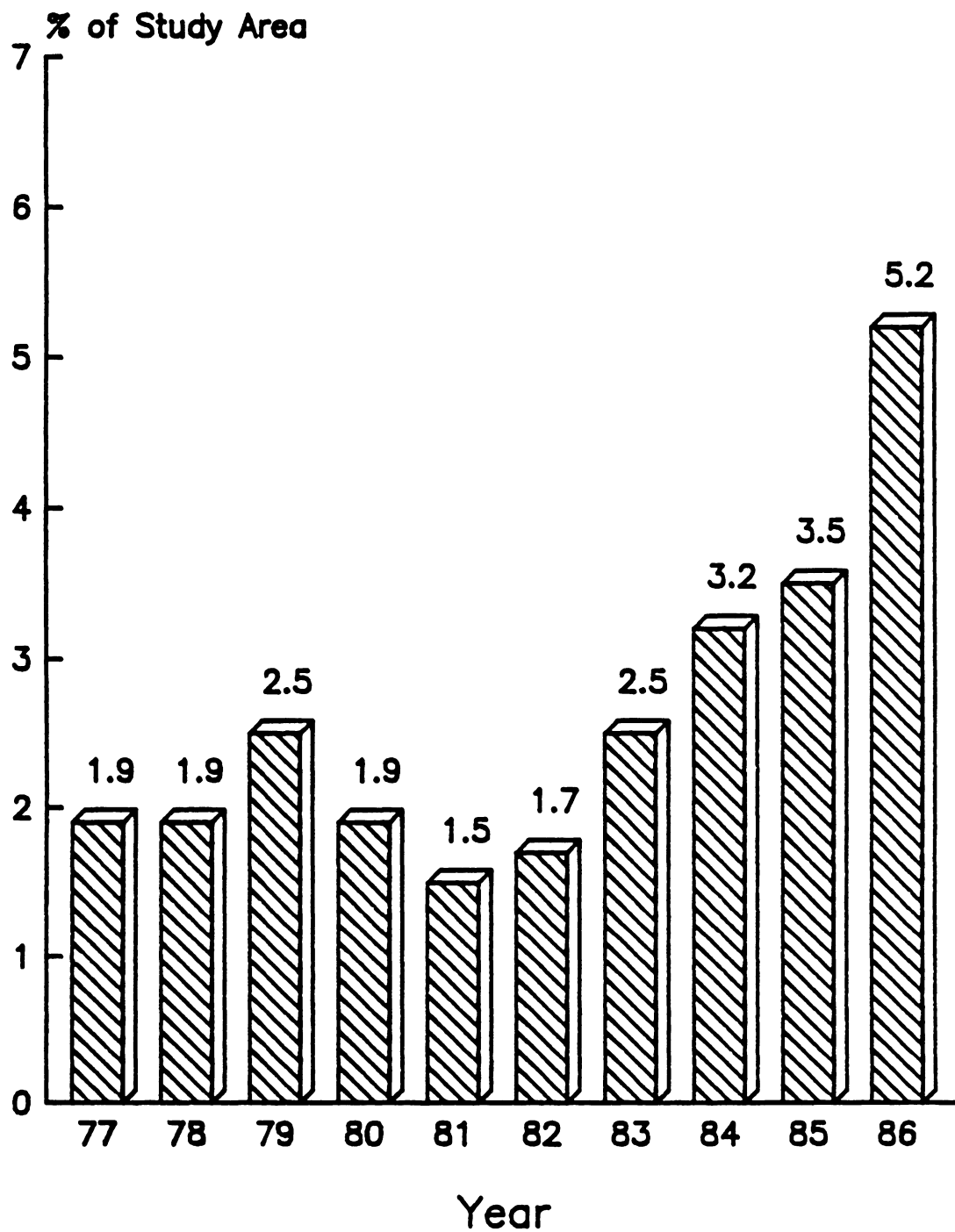


Figure 5. The percentage of the High Knob area in timber stands 0-5 years of age from 1977-86.

Table 1. The general characteristics of the High Knob and Stony Creek study areas.

Characteristic	High Knob	Stony Creek
Size (ha)	14500	9000
Elevation (m)	530-1269	610-1280
Mean Site Index (m, base age 50)	25	20
Forest Overstory Composition (%)		
Yellow popular dominated	47.1	5.9
Oak dominated	48.5	77.4
Conifer dominated	1.3	5.7
Mean Annual Temperature (C)		
Maximum	18.1	18.7
Minimum	6.0	5.2
Mean Annual Precipitation (cm)	115.5	97.5
Mean Annual Snowfall (cm)	200.2	55.8

Table 2. Winter weather patterns (1 Dec-31 Mar) at High Knob (HK) and Stony Creek (SC), Virginia, over an 11-year period (1974-85) and over the duration of the study.

Measurement	1974-85		1985-86		1986-87	
	HK	SC	HK	SC	HK	SC
Mean Temperature (C)						
Maximum	8.9	8.5	7.6	8.5	8.7	7.6
Minimum	-4.1	-2.7	-2.9	-2.8	-1.5	-1.9
Mean Precipitation (cm)	33.8	28.1	26.9	16.2	35.6	34.8
Mean Snowfall (cm)	188.2	50.7	172.5	35.8	97.5	114.6
Number of Days with Snow Accumulation (cm)						
2.5-15.0	-	-	23	17	16	17
> 15.0	-	-	8	0	3	18

Stony Creek

The control or reference area was located within the Stony Creek drainage of the Blacksburg Ranger District of the Jefferson National Forest in Giles county, Virginia, (Figure 6) and is referred to as Stony Creek (SC). This area was chosen because it had a history of high legal deer harvests, with deer reflecting good physical characteristics. The SC area is positioned approximately 22 km northwest of Blacksburg, Virginia and is within the Ridge and Valley Physiographic Province. Excessively steep slopes with their associated ridges and hollows also dominate the topography of this study area. Elevation ranged from 610 m to 1280 m.

The SC study area encompasses approximately 9,000 ha and is dominated in the overstory by deciduous hardwood species. From USFS forest stand data, it was estimated that yellow poplar - white oak - northern red oak and white oak - northern red oak - hickory forest cover types composed 5.9 and 73.7% of the area, respectively. Pure stands of yellow poplar again composed less than 1% of the area. Forest types dominated by coniferous species composed 5.7% of the area and included the following types: white pine, white pine-hemlock (*Tsuga canadensis*), hemlock, hemlock-hardwood, pitch pine (*P. rigida*)-hardwood, shortleaf pine (*P. echinata*), Virginia pine (*P. virginianus*), and pitch pine. This area also was similar to HK on the harsher, more exposed sites, with one exception. Chestnut and scarlet oak were accompanied by Virginia and table mountain pine (*P. pungens*) in the overstory (approximately 3.7% of area) with thick stands of mountain laurel in the understory. The most abundant plants found in the understory during the growing season were hog-peanut (*Amphicarpa bracteata*) and teaberry (*Gaultheria procumbens*). Also from USFS stand data, it was determined that site indexes ranged from 12-31 with an average of 20 (height [m] at base age 50 for upland oaks).

The soils found in the Blacksburg Ranger District are shallow to moderately deep, well drained, have a fine, loamy texture, and are derived from sedimentary rocks. Approximately 75%

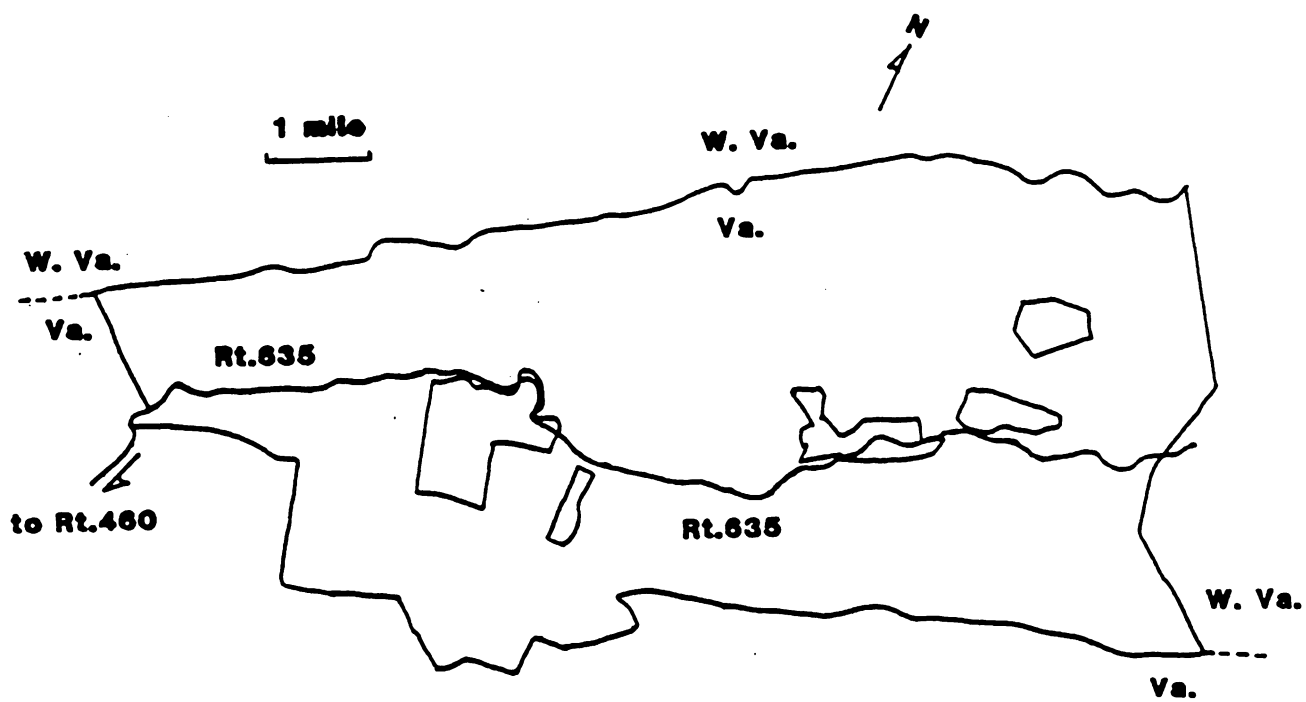


Figure 6. The location of the Stony Creek study area.

of the soils have a low potential for productivity (site index less than 21 m for upland oaks at base age 50) (Gaudette 1986).

Over a 10-year period (1977-86), the harvesting of timber on the area has remained at a somewhat low, but steady rate, with a peak occurring in 1983 (Figure 7). However, the percent of the area composed of stands 0-5 years of age has steadily increased over this time period (Figure 8).

From 1975-85, the mean annual maximum and minimum temperatures were 18.7 C and 5.2 C, respectively (Table 1). Average annual precipitation and snowfall were 97.5 cm and 55.8 cm, respectively. Over the duration of the study, winter temperature extremes also tended to be less severe than the norm (Table 2). Winter precipitation was substantially lower in 1985-86 and slightly higher in 1986-87 than the norm (Table 2). Total snowfall was slightly lower in 1985-86 and substantially greater in 1986-87 than the norm (Table 2). The number of days with snow accumulation 2.5-15.0 cm and > 15.0 cm in depth was 17 and 0, respectively, in 1985-86 and 17 and 18, respectively, in 1986-87.

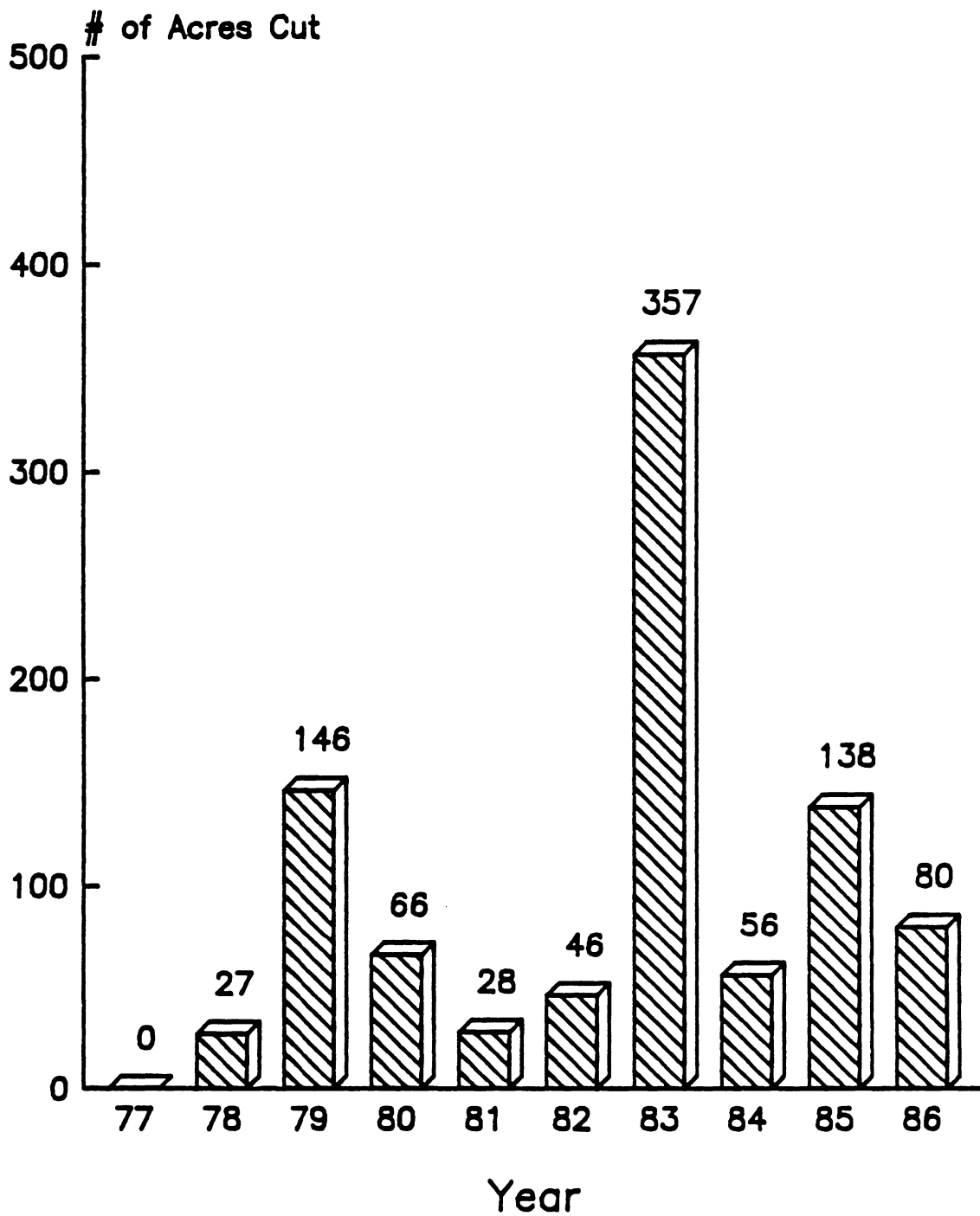


Figure 7. The number of hectares regenerated by clear-cutting within the Stony Creek study area from 1977-86.

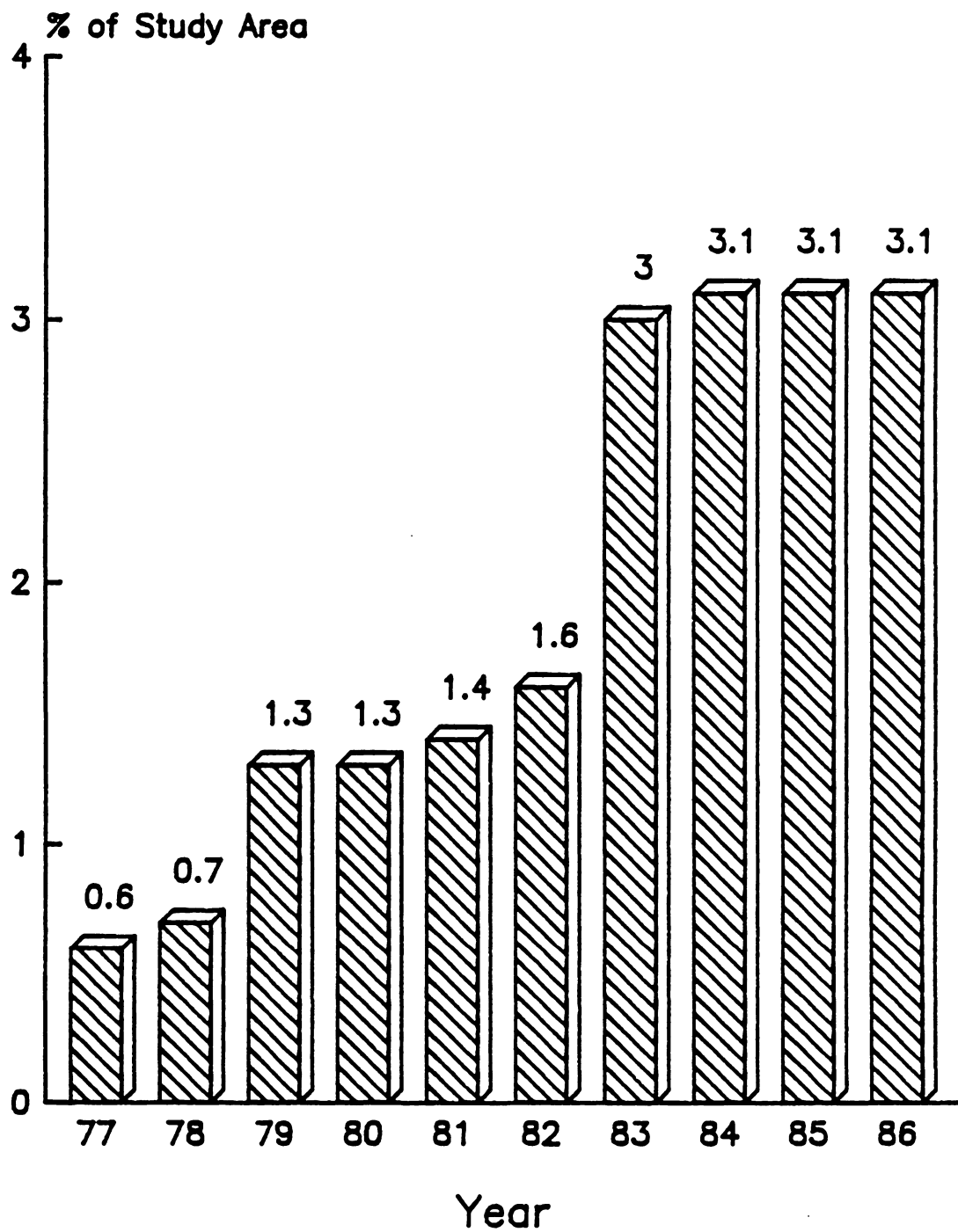


Figure 8. The percentage of the Stony Creek area in timber stands 0-5 years of age from 1977-86.

Methods

Relative Deer Abundance

In March, 1986, 5 transects were established on HK for conducting pellet group counts and thereby obtaining a relative index of deer density. Previous to this study, Gaudette (1986) in February and March, 1985, had established 6 transects for the same purpose on the SC study area. In almost all cases, each transect extended from the valley bottom to the ridgetop or mountaintop in a direction diagonal to the main contours of the mountainside to avoid following a spur ridge or hollow for great distances. Also, an attempt was made to position each transect so that differing aspects, slopes, and overstory cover types were sampled proportionate to their occurrence on the study areas. Transects varied in length from 898-2500 m depending on valley width and study area.

Beginning at a random distance from the start of each transect, 0.004-ha circular plots (3.6 m radius) were established at 50-m intervals. A total of 250 plots was established at HK and 173 plots at SC. At each plot, the center was marked with vinyl flagging (for future relocation) and the number of deer pellet groups on top of the leaf litter were recorded (Overton 1971). Pellet group counts were conducted in late winter (February and March), 1986 and 1987, on the relocated plots in both study areas.

Nutritional Assessment

Hunter Harvest Data

Data from hunter-killed deer on both study areas over the periods of November 18-30, 1985, and November 17-29, 1986 were obtained with the cooperation of the Virginia Department of Game and Inland Fisheries (VDGIF). Information recorded included dressed (eviscerated) body weights of yearling males to the nearest pound (later converted to kilograms) and antler beam diameters (2.5 cm above the burr) and the number of antler points (2.5 cm or greater in length) of 1.5- and 2.5+ -year-old males.

Deer Collections

From September 3-26, 1985, March 24-27, 1986, and March 23-25, 1987, a total of 60 white-tailed deer was collected by VDGIF personnel--10 from each area during each sampling period. Each deer sacrificed was killed by a rifle shot to the neck between 1700 and 0600 hours. From each deer the following were obtained: body weights and other physical characteristics, 3 vials (15-cc each) of whole blood, 3 vials (10-cc each) of heparinized whole blood, kidneys with perirenal fat attached, right femur, both mandibles, reproductive tract, rumen contents, abomasum contents (September collection only), and fecal sample.

Physical Measurements

Ages of deer were estimated by tooth replacement and wear (Severinghaus 1949). Whole body weight and dressed body weight were recorded for each deer to the nearest pound (later converted to kilograms). The length (cm) of the femur and right hind foot, from the tip of the hoof

to the end of the tuber calcis, was measured and used in a ratio (femur to hind foot) as described by Klein (1964). Also noted for each deer was its sex.

Blood Collection and Analysis

Blood was collected within 5 minutes of death (Wesson et al. 1979), and drawn via heart puncture using 15-ml evacuated blood tubes and 20-gauge, 38-mm needles. Also within 15 minutes, two 5-ml heparinized whole blood aliquots were deproteinized with a premeasured, 5-ml quantity of ice-cold perchloric acid (Mellanby and Williamson 1974) for later analysis of beta-hydroxybutyrate (March collections only). All samples were stored on wet ice. Within 18 hours after blood collection, serum, plasma, and deproteinized plasma was extracted from all samples via centrifugation using a clinical centrifuge for 15 minutes. Each filtrate was then pipetted in 1 to 4 ml aliquots into 5 ml polypropylene bacterial culture tubes and frozen. Also at this time, packed-cell volume (PCV) was determined from heparinized whole blood using a hematocrit centrifuge.

Serum samples were later analyzed for total protein, urea nitrogen, total cholesterol, triglycerides, nonesterified fatty acids, calcium, phosphorus, sodium, potassium, and glucose. All of the above analyses, except nonesterified fatty acids, were conducted on an automated clinical chemistry analyzer by Pathologists' Service Professional Associates, Inc., Tucker, Georgia, 30084, USA. The analysis for nonesterified fatty acids was completed in the physiology laboratory in Cheatham Hall, VPI & SU, using an enzymatic colorimetric test kit purchased from Wako Chemicals, Inc., Dallas, Texas, 75234, USA.

The deproteinized plasma samples were further prepared for B-HB analysis by thawing and carefully neutralizing with potassium hydroxide. Once neutralized, procedures described by Card (1981:144) were followed with one exception--final whole blood concentrations were calculated as described by Mellanby and Williamson (1974).

Stored Fat Analysis

Kidneys, femurs, and mandibles were placed in self-sealing plastic bags and stored on wet ice while in the field and frozen within 18 hours. Kidneys with their perirenal fat attached were used to determine the kidney fat index as describe by Riney (1955) with one exception--a third cut parallel to the long axis and tangent to the lobes of the kidney was made. Both kidneys were used in calculating a final (or average) kidney fat index for each animal. The right femur and mandible were analyzed for femur marrow fat and mandibular marrow fat, respectively, by ether extraction (Warren and Kirkpatrick 1978) and expressed on a dry-weight basis.

Reproductive Measures

Each uterus with attached ovaries or scrotum with testes was placed in a self-sealing plastic bag and stored on wet ice while in the field and frozen within 18 hours. All ovaries removed from uteri were preserved in formalin after thawing. Once hardened by the formalin, each ovary was sliced parallel to its long axis in 1- to 2-mm sections (Cheatham 1949b). Ovaries collected in September were macroscopically searched for corpora rubra and corpora lutea as evidence of the previous year's reproduction and current ovulation or pregnancy, respectively. Ovaries collected in March were examined for corpora lutea as evidence of pregnancy, or in combination with fetal data, as evidence of potential prenatal mortality.

Each gravid uterus collected in March was carefully opened to expose the number of fetuses within. Each fetus was weighed to the nearest 0.1 g and measured from crown to rump to the nearest 0.1 cm.

All scrota collected were carefully opened to expose the testes, which were then separated from the epididymides and vas deferens. Testes were weighed to the nearest 0.1 g.

Gastrointestinal Tract Analysis

Each intact rumen was opened and the contents collected in a plastic tub. After a thorough

mixing, an approximate 750-cc random sample was preserved in 10% formalin for future macroscopic food habits analysis. Another approximate 750-cc random sample was placed in a self-sealing plastic bag, stored on wet ice while in the field, and frozen within 18 hours. During the September collection, abomasums were opened and scraped by VDGIF personnel and the contents were preserved in 10% formalin for later parasite counts (Eve and Kellogg 1977).

Treatment of preserved rumen samples followed the procedure described by Puglisi et al. (1978). After washing, all retained items were separated into 8 broad categories: (1) Fruits, (2) Leaves--separated into deciduous woody, evergreen woody, evergreen forb, and herbaceous forb, (3) Stems--woody or herbaceous, (4) Buds, (5) Fungi, (6) Ferns, (7) Grasses, and (8) Roots--tubers or fibrous. The plant parts were identified to genus or species whenever possible. All food items were quantified volumetrically to the nearest 1 ml and on a dry-weight basis to the nearest 0.01 g. Percent frequency of occurrence and aggregate percent volume and percent weight were calculated for each food item from the same area and sampling period.

Subsamples of the frozen rumen samples were freeze-dried and ground in a Wiley mill to pass through a 2-mm screen. Moisture-free samples were analyzed for percent neutral detergent fiber, percent acid detergent fiber, and percent lignin via methods described by Van Soest (1967) and percent crude protein via the Kjeldahl method (AOAC 1980). All of the above analyses, except lignin, were conducted by the Forage Testing Laboratory, VPI & SU. Lignin content was determined by the author. Percent neutral detergent solubles (100 - % neutral detergent fiber) and percent lignin were used to predict rumen content digestibility via a regression equation developed by Mould and Robbins (1982).

In accordance with procedures described by Prestwood et al. (1973), abomasal parasite counts were conducted by VDGIF personnel on the abomasum contents. Results of abomasal parasite counts conducted on 5 deer collected from each study area in September, 1984, also were obtained from the VDGIF.

Fecal Analysis

Each fecal sample was placed in a glass jar with a lid and within 18 hours placed in a forced-air oven to dry at 50 C. After drying, each fecal sample was ground in a benchtop Wiley mill to pass through a 1-mm screen. Moisture-free samples were analyzed for acid detergent fiber via methods described by Van Soest (1967) and crude protein via the Kjeldahl method (AOAC 1980). All of the above analyses were conducted by the Forage Testing Laboratory, VPI & SU. These 2 fractions also were used to calculate a fiber to protein ratio.

Habitat Assessment

Soil Measurements

In late September, 1986, through early October, 1986, soil sampling was conducted on both areas. Beginning randomly at either the first, second, or third plot of each transect at HK or the first or second plot of each transect at SC, every third pellet group plot of each transect at HK and every second pellet group plot of each transect at SC was revisited. At each plot, all leaf litter and duff were removed and the top 15 to 20 cm of mineral soil was collected, placed in a self-sealing plastic bag, and labeled by transect, plot, and slope position. A total of 82 samples was collected at each area. All soil samples were submitted to the Soil Testing Laboratory, VPI & SU, and analyzed for pH, percent organic matter, and calcium, phosphorus, magnesium, and potassium in parts per million.

Forage Abundance

From August 29, 1986 to September 16, 1986, a double sampling, clip and weigh method (Gysel and Lyon 1980), with some modifications, was used to estimate the relative quantities of 7

forage classes on the two areas. At every relocated pellet group plot center, the nearest edge (to the center of the pellet group plot) of a 1 x 1 x 1.5 m volumetric plot was randomly established on either side of the transect within a 0.5-5 m distance. This was done to alleviate any potential inaccuracy due to vegetation degrading at plot center from previous sampling. Ocular estimates of the percent volume space occupied by woody leaves¹, forbs², grasses³, fungi⁴, soft mast⁵, hard mast⁶, and vines⁷ for each category were conducted by the same observer. The first major modification to the technique was to clip only 1 random quarter section of the volume space, alleviating the time element involved in clipping a plot of this size. However, vegetation was not evenly distributed within each volumetric plot, resulting in the potential to have a positive ocular estimate for a particular forage class and not have anything to clip in the quarter section. Therefore, before the quarter section was clipped, another ocular estimate of the volume space occupied by the 7 forage classes within the quarter section was made. Thus, at a subsample of points along each transect, an ocular estimate for each forage class present in the predetermined quarter section was made, the forage clipped, placed in a self-sealing plastic bag, and labeled. A total of 25 plots out of 250 was clipped at HK and a total of 18 plots out of 173 was clipped at SC. Upon return from the field, all forage clipped was temporarily frozen and eventually dried in a forced-air oven at 50 C and weighed to the nearest 0.01 g.

Because it is readily apparent that all deciduous woody leaves, herbaceous forbs, forest grasses, soft mast, most likely hard mast, and deciduous vine leaves are not part of the winter forage base in March, the above technique was not repeated at this time. It was believed that reasonable

¹ includes the leaves of evergreen (both conifer and broad-leaved) and deciduous tree and shrub species

² includes the leaves of ferns and evergreen and herbaceous plants that do not have the ability to "climb" or take on a shrubby growth form

³ includes only grasses found within the boundaries of an existing or regenerating forest stand

⁴ includes any type of fungal growth

⁵ includes all fleshy fruits of any plant, tree, or shrub

⁶ includes only fruits with a noticeably hardened outer shell

⁷ includes the leaves of all plants that are known as having the ability to "climb"

estimates of forage quantities, for comparative purposes between areas, of the remaining vegetative categories could be determined from the data collected in September. The percentages of evergreen species composing the estimated quantities of woody leaves and forbs in September were derived by calculating the frequency of occurrence of deciduous and evergreen species at clipped and unclipped plots. These percentages were then multiplied by the September estimate of their respective vegetative class to derive an estimated quantity of evergreen woody leaves and evergreen forbs in March 1987.

To compare potential oak mast abundance between areas, annual oak mast surveys conducted by the VDGIF since 1973 were obtained. At each area, 8 mature oak trees, 4 white oak and 4 red oak, were selected along an elevation gradient. One tree of each oak group was positioned at a low, medium (south exposure), medium (north exposure), and high elevation. In September of each year, each tree was relocated and acorns counted on 10 randomly selected limbs in the upper canopy using binoculars. The counts are totaled over the 8 trees and divided by 80 to derive an average number of acorns/limb index to reflect mast abundance.

Forage Quality

In late September, 1986 and late March, 1987, common deer forages were collected on both areas along the previously mentioned transects. Specifically, collections included succulent leaves of sourwood (*Oxydendrum arboreum*), sassafras (*Sassafras albidum*), and greenbrier (*Smilax* spp.) in September, and leaves of rhododendron (*Rhododendron maximum*), mountain laurel, teaberry, and galax (*Galax aphylla*) in March. An attempt was made to collect 10 samples of each forage on each area; however, due to availability of certain forages, sample size varied between areas. Direct utilization of these forages by deer on both areas was evidenced by either field observation or food habits results.

Upon returning from the field, all forage samples were frozen for later analysis. Forage samples were eventually dried in a forced-air oven at 50 C and ground in a benchtop Wiley mill to pass through a 1-mm screen. Moisture-free samples were analyzed for percent neutral detergent fiber, percent acid detergent fiber, and percent lignin via methods described by Van Soest (1967) and percent crude protein via the Kjeldahl method (AOAC 1980). All of the above analyses, except lignin, were conducted by the Forage Testing Laboratory, VPI & SU. Lignin content was determined by the author. Percent neutral detergent solubles (100 - % neutral detergent fiber) and percent lignin were utilized to predict forage digestibility via a regression equation developed by Mould and Robbins (1982).

Extent of Poaching and Free-roaming Dogs

An attempt was made to derive an index or a relationship between county game violations and county per capita income, hypothesizing that these two attributes might be inversely related. Data on game violations, however, were deemed inaccessible rather late in the study, subsequently terminating this idea. Therefore, methods used to address this issue consisted of a factual and current review of the literature.

An index approach was also used to address the issue of free-roaming dogs. Since 1979, VDGIF Area Game Managers have been conducting track counts at scent stations throughout Virginia. In late fall of each year, 100 scent stations were created and baited using a fatty acid (1979-1983) or a can of sardines (1984-1986). Once baited, the stations were checked for tracks during 2 consecutive days. Not only were furbearer tracks recorded, but feral dog and cat tracks as well. Thus, it was believed that these data would provide an adequate and relatively good indication to the extent of free-roaming dogs for comparative purposes.

Statistical Analysis

The main emphasis of this study was to determine if significant differences occurred between HK and SC. Several of the data sets have multiple levels of other variables of key importance. Thus, most data sets were easily set up in an analysis of variance (ANOVA) design. Statistical significance was set at $P < 0.1$.

Pellet group data have a poisson distribution, and hence, were transformed using a square root function to approach a more normal distribution. Analysis of variance using the general linear model (GLM) procedure of the statistical analysis system (SAS) (Goodnight et al. 1982) was employed for analysis of this data set. The main effects included area and sampling period, along with an interaction term.

All deer related variables were analyzed via ANOVA using the GLM procedure. The September collection data set was analyzed separately from the 2 March collection data sets. The main effects for the September analyses were area, sex, and age class, along with an area x age class interaction term. Corpora rubra counts also were transformed by a square root function and did not include sex as a main effect. Testes weight did not include a sex main effect. Abomasal parasite counts also included year as a main effect and area x year as an interaction term, but excluded the area x age class interaction term. Sources of variation for the March collection data included area, year, sex, and age class and the interaction terms, area x year and area x age class. Corpora lutea and fetal counts were transformed by a square root function and did not include a sex main effect.

Hunter-harvest data also were analyzed via ANOVA using the GLM procedure. The sources of variation for the antler characteristics included area, year, and age class with an area x age class interaction term. The main effects for DBW of yearling males were area and year with an interaction term.

Quantity estimates and standard errors of various forage classes were derived as described by Freese (1971:43). However, the "large sample data" were the ocular estimates of the whole volumetric plot and the "small sample data" were the ocular estimates of the randomly chosen quarter section of each clipped plot. The forage quantity estimates and forage quality variables were analyzed for area differences using a 2-sample t-test. Soils data were analyzed via ANOVA using the GLM procedure. Area and land form were the main effects, along with an interaction term.

For variables analyzed using ANOVA, estimates of least-squares means (LSM) and standard errors (SE) were determined. Because the main emphasis of this study was to make area comparisons, only area LSM and SE were reported for the September deer data, while area by year LSM and SE were reported for the pellet-group data, March deer data, and hunter-harvest data. Area by slope position LSM and SE were reported for soils data. All other variables reported were standard arithmetic means and standard errors. Arithmetic means and standard errors for all deer-related variables by area, year (March collection), sex (excluding hunter-harvest data) and age class, for pellet-group data by area and year, and for soils data by area and slope position are presented in the Appendices.

Results

Relative Deer Abundance

There were significant area and area x year interaction effects on pellet-group counts (Table 3). Pellet-group density was higher at SC than at HK (Table 4). However, the difference between areas was 4x greater in 1987 than in 1986, resulting in a significant area x year interaction.

Nutritional Assessment

Hunter Harvest Data

A significant area effect was found on yearling buck dressed body weight (Table 5). Deer were heavier at SC than at HK (Table 6). There were significant area, year, area x year interaction, and age class effects on antler beam diameter (Table 5). Deer had larger antler diameters at SC than at HK, and larger antler diameters in 1986 than in 1985 (Table 6). However, the difference between areas was much greater in 1986 than in 1985, resulting in a significant area x year interaction. Adult bucks had greater beam diameters than yearling bucks (22.7 vs. 14.0 mm). There also were

Table 3. Mean squares (MS) and p-values (P) for the number of pellet groups/plot counted while conducting pellet-group surveys at High Knob and Stony Creek, Virginia, in March 1986 and 1987.

Model Variables	df	MS	P
Area	1	1.29	0.004
Year	1	0.01	0.837
Area X Year	1	0.45	0.083
Error	842	0.15	

Table 4. Least-squares means (LSM) and standard errors (SE) for the number of pellet groups/plot counted while conducting pellet-group surveys at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987.

Year	Area	n	LSM	SE
1986	HK	173	0.91	0.02
	SC	250	0.94	0.03
1987	HK	173	0.86	0.02
	SC	250	0.98	0.03

Table 5. Mean squares (MS) and p-values (P) for variables measured from hunter harvested white-tailed deer at High Knob and Stony Creek, Virginia, in November 1985 and 1986. Measurements included dressed body weights of yearling bucks (DBW), antler main beam diameters (MBD), and the number of antler points (NAP).

Model Variables	df	DBW		MBD		NAP	
		MS	P	MS	P	MS	P
Area	1	7240.82	0.0001	134.60	0.006	49.30	0.0001
Year	1	4.22	0.923	50.13	0.092	5.97	0.158
Area X Year	1	4.55	0.920	49.12	0.095	1.65	0.457
Age Class	1	-	-	2263.05	0.0001	378.68	0.0001
Area X Age Class	1	-	-	22.36	0.256	5.28	0.185
Error	94	449.82		17.43 ¹		2.97 ²	

¹ df = 145

² df = 151

Table 6. Least-squares means (LSM) and standard errors (SE) for variables measured from hunter harvested white-tailed deer at High Knob (HK) and Stony Creek (SC), Virginia, in November 1985 and 1986. Measurements included dressed body weights of yearling bucks (DBW), antler main beam diameters (MBD), and the number of antler points (NAP).

Year	Area	n	DBW (kg)		n	MBD (mm)		n	NAP	
			LSM	SE		LSM	SE		LSM	SE
1985	HK	17	35.4	1.1	27	17.3	0.8	28	3.7	0.3
	SC	34	39.0	0.7	49	18.2	0.6	54	4.8	0.2
1986	HK	15	35.4	1.1	22	17.3	0.9	22	3.9	0.4
	SC	32	39.2	0.8	53	20.7	0.6	53	5.4	0.2

significant area and age class effects on the number of antler points (Table 5). Deer had more antler points at SC than at HK (Table 6). Adult bucks had more antler points than yearling bucks (6.2 vs. 2.7 points).

September Deer Collection

Physical Characteristics and Fat Indices

No significant area effects were found on any of the physical characteristics or fat indices (Table 7). There were significant age class and sex effects on both whole body weight and dressed body weight (Table 7). In both cases, yearlings (43.9 and 30.7 kg [whole and dressed body weight, respectively]) and females (46.0 and 31.4 kg) were lighter than 2.5+ -year-olds (57.4 and 41.2 kg) and males (55.3 and 40.6 kg), respectively. A significant age class effect was found on the femur/hindfoot ratio (Table 7). No significant area differences ($P > 0.1$) were found on either femur or hindfoot length in September. The ratio was smallest in yearlings (0.535) and greatest in adults (2.5+ -years-old, 0.550). Among the fat indices, a significant sex effect was found on the kidney fat index (Table 7). Males had a greater kidney fat index (29.3%) than did females (15.6%). Area LSM for all physical and fat measurements are presented in Table 8.

Blood Indices

Significant area, age class, and sex effects were found on serum total protein content (Table 9). Deer at SC had greater concentrations than deer at HK (Table 10). Adults and males had greater total protein levels (7.6 and 7.4 g/dl, respectively) than yearlings and females (6.8 and 7.0 g/dl, respectively). There was a significant sex effect on blood urea nitrogen (Table 9). Males had greater concentrations than females (17.8 vs. 11.7 mg/dl). A significant area effect on total cholesterol was found (Table 9). Concentrations were greater in deer from SC than from HK (Table 10). No significant effects were found on triglyceride or nonesterified fatty acid levels (Table 9). Serum phosphorus levels exhibited a significant age class effect (Table 11). Greater levels were found in yearlings than in adults (9.9 vs. 7.7 mg/dl). No significant effects were found on serum calcium,

Table 7. Mean squares (MS) and p-values (P) for physical characteristics and fat indices of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985. Measurements included whole body weight (WBW), dressed body weight (DBW), the femur to hindfoot ratio (F/HF), kidney fat index (KFI), femur marrow fat (FMF), and mandibular marrow fat (MMF).

Model Variables	df	WBW		DBW		F/HF		KFI		FMF		MMF	
		MS	P	MS	P	MS	P	MS	P	MS	P	MS	P
Area	1	20.67	0.351	40.45	0.149	1.82	0.585	6.56	0.578	52.88	0.440	13.78	0.601
Age Class	1	548.62	0.0002	338.77	0.0005	3.21	0.471	69.57	0.084	235.36	0.114	33.78	0.416
Area X Age Class	1	2.66	0.734	0.19	0.918	2.29	0.541	0.03	0.966	103.28	0.285	1.30	0.871
Sex	1	247.09	0.004	240.08	0.002	40.40 ¹	0.993	2.22	0.745	526.32	0.024	16.96	0.562
Error	15	22.37		17.48		5.87 ²		20.32		84.03		48.41	

¹ MS was multiplied by 10⁵

² df = 14

Table 8. Least-squares means (LSM) and standard errors (SE) for physical characteristics and fat indices of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985. Measurements included whole body weight (WBW), dressed body weight (DBW), the femur to hindfoot ratio (F/HF), kidney fat index (KFI), femur marrow fat (FMF), and mandibular marrow fat (MMF).

Area	n	WBW (kg)		DBW (kg)		F/HF		KFI (%)		FMF (%)		MMF (%)	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
HK	10	49.6	1.5	34.5	1.4	0.544	0.005	20.7	3.0	88.6	2.3	89.7	0.8
SC	10	51.7	1.6	37.5	1.4	0.541	0.005	24.2	3.0	90.3	2.3	90.4	0.9 ¹

¹ n = 9

Table 9. Mean squares (MS) and p-values (P) for blood characteristics (Part I) of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985. Constituents measured included total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), and nonesterified fatty acids (NEFA).

Model Variables	df	TP		BUN		TC		TRI		NEFA	
		MS	P	MS	P	MS	P	MS	P	MS	P
Area	1	2.61	0.002	14.73	0.488	416.21	0.043	259.50	0.515	0.10	0.845
Age Class	1	1.86	0.008	12.08	0.529	7.65	0.767	1027.95	0.205	5.54	0.170
Area X Age Class	1	0.32	0.223	23.89	0.380	170.21	0.176	479.07	0.379	1.62	0.445
Sex	1	0.64	0.092	104.00	0.079	53.68	0.437	97.06	0.689	0.57	0.647
Error	14	0.19		29.08		84.13		582.23		2.63 ¹	

¹ df = 13

Table 10. Least-squares means (LSM) and standard errors (SE) for blood characteristics (Part I) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985. Constituents measured included total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), and nonesterified fatty acids (NEFA).

Area	n	TP (g/dl)		BUN (mg/dl)		TC (mg/dl)		TRI (mg/dl)		NEFA (mM)	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
HK	10	6.8	0.1	13.8	1.7	61.4	3.0	45.3	7.8	118.3	16.6
SC	9	7.6	0.2	15.7	1.9	71.1	3.2	37.6	8.3	113.2	19.4 ¹

¹ n = 8

Table 11. Mean squares (MS) and p-values (P) for blood characteristics (Part II) of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985. Constituents measured included calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV).

Model Variables	df	Ca		P		Na		K		GLU		PCV	
		MS	P	MS	P	MS	P	MS	P	MS ¹	P	MS	P
Area	1	0.38	0.391	5.09	0.246	52.51	0.197	0.63	0.755	4.71	0.838	63.11	0.259
Age Class	1	0.03	0.800	13.37	0.070	5.67	0.662	0.002	0.985	55.74	0.486	4.04	0.769
Area X Age Class	1	0.002	0.949	0.39	0.741	2.83	0.757	3.35	0.476	56.70	0.482	8.33	0.674
Sex	1	1.44	0.109	1.05	0.591	33.55	0.297	3.88	0.444	33.55	0.587	17.36	0.546
Error	14	0.49		3.48		28.62		6.28		108.84		45.09 ²	

¹ MS were multiplied by 10^{-2}

² df = 12

sodium, potassium, and glucose levels or packed-cell volume (Table 11). Area LSM for serum minerals, glucose, and packed-cell volumes are presented in Table 12.

Reproductive Measures

No significant area effects were found on any of the reproductive measures (Table 13). A significant age class effect was found on corpora rubra counts (Table 13). Yearling does had no corpora rubra while does 2.5+ years of age had 1.1 corpora rubra. Area LSM for all reproductive measurements are presented in Table 14.

Gastrointestinal Tract Analysis

The results of the food habit analysis are reported in Table 15. Subtotals of the 6 categories did not differ substantially between areas with one exception. High Knob deer appeared to have eaten more deciduous woody and herbaceous leaves and less mushrooms than deer at SC (Table 15).

No significant effects were found on any of the rumen chemical components (Tables 16). Area LSM for the rumen chemical components are presented in Table (17).

Significant area and year effects were found on the abomasal parasite counts (Table 18). Deer at HK had roughly 3x more parasites than deer at SC, with both deer herds having greater parasite loads in September 1984 as compared to September 1985 (Table 19).

Fecal Analysis

No significant area effects on any of the fecal chemical components were found (Table 20). There was a significant age class effect on the fiber/protein ratio (Table 20). Adults had a greater ratio than yearlings (3.4 vs. 2.3). Area LSM for fecal chemical components are presented in Table 21.

Table 12. Least-squares means (LSM) and standard errors (SE) for blood characteristics (Part II) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985. Constituents measured included calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV).

Area	n	Ca (mg/dl)		P (mg/dl)		Na (meq/l)		K (meq/l)		GLU (mg/dl)		PCV (%)	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
HK	10	10.2	0.2	8.3	0.6	139.0	1.7	10.7	0.8	203.8	33.8	48.9	2.4 ¹
SC	9	10.5	0.2	9.3	0.6	142.4	1.8	10.4	0.9	214.2	35.8	44.9	2.3

¹ n = 8

Table 13. Mean squares (MS) and p-values (P) for reproductive measures of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985. Measurements included testes weight (TW) and corpora rubra counts (CR).

Model Variables	df	TW		CR	
		MS ¹	P	MS	P
Area	1	443.76	0.420	0.01	0.793
Age Class	1	208.03	0.574	4.49	0.002
Area X Age Class	1	-	-	0.01	0.793
Error	6	575.47 ²		0.17	

¹ MS were multiplied by 10⁴

² df = 5

Table 14. Least-squares means (LSM) and standard errors (SE) for reproductive measures of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985. Measurements included testes weights (TW) and corpora rubra counts (CR).

Area	n	TW (g)		n	CR	
		LSM	SE		LSM	SE
HK	5	65.5	10.9	3	0.43	0.08
SC	3	48.3	17.7	7	0.49	0.07

Table 15. Percent frequency and aggregate % volume and % weight of food items found in rumen contents of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985.

Food Item	HK(n = 10)			SC(n = 10)		
	% Freq.	% Vol.	% Wt.	% Freq.	% Vol.	% Wt.
Fruit						
Acorns	80	44.4	82.2	100	38.7	75.4
Deerberry	-	-	-	10	0.8	0.5
Black Cherry	10	2.1	3.2	30	1.1	1.7
Wild Apple	10	0.3	tr	20	6.8	2.5
Yellow-poplar	10	tr	tr	-	-	-
Grass Seed pods	10	0.2	tr	-	-	-
Subtotal		47.0	85.4		47.4	80.1
Leaves						
Deciduous hardwoods						
Sourwood	20	3.9	1.2	20	4.7	1.7
Greenbriar	10	tr	tr	20	tr	tr
Dead	10	0.7	0.1	40	0.7	0.1
Other	80	13.8	3.5	90	3.4	1.2
Evergreen hardwoods						
Rhododendron	-	-	-	10	0.1	0.1
Evergreen plants						
Teaberry	-	-	-	30	0.5	0.3
Herbaceous plants						
Partridgeberry	-	-	-	40	0.3	0.2
Indianpipe	-	-	-	20	0.1	0.1
Potentilla	-	-	-	10	tr	tr
Wild Oates	-	-	-	20	0.1	tr
Crown Vetch	20	4.6	1.4	-	-	-
Other	60	5.7	1.1	100	3.9	1.2
Subtotal		28.7	7.3		13.8	4.9
Stems						
Dead woody	40	1.2	0.4	60	0.5	0.4
Woody	80	2.5	1.4	30	0.5	0.3
Herbaceous	40	6.1	1.9	80	7.5	3.6
Subtotal		9.8	3.7		8.5	4.3
Fungi						
Mushrooms	100	14.2	3.5	100	29.6	10.4
Lichen	-	-	-	30	tr	tr
Subtotal		14.2	3.5		29.6	10.4

Table 15. Continued.

Food Item	HK(n = 10)			SC(n = 10)		
	% Freq.	% Vol.	% Wt.	% Freq.	% Vol.	% Wt.
Grasses	50	0.3	0.1	80	tr	0.1
Fibrous Roots	-	-	-	40	0.7	0.2
Total		100	100		100	100

Table 16. Mean squares (MS) and p-values (P) for rumen content chemical components of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985. Components measured included rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD).

Model Variables	df	CP		ADF		Lignin		DMD	
		MS	P	MS	P	MS	P	MS	P
Area	1	2.01	0.806	2.71	0.796	16.87	0.527	8.96	0.692
Age Class	1	0.14	0.947	17.50	0.514	32.02	0.387	26.06	0.502
Area X Age Class	1	2.01	0.806	5.85	0.704	7.09	0.681	2.62	0.830
Sex	1	10.03	0.585	4.91	0.728	1.64	0.842	4.46	0.780
Error	15	32.39		39.26		40.38		55.21	

Table 17. Least-squares means (LSM) and standard errors (SE) for rumen content chemical components of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985. Components measured included rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD).

Area	n	CP (%)		ADF (%)		Lignin (%)		DMD (%)	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE
HK	10	20.5	1.8	26.9	2.0	22.5	2.1	64.6	2.4
SC	10	21.2	1.9	26.1	2.1	24.4	2.1	63.2	2.5

Table 18. Mean squares (MS) and p-values (P) for abomasal parasite counts of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985.

Model Variables	df	MS ¹	P
Area	1	585.21	0.0002
Year	1	459.05	0.0007
Area X Year	1	1.75	0.812
Sex	1	31.93	0.314
Age Class	1	47.14	0.470
Error	24	30.23	

¹ MS were multiplied by 10^{-4}

Table 19. Least-squares means (LSM) and standard errors (SE) for abomasal parasite counts of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985.

Year	Area	n	LSM	SE
1984	HK	5	1860	334
	SC	6	907	250
1985	HK	10	1059	281
	SC	10	3	268

Table 20. Mean squares (MS) and p-values (P) for fecal chemical components of white-tailed deer collected at High Knob and Stony Creek, Virginia, in September 1985. Components measured included fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ratio (F/P).

Model Variables	df	CP		ADF		F/P	
		MS	P	MS	P	MS	P
Area	1	2.51	0.681	86.17	0.212	0.45	0.557
Age Class	1	31.19	0.160	142.80	0.114	3.88	0.100
Area X Age Class	1	13.88	0.340	1.78	0.853	0.004	0.954
Sex	1	20.02	0.255	42.78	0.373	1.89	0.240
Error	15	14.29		50.82		1.26	

Table 21. Least-squares means (LSM) and standard errors (SE) for fecal chemical components of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1985. Components measured included fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ratio (F/P).

Area	n	CP (%)		ADF (%)		F/P	
		LSM	SE	LSM	SE	LSM	SE
HK	10	16.6	1.2	46.6	2.3	3.0	0.4
SC	10	17.3	1.3	42.3	2.4	2.7	0.4

March Deer Collections

Physical Characteristics and Fat Indices

There were significant area, year, area x year interaction, and age class effects on both whole body weight and dressed body weight (Table 22). Deer were heavier at SC than at HK, and heavier in 1986 than in 1987 (Table 23). However, the difference between areas was much greater in 1986 than in 1987, resulting in a significant area x year interaction. Fawns were the lightest (24.9 and 18.8 kg [whole and dressed body weight, respectively]), whereas yearlings (38.9 and 29.2 kg) were lighter than adults (46.6 and 33.6 kg). No significant effects on the femur/hindfoot ratio were found (Table 22). However, HK deer had significantly ($P = 0.0001$) shorter femurs than SC deer (22.3 cm vs. 24.0 cm). Also, HK deer had a significantly ($P = 0.0001$) shorter hindfoot length than SC deer (40.4 cm vs. 43.2 cm).

Of the fat indices, the kidney fat index exhibited significant area, year, area x year interaction, and sex effects (Table 22). Deer had greater kidney fat levels at SC than at HK (upon combining both collection periods together), and greater levels in 1986 than in 1987 (Table 23). However, because kidney fat levels in HK deer were lower than in SC deer in 1986, but a higher in 1987, an interaction effect between area and year resulted. Females had a greater kidney fat index than males (25.1% vs. 4.1%). A significant area x year interaction effect was found on femur marrow fat and mandibular marrow fat levels (Table 22). Bone marrow fat levels were greater in SC deer in 1986 than in HK deer, but lower in 1987 (Table 23). This crossover masked any potential area differences and resulted in the significant interaction effect.

Blood Indices

A significant age class effect was found on total protein levels (Table 24). Yearlings had the lowest level (5.0 g/dl), while fawns had a lower level than adults (5.6 vs. 6.2 g/dl). No significant effects were found on blood urea nitrogen levels (Table 24). There were significant year and area x year interaction effects on total cholesterol (Table 24). Deer had greater concentrations in 1986

Table 22. Mean squares (MS) and p-values (P) for physical characteristics and fat indices of white-tailed deer collected at High Knob and Stony Creek, Virginia, in March 1986 and 1987. Measurements included whole body weight (WBW), dressed body weight (DBW), kidney fat index (KFI), femur marrow fat (FMF), mandibular marrow fat (MMF), and the femur to hindfoot ratio (F/HF).

Model Variables	df	WBW		DBW		F/HF		KFI		FMF		MMF	
		MS	P	MS	P	MS ¹	P	MS	P	MS	P	MS	P
Area	1	175.27	0.007	56.67	0.026	0.18	0.831	867.78	0.047	63.95	0.248	10.11	0.734
Year	1	121.17	0.022	71.16	0.013	4.63	0.297	1104.70	0.026	44.68	0.333	2.02	0.879
Area X Year	1	108.33	0.030	57.45	0.025	0.53	0.721	3691.32	0.0002	438.52	0.004	558.68	0.016
Sex	1	1.37	0.800	18.78	0.188	1.71	0.523	1587.03	0.008	26.58	0.454	56.65	0.423
Age Class	2	1002.36	0.0001	453.95	0.0001	4.64	0.336	33.97	0.846	29.32	0.537	62.17	0.494
Area X Age Class	2	45.27	0.133	8.56	0.447	1.32	0.728	55.88	0.761	37.41	0.454	14.98	0.841
Error	31	21.04		10.37		4.12		203.34		46.28		86.10 ²	

¹ MS were multiplied by 10⁴

² df = 30

Table 23. Least-squares means (LSM) and standard errors (SE) for physical characteristics and fat indices of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Measurements included whole body weight (WBW), dressed body weight (DBW), kidney fat index (KFI), femur marrow fat (FMF), mandibular marrow fat (MMF), and the femur to hindfoot ratio (F/HF).

Year	Area	n	WBW (kg)		DBW (kg)		F/HF		KFI (%)		FMF (%)		MMF (%)	
			LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
1986	HK	10	34.6	1.6	26.1	1.1	0.550	0.007	4.3	4.9	88.0	2.3	79.4	3.2
	SC	10	43.3	1.9	31.6	1.3	0.551	0.008	37.8	5.8	93.2	2.8	87.3	3.8
1987	HK	10	34.3	1.7	25.7	1.2	0.561	0.008	14.6	5.3	93.4	2.5	87.9	3.6 ¹
	SC	10	35.0	1.9	25.4	1.4	0.557	0.009	1.8	6.1	82.6	2.9	77.7	3.9

¹ n = 9

Table 24. Mean squares (MS) and p-values (P) for blood characteristics (Part I) of white-tailed deer collected at High Knob and Stony Creek, Virginia, in March 1986 and 1987. Constituents measured included total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), nonesterified fatty acids (NEFA), and beta-hydroxybutyrate (B-HB).

Model Variables	df	TP		BUN		TC		TRI		NEFA		B-HB	
		MS	P	MS	P	MS	P	MS ¹	P	MS	P	MS ¹	P
Area	1	0.18	0.444	80.38	0.128	251.49	0.058	3.93	0.114	52.52	0.088	4.33	0.106
Year	1	0.63	0.159	13.27	0.529	387.37	0.021	5.05	0.075	87.80	0.030	7.46	0.036
Area X Year	1	0.14	0.501	10.90	0.568	718.50	0.002	0.37	0.619	100.73	0.020	3.62	0.137
Sex	1	0.05	0.661	53.54	0.211	3.10	0.828	3.41	0.140	24.38	0.238	5.43	0.072
Age Class	2	3.28	0.0003	41.09	0.300	32.71	0.609	2.84	0.165	3.55	0.810	4.19	0.084
Area X Age Class	2	0.41	0.275	30.80	0.401	28.02	0.653	0.70	0.626	20.33	0.238	0.20	0.876
Error	28	0.30		32.69		64.85		1.48		16.82		1.55	

¹ MS were multiplied by 10^{-3}

than in 1987 (Table 25). Deer at SC had greater concentrations than deer at HK in 1986, but lower concentrations in 1987, resulting in the significant area x year interaction. A significant year effect was found on triglyceride levels (Table 24). Concentrations were much greater in 1986 than in 1987 (Table 25). There were significant area, year, and area x year interaction effects on nonesterified fatty acid levels (Table 24). Deer had greater levels at SC than at HK, and greater levels in 1986 than in 1987 (Table 25). In 1986, SC deer had substantially higher concentrations than HK deer, but lower levels in 1987 (Table 25). This crossover resulted in a significant interaction effect. Beta-hydroxybutyrate levels exhibited significant year, sex, and age class effects (Table 24). Concentrations were greater in 1986 than in 1987 (Table 25), and greater in female deer than in male deer (140.5 and 101.2 mM, respectively). Adults had the lowest beta-hydroxybutyrate levels (98.3 mM), while yearlings had a lower level than fawns (125.2 vs. 139.0 mM).

Significant area, age class, and area x age class effects were found on serum calcium levels (Table 26). Deer had higher levels at SC than at HK (Table 27). Yearlings had the lowest level (9.1 mg/dl), while adults had a lower level than fawns (9.7 vs. 10.6 mg/dl). Deer at SC had higher levels than deer at HK among the age classes, except adults. This resulted in the significant area x age class interaction. A significant age class effect was found on phosphorus concentrations (Table 26). Adults had the lowest concentration (7.8 mg/dl), while yearlings had lower concentrations than fawns (8.8 vs. 9.8 mg/dl). There were significant area, age class, and area x age class interaction effects on serum sodium levels (Table 26). Deer had greater levels at SC than at HK (Table 27). Yearlings had the lowest level (133.8 meq/l), while fawns had a lower level than adults (141.7 vs. 143.3 meq/l). The interaction effect between area and age class followed the same pattern as that of calcium. No significant effects on serum potassium levels were found (Table 26). A significant sex effect was found on glucose concentrations (Table 26). Males had a greater concentration than females (281.4 vs. 190.1 mg/dl). A significant area effect on packed-cell volume was found (Table 26). Deer had greater values at HK than at SC (Table 27).

Table 25. Least-squares means (LSM) and standard errors (SE) for blood characteristics (Part I) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Constituents measured included total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), nonesterified fatty acids (NEFA), and beta-hydroxybutyrate (B-HIB).

Year	Area	n	TP (g/dl)		BUN (mg/dl)		TC (mg/dl)		TRI (mg/dl)		NEFA (mM)		B-HIB (mM)	
			LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
1986	HK	9	5.6	0.2	12.4	2.1	42.7	2.9	21.8	14.1	87.1	47.3	114.3	14.4
	SC	10	5.9	0.2	10.4	2.3	59.0	3.3	52.2	15.6	294.8	52.5	161.8	16.0
1987	HK	8	5.4	0.2	12.2	2.3	45.4	3.3	1.1	15.7	93.3	52.9	103.4	16.1
	SC	10	5.4	0.2	7.7	2.4	40.6	3.4	16.3	16.4	52.2	55.2	103.8	16.8

Table 26. Mean squares (MS) and p-values (P) for blood characteristics (Part II) of white-tailed deer collected at High Knob and Stony Creek, Virginia, in March 1986 and 1987. Constituents measured included calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV).

Model Variables	df	Ca		P		Na		K		GLU		PCV	
		MS	P	MS	P	MS	P	MS	P	MS ¹	P	MS	P
Area	1	2.11	0.082	4.54	0.202	361.25	0.012	0.39	0.520	60.08	0.289	191.41	0.072
Year	1	0.99	0.227	0.80	0.586	90.27	0.192	1.00	0.309	0.54	0.919	49.78	0.348
Area X Year	1	1.36	0.159	6.29	0.135	91.97	0.188	0.09	0.750	3.13	0.807	1.48 ²	0.999
Sex	1	0.11	0.678	1.14	0.517	0.09	0.966	0.002	0.960	29.26	0.024	10.96	0.658
Age Class	2	3.28	0.013	8.96	0.049	204.18	0.028	1.93	0.145	54.55	0.360	53.88	0.386
Area X Age Class	2	2.31	0.042	0.23	0.915	213.43	0.024	0.67	0.498	84.32	0.213	20.73	0.688
Error	28	0.65		2.66		50.52		0.93		51.60		54.77	

¹ MS were multiplied by 10^{-2}

² MS was multiplied by 10^5

Table 27. Least-squares means (LSM) and standard errors (SE) for blood characteristics (Part II) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Constituents measured included calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV).

Year	Area	n	Ca (mg/dl)		P (mg/dl)		Na (meq/l)		K (meq/l)		GLU (mg/dl)		PCV (%)	
			LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
1986	HK	9	9.1	0.3	7.7	0.6	132.4	2.6	8.8	0.4	226.6	26.2	50.4	2.7
	SC	10	10.1	0.3	9.5	0.7	143.0	2.9	9.1	0.4	247.8	29.1	45.4	3.0
1987	HK	8	9.9	0.3	9.1	0.7	139.9	2.9	9.3	0.4	216.7	29.3	53.3	3.0
	SC	10	10.0	0.3	8.9	0.7	143.1	3.0	9.4	0.4	251.8	30.6	48.2	3.2

Reproductive Measures

A significant age class effect on testes weight was found (Table 28). Fawn bucks had the lightest testes (7.8 g), while yearling bucks had a lower testes weight than adult bucks (19.8 g vs. 20.8 g). There was a significant age class effect on corpora lutea counts (Table 28). Fawn does did not have any corpora lutea, whereas yearling and adult does had 0.96 and 1.78 corpora lutea, respectively (all corpora lutea values are retransformed LSM). There were significant age class and area x year interaction effects on fetal counts (Table 28). Age class patterns followed exactly as stated for corpora lutea counts. More significantly, does (1.5+ -years-old) at SC had more fetuses/doe in 1986 than at HK, but fewer in 1987 (Table 29). This crossover masked any potential area effects and resulted in a significant area x year interaction. All fetal measurements exhibited significant area, year, and area x year interaction effects (Table 28). Crown to rump length and weight of fetuses were greater at SC than at HK, and greater in 1986 than in 1987 (Table 29). However, the differences between areas were much greater in 1986 than in 1987, resulting in a significant area x year interaction.

Gastrointestinal Tract Analysis

Spring food habitats analyses differed markedly between areas and years. In March, 1986, acorns represented 86.0% and 93.8% of the SC rumen contents by volume and dry-weight, respectively, while found in only trace amounts in the HK rumen contents (Table 30). The bulk of the HK rumen contents in 1986 were made up of leaves of rhododendron and teaberry, grasses, and root tubers (Table 30). However, root tubers were only found in 20% of the HK rumens. In March, 1987, food habits between areas were fairly similar. No fruit of any kind was found in rumen contents at either area (Table 31). While quantities of leaves were similar between areas, species utilized shifted between areas. High Knob rumen contents contained much higher quantities of rhododendron leaves, while SC rumen contents contained much higher quantities of teaberry leaves (Table 31). Grasses were found in substantial quantities, with HK and SC having 21.0% and 31.5%, respectively, by volume (Table 31). Noticeable increases between years for both areas

Table 28. Mean squares (MS) and p-values (P) for reproductive measures from white-tailed deer collected at High Knob and Stony Creek, Virginia, in March 1986 and 1987. Measurements included testes weight (TW), corpora lutea counts (CL), fetal counts (FC), fetal crown to rump length (CRL), and fetal weight (FW).

Model Variables	df	TW		CL		FC		CRL		FW	
		MS	P	MS ³	P	MS ³	P	MS	P	MS	P
Area	1	21.60	0.113	3.33	0.458	1.32	0.594	186.09	0.011	701.27	0.001
Year	1	0.36	0.814	16.25	0.111	6.01	0.262	107.10	0.044	389.36	0.009
Area X Year	1	-	-	11.45	0.117	24.63	0.030	102.77	0.048	532.89	0.003
Age Class	1	70.60 ¹	0.012	36.07	0.022	23.29	0.34	0.74	0.859	0.36	0.929
Age X Age Class	1	-	-	3.22	0.466	0.37	0.775	23.14	0.328	23.97	0.480
Error	19	5.90 ²		5.82		4.51		22.83 ⁴		45.96 ⁴	

¹ df = 2

² df = 5

³ MS were multiplied by 10²

⁴ df = 17

Table 29. Least-squares means (LSM) and standard errors (SE) for reproductive measures from white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Measurements included testes weight (TW), corpora lutea counts (CL), fetal counts (FC) of 1.5+ -year-old does, fetal crown to rump length (CRL) of 1.5+ -year-old does, and fetal weight (FW) of 1.5+ -year-old does.

Year	Area	n	TW (g) ¹		CL		FC		CRL (cm)		FW (kg)	
			LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
1986	HK	7	6.0	0.3 ²	1.42	0.10	1.32	0.08	20.5	1.9	0.34	0.09
	SC	4	14.5	4.8 ²	1.47	0.15	1.47	0.13	32.5	3.1	1.13	0.14
1987	HK	5	5.5	0.9 ²	1.39	0.11	1.43	0.10	20.4	2.3	0.39	0.11
	SC	9	21.7 ³	-	1.15	0.08	1.15	0.08	23.4	2.0 ⁴	0.52	0.09 ⁴

¹ Values presented are arithmetic means and standard errors

² n = 3

³ n = 1

⁴ n = 7

Table 30. Percent frequency and aggregate % volume and % weight of food items found in rumen contents of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986.

Food Item	HK(n = 10)			SC(n = 10)		
	% Freq.	% Vol.	% Wt.	% Freq.	% Vol.	% Wt.
Fruit						
Acorns	10	tr	tr	100	86.0	93.8
Subtotal		tr	tr		86.0	93.8
Leaves						
Evergreen hardwoods						
Rhododendron	70	11.7	19.6	60	5.2	2.5
Moutain Laurel	20	4.1	6.3	-	-	-
Evergreen plants						
Teaberry	80	11.3	11.0	80	2.7	1.3
Galax	80	5.7	6.0	40	tr	0.1
Other	30	tr	0.3	-	-	-
Herbaceous plants						
Partridgeberry	-	-	-	20	tr	tr
Potentilla	20	0.5	0.3	60	tr	0.1
Crown Vetch	30	1.1	0.8	-	-	-
Other	80	1.1	0.9	60	1.0	0.2
Subtotal		35.5	45.2		8.9	4.2
Stems						
Woody	60	tr	0.8	60	0.2	0.2
Herbaceous	50	0.4	1.5	20	0.2	0.1
Subtotal		0.4	2.3		0.4	0.3
Buds						
Silver Maple	10	2.3	5.1	10	tr	0.1
Other	30	tr	0.4	-	-	-
Subtotal		2.3	5.5		tr	0.1
Fungi	40	2.6	3.3	50	3.0	1.0
Ferns	20	1.5	1.3	10	tr	tr
Grasses	100	35.8	20.4	80	1.7	0.5
Roots						
Tubers	20	21.9	22.0	-	-	-
Fibrous	-	-	-	30	tr	0.1
Subtotal		21.9	22.0		tr	0.1
Total		100	100		100	100

Table 31. Percent frequency and aggregate % volume and % weight of food items found in rumen contents of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1987.

Food Item	HK(n = 10)			SC(n = 10)		
	% Freq.	% Vol.	% Wt.	% Freq.	% Vol.	% Wt.
Fruit	-	-	-	-	-	-
Leaves						
Evergreen hardwoods						
Rhododendron	90	41.6	48.0	30	14.3	17.5
Moutain Laurel	-	-	-	60	9.5	10.8
Hemlock	-	-	-	20	tr	0.1
Redceder	-	-	-	10	tr	0.1
Evergreen plants						
Teaberry	60	2.6	3.9	100	20.8	21.0
Galax	50	0.5	0.7	70	1.2	1.9
Trailing Arbuteus	-	-	-	20	tr	0.2
Lycopodium spp.	-	-	-	20	0.6	0.4
Herbaceous plants						
Partridgeberry	-	-	-	40	0.6	0.3
Potentilla	40	1.1	1.0	40	4.2	2.6
Crown Vetch	30	4.7	2.0	10	0.6	0.4
Rattlesnake Plantain	10	1.1	0.3	10	tr	tr
Clover spp.	10	tr	tr	-	-	-
Dead	10	tr	tr	30	0.6	0.5
Other	60	1.1	0.5	40	1.2	1.0
Subtotal		52.7	56.4		53.6	56.8
Stems						
Woody	100	5.3	9.8	90	6.6	11.9
Dead Wood	10	tr	0.1	30	1.2	1.1
Herbaceous	-	-	-	10	tr	tr
Subtotal		5.3	9.9		7.8	13.0
Buds						
Rhododendron	60	6.8	8.3	-	-	-
Oak spp.	-	-	-	10	tr	1.5
Black Birch	10	1.1	1.6	-	-	-
Striped Maple	-	-	-	10	tr	0.6
Silver Maple	50	2.6	4.3	10	tr	0.5
Other	30	tr	0.6	20	tr	0.6
Subtotal		10.5	14.8		tr	3.2
Fungi						
Shelf	50	7.4	7.0	80	7.1	7.9
Lichen	20	0.5	0.4	10	tr	0.1
Subtotal		7.9	7.4		7.1	8.0
Ferns	10	tr	0.1	10	tr	0.3

Table 31. Continued.

Food Item	HK(n = 10)			SC(n = 10)		
	% Freq.	% Vol.	% Wt.	% Freq.	% Vol.	% Wt.
Grasses	90	21.0	10.3	90	31.5	18.5
Roots						
Tubers	20	2.6	1.1	-	-	-
Fibrous	-	-	-	10	tr	0.3
Subtotal		2.6	1.1		tr	0.3
Total		100	100		100	100

were found in quantities of woody stems, buds (especially rhododendron at HK), and shelf fungi (Tables 30 and 31).

Chemical analysis of rumen contents revealed significant area and area x year interaction effects on rumen protein levels (Table 32). Deer had greater protein levels at HK than at SC (Table 33). However, the difference between areas was much greater in 1986 than in 1987 (Table 33), resulting in a significant area x year interaction. There also were significant area and area x year interaction effects on rumen acid detergent fiber levels (Table 32). Deer had greater acid detergent fiber levels at SC than at HK (Table 33). The interaction effect followed that of rumen protein. Significant year and area x year interaction effects were found on rumen lignin content (Table 32). In 1986, deer had greater rumen lignin levels than in 1987 (Table 33). Deer tended to have a higher lignin level at SC in 1986 than at HK, but a slightly lower level in 1987 (Table 33). This crossover resulted in the significant interaction term. There were significant area, year, and area x year interaction effects on predicted digestibilities of rumen contents (Table 32). Predicted digestibilities were higher for HK deer than for SC deer, and were higher in 1987 than in 1986 (Table 33). However, the difference between areas was much greater in 1986 than in 1987, resulting in the significant area x year interaction.

Fecal Analysis

There were significant area and year effects on fecal protein levels (Table 34). Protein levels were greater in feces collected from HK deer than in SC deer and greater in 1986 than in 1987 (Table 35). Significant area x year interaction, sex, and age class effects were found on fecal acid detergent fiber content (Table 34). Feces collected from SC deer had greater acid detergent fiber levels than from HK deer in 1986, but lower levels in 1987 (Table 35). This crossover resulted in the significant interaction term. Male deer had greater acid detergent fiber levels than female deer (57.9 vs. 52.4 %). Fawns had the lowest amount of acid detergent fiber (51.7 %), while yearlings had a lower amount than adults (55.8 vs. 57.9 %). The fiber/protein ratio exhibited significant

Table 32. Mean squares (MS) and p-values (P) for rumen content chemical components of white-tailed deer collected at High Knob and Stony Creek, Virginia, in March 1986 and 1987. Components measured included rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD).

Model Variables	df	CP		ADF		Lignin		DMD	
		MS	P	MS	P	MS	P	MS	P
Area	1	132.96	0.0001	154.57	0.002	12.04	0.114	110.44	0.018
Year	1	1.32	0.608	0.45	0.859	905.87	0.0001	415.26	0.0001
Area X Year	1	15.30	0.088	75.96	0.027	21.26	0.038	133.60	0.010
Sex	1	0.11	0.878	18.99	0.256	4.45	0.330	35.12	0.172
Age Class	2	3.91	0.460	9.20	0.530	0.68	0.861	6.64	0.694
Area X Age Class	2	2.02	0.666	31.98	0.757	1.43	0.731	5.42	0.742
Error	31	4.93		14.23		4.55		17.99	

Table 33. Least-squares means (LSM) and standard errors (SE) for rumen content chemical components of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Components measured included rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD).

Year	Area	n	CP (%)		ADF (%)		Lignin (%)		DMD (%)	
			LSM	SE	LSM	SE	LSM	SE	LSM	SE
1986	HK	10	21.5	0.8	30.4	1.3	25.9	0.7	61.2	1.5
	SC	10	16.0	0.9	38.1	1.5	28.8	0.9	53.1	1.7
1987	HK	10	19.6	0.8	34.0	1.4	16.0	0.8	64.7	1.6
	SC	10	17.0	0.9	35.0	1.6	15.4	0.9	65.4	1.8

Table 34. Mean squares (MS) and p-values (P) for fecal chemical components of white-tailed deer collected at High Knob and Stony Creek, Virginia, in March 1986 and 1987. Components measured included fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ratio (F/P).

Model Variables	df	CP		ADF		F/P	
		MS	P	MS	P	MS	P
Area	1	142.16	0.001	38.35	0.175	10.29	0.261
Year	1	41.08	0.077	0.64	0.858	8.01	0.320
Area X Year	1	10.43	0.364	114.12	0.022	9.50	0.280
Sex	1	4.95	0.530	106.19	0.027	26.83	0.074
Age Class	2	17.97	0.247	82.20	0.025	25.22	0.054
Area X Age Class	2	3.28	0.767	1.13	0.944	0.17	0.977
Error	31	12.31		19.92		7.86	

Table 35. Least-squares means (LSM) and standare errors (SE) for fecal chemical components of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Components measured included fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ratio (F/P).

Year	Area	n	CP (%)		ADF (%)		F/P	
			LSM	SE	LSM	SE	LSM	SE
1986	HK	10	17.7	1.2	54.4	1.5	3.3	1.0
	SC	10	12.3	1.4	56.2	1.8	5.7	1.1
1987	HK	10	14.0	1.3	58.1	1.7	5.6	1.1
	SC	10	11.0	1.5	51.9	1.9	5.6	1.2

sex and age class effects (Table 34). Males had a greater ratio than females (6.4 vs. 3.7). Fawns had the lowest ratio (3.3), while yearlings had a lower value than adults (5.1 vs. 6.7).

Habitat Assessment

Soil Measurements

There were significant area differences among all soil measurements (Table 36). In all cases, SC had greater values than HK (Table 37). There also was a significant land form effect on soil phosphorus and magnesium levels (Table 36). In both cases, coves had the highest levels, while either ridgetops (phosphorus) or shoulders (magnesium) had the lowest levels (Table 37).

Forage Abundance

Quantities of fungi, soft mast, and hard mast were not found in a sufficient number of plots to derive estimates. Thus, only estimated quantities of woody leaves, forbs, vines, and grasses are reported. In all cases, it was estimated that HK had significantly larger quantities of the above forage classes than SC in September, 1986 (Table 38).

In March 1987, it was intuitive that the leaves of deciduous woody tree and shrub species, herbaceous plant species, and deciduous vines, forest grasses, fungi, soft mast, and hard mast were not part of the forage base at either area. The percent frequency of occurrence of evergreen trees and shrubs in clipped and nonclipped vegetative plots in September was 5% greater at SC than at HK, which resulted in a slightly higher estimated amount of woody leaves at SC (Table 39). The percent frequency of occurrence of evergreen forbs (plants) was slightly over 18% greater at SC than at HK; however, the forb estimate derived was greater at HK (Table 39). Because these estimates were not the result of direct measurement, no statistical analyses were performed.

Table 36. Mean squares (MS) and p-values (P) for measurements of soils collected at High Knob and Stony Creek, Virginia, in September/October 1986. Measurements included soil pH, calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), and organic matter (OM).

Model Variables	df	pH		Ca		P		Mg		K		OM	
		MS	P	MS ¹	P	MS	P	MS ¹	P	MS	P	MS	P
Area	1	25.73	0.0001	799.00	0.0001	114.62	0.003	1.02	0.0001	847.42	0.093	22.59	0.079
Land Form	4	0.40	0.666	6.27	0.783	28.16	0.079	0.12	0.058	246.58	0.508	21.17	0.023
Area X Land Form	4	0.44	0.663	3.74	0.903	25.12	0.113	0.09	0.150	492.02	0.162	6.68	0.453
Error	154	0.68		14.42		13.22		0.53		297.01		7.26	

¹ MS were multiplied by 10^{-4}

Table 37. Least-squares means (LSM) and standard errors (SE) for measurements of soils collected by land form at High Knob (HK) and Stony Creek (SC), Virginia, in September/October 1986. Measurements included soil pH, calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), and organic matter (OM).

Land Form	Area	n	PPM											
			pH		Ca		P		Mg		K		OM (%)	
			LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Cove	HK	13	4.5	0.2	103.4	105.3	1.3	1.0	16.2	6.4	36.6	4.8	5.4	0.7
	SC	9	6.0	0.3	737.3	126.6	6.4	1.2	45.6	7.7	36.8	5.7	7.4	0.9
Flood Plain	HK	3	4.6	0.5	68.0	219.3	1.0	2.1	11.3	13.4	32.0	10.0	3.8	1.6
	SC	8	5.2	0.3	483.0	134.3	2.6	1.3	45.0	8.2	41.4	6.1	5.2	1.0
Ridgetop	HK	14	4.6	0.2	30.0	101.5	0.7	1.0	7.1	6.2	26.4	4.6	3.8	0.7
	SC	9	5.4	0.3	616.0	126.6	1.6	1.2	27.1	7.7	46.3	5.7	5.2	0.9
Shoulder	HK	16	4.7	0.2	44.3	94.9	0.6	0.9	8.9	5.8	34.3	4.3	4.2	0.7
	SC	15	5.8	0.2	705.6	98.1	3.3	0.9	22.1	6.0	34.1	4.4	3.6	0.7
Side Slope	HK	36	4.7	0.1	133.3	63.3	1.2	0.6	24.0	3.9	40.4	2.9	4.4	0.4
	SC	41	5.7	0.1	678.1	59.3	1.7	0.6	29.6	3.6	40.3	2.7	5.0	0.4

Table 38. Estimated quantities (g/m²) and standard errors (SE) of vegetative classes present at High Knob (HK) and Stony Creek (SC), Virginia, in September 1986.

Vegetative Class	HK		SC	
	$\bar{X}$	SE	$\bar{X}$	SE
Woody Leaves ¹	15.02	0.56	12.82	0.71
Forbs ¹	7.10	0.55	1.81	0.21
Vines ¹	0.71	0.06	0.19	0.004
Grasses ¹	0.20	0.003	0.12	0.002

¹ Significantly different between areas ($P < 0.1$)

Table 39. Estimated quantities (g/m^2) of vegetative classes present and % frequency of occurrence (FOC) of evergreen species in clipped and unclipped plots at High Knob (HK) and Stony Creek (SC), Virginia, in March 1987.

Vegetative Class	HK		SC	
	g/m^2	%FOC	g/m^2	%FOC
Woody Leaves	2.1	14.2	2.5	19.2
Forbs	1.7	24.3	0.8	42.7

The oak mast survey results showed a cyclic pattern. A peak occurred every 5-6 years at SC and around every 7-8 years at HK, though not as readily recognizable (Figure 9). Over the duration of the study (survey years 1985-86), the mast crop index peaked and plummeted at both areas, with the more dramatic drop occurring at SC. In September, 1985, the oak mast index was 43.8 acorns/limb (excellent rating) at SC and 16.4 acorns/limb (fair rating) at HK. In September, 1986, the oak mast index was 6.7 acorns/limb (fair rating) at SC and 11.1 acorns/limb (fair rating) at HK. Although HK has had a higher index than SC in more years (8 vs. 6), the average difference between indices between areas over those years was substantially lower at HK. In other words, when HK was indexed higher than SC, the absolute difference between area indices for that year was, on average, much less than when SC was indexed higher than HK (4.8 acorns/limb vs. 12.0 acorns/limb). However, within each VDGIF rating category, HK tended to have a greater index than SC (Table 40).

Forage Quality

Area effects were found on at least 1 forage chemical component for each forage analyzed. Stony Creek had significantly greater calcium contents than HK in sassafras, rhododendron, and galax (Table 41). High Knob had a significant greater phosphorus (P) content than SC in sassafras and teaberry, but a significantly lower P content in sourwood (Table 41). High Knob also had significantly greater levels of magnesium in sassafras, sourwood, and greenbrier (Table 41). Potassium, protein, and ADF content were significantly greater in sassafras and sourwood at HK than at SC (Table 41). Lignin content was significantly greater at HK than at SC in all forages, except galax (Table 41). Predicted digestibilities of sassafras, sourwood, rhododendron, and teaberry were significantly greater at SC than at HK (Table 41).

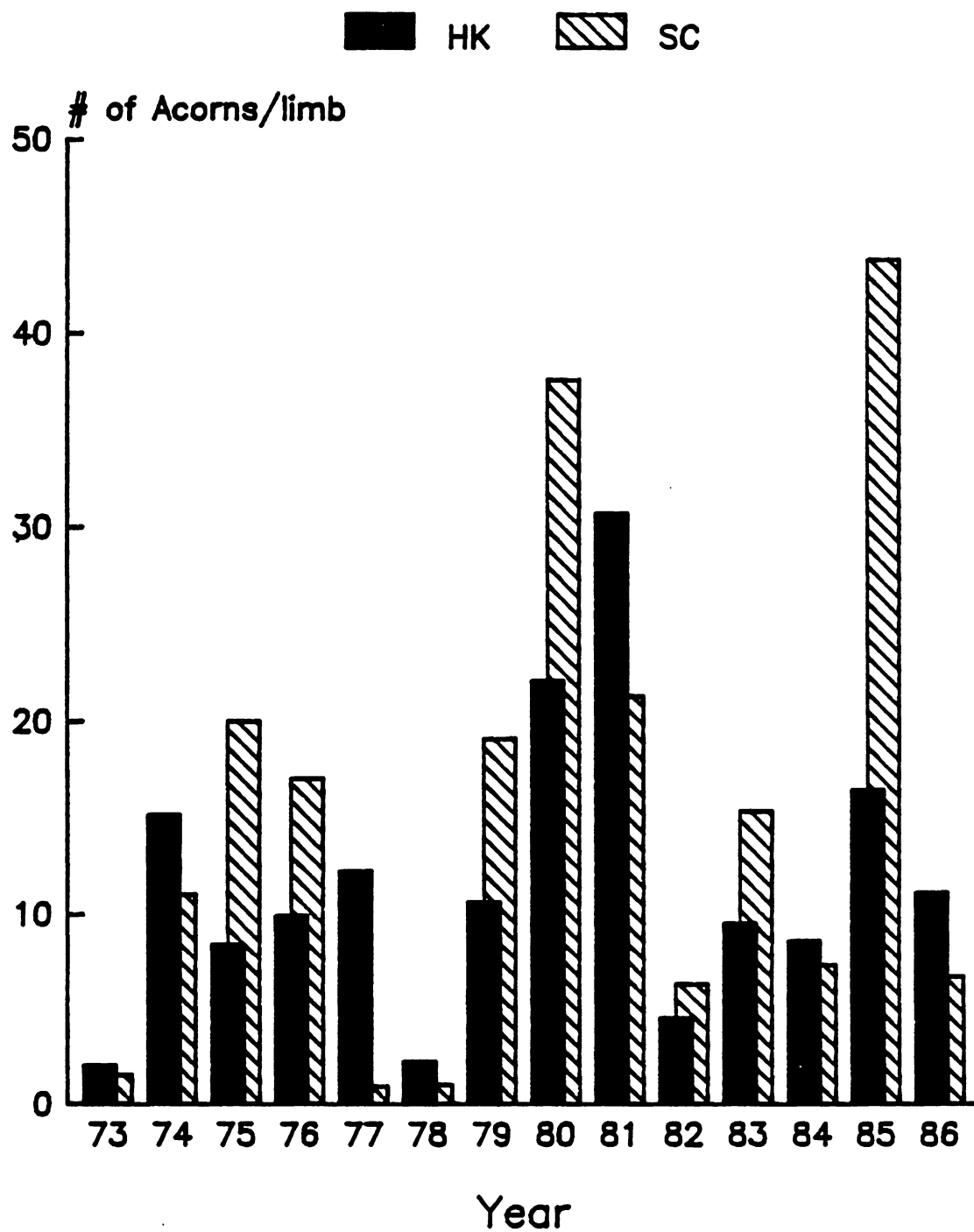


Figure 9. The VCGIF oak mast index for High Knob (HK) and Stony Creek (SC), Virginia, from 1973-86.

Table 40. Average VCGIF oak mast index (acorns/limb) within each VCGIF rating category at High Knob (HK) and Stony Creek (SC), Virginia, over the time period of 1973-86.

VCGIF Rating	n	HK	n	SC
Failure (0-1)	0	-	1	0.9
Poor (1-5)	3	2.9	2	1.3
Fair (5-20)	9	12.0	7	11.0
Good (20-35)	2	26.4	2	20.7
Excellent (> 35)	0	-	2	40.7

Table 41. Nutritional components of common white-tailed deer forages collected at High Knob (HK) and Stony Creek (SC), Virginia, in September 1986 and March 1987. Components measured included calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD).

Species	Area	n	Ca (%)		P (%)		Mg (%)		K (%)	
			$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Sassafras	HK	10	0.95*	0.09	0.34*	0.01	0.20*	0.01	1.59*	0.04
	SC	12	1.26	0.14	0.28	0.02	0.13	0.01	1.23	0.05
Sourwood	HK	9	0.93	0.10	0.35*	0.02	0.20*	0.01	1.11*	0.11
	SC	14	1.17	0.11	0.43	0.02	0.15	0.01	0.73	0.04
Mtn. Laurel	HK	9	0.83	0.04	0.11	0.01	0.15	0.01	0.42	0.03
	SC	9	1.21	0.22	0.11	0.01	0.15	0.01	0.38	0.03
Rhododendron	HK	8	0.84*	0.06	0.08	0.01	0.15	0.01	0.35	0.04
	SC	8	1.15	0.14	0.08	0.01	0.14	0.01	0.41	0.05
Galax	HK	10	0.55*	0.03	0.11	0.01	0.18	0.01	0.38	0.02
	SC	2	0.91	0.07	0.14	0.03	0.17	0.02	0.51	0.12
Teaberry	HK	9	0.89	0.10	0.09*	0.01	0.19	0.02	0.57	0.04
	SC	8	1.01	0.08	0.07	0.01	0.17	0.01	0.53	0.02
Smilax	HK	10	0.91	0.08	0.38	0.02	0.21*	0.01	1.38	0.07
	SC	13	1.05	0.08	0.39	0.03	0.18	0.01	1.41	0.04

Table 41. Continued.

Species	Area	n	CP (%)		ADF (%)		Lignin (%)		DMD (%)	
			$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Sassafras	HK	10	10.7*	0.3	35.8*	1.4	17.8*	1.1	64.2*	1.7
	SC	12	9.5	0.3	30.9	0.6	13.1	0.7	71.9	1.0
Sourwood	HK	9	10.9*	0.4	24.9*	1.5	8.7*	1.4	79.5*	2.0
	SC	14	9.3	0.2	20.6	0.4	5.7	0.3	85.2	0.6
Mtn. Laurel	HK	9	8.4	0.2	33.9	1.1	19.3*	0.8	66.6	1.0
	SC	9	7.7	0.5	31.6	0.9	16.9	0.8	68.9	1.1
Rhododendron	HK	8	5.7	0.1	40.1	1.4	19.1*	1.3	63.4*	1.8
	SC	8	5.6	0.3	36.6	1.7	15.2	1.3	68.1	2.0
Galax	HK	10	9.6	0.3	22.1	0.4	4.6	0.2	87.6	0.5
	SC	2	9.8	0.5	22.9	1.5	4.9	0.1	87.0	0.2
Teaberry	HK	9	7.2	0.2	35.2	0.8	17.2*	0.7	64.8*	1.0
	SC	8	6.9	0.3	33.3	1.5	13.8	1.2	69.5	2.1
Smilax	HK	10	10.6	0.4	25.3	0.8	7.2*	0.4	80.8	0.8
	SC	13	10.7	0.5	24.0	0.4	6.9	0.3	81.5	0.6

* Significantly different between areas ($P < 0.1$)

Extent of Poaching and Free-roaming Dogs

The magnitude of the illegal deer kill has always been an unknown and a concern of many states' wildlife biologists. Most of the studies encountered in the literature pertaining to poaching reported methodologies for estimating illegal kill (Leglar and Hayne 1966, Kaminsky and Giles 1974, Beattie et al. 1980, Wright 1980) or profiled the socioeconomic status of the game violator (Kaminsky and Giles 1974, Sawhill and Winkel 1974, Glover and Baskett 1984). However, studies reporting documented effects of poaching on white-tailed deer abundance in the literature were sparse.

Teer (1984) reported that illegal hunting limited the deer population in the northern section of the Llano Basin in Texas. He compared 2 extensive areas that were similar in range vegetation and soils and similar in the kinds and stocking rates of domestic livestock. The only difference between areas was believed to be the attitude of landowners toward deer in the lower-density area. He believed that the low-density area (north of the Llano River) could support larger numbers of deer since certain ranches in the area did have deer densities which exceeded, by several times, the average density of the area. These higher density ranches were found to have envoked and maintained a strict hunting policy as early as 1940, and in one instance, a special warden was hired to patrol ranch boundaries. Teer believed this presumably decreased illegal hunting on these ranches, resulting in an increased deer density. Torgerson and Porath (1984) and Gladfelter (1984) reported that in some cases, illegal hunting may exceed the legal harvest in the Midwest. Based on this information, it is intuitive that an illegal deer kill approaching or exceeding the legal kill of a low-density deer herd could limit herd growth substantially. Over the course of this study, 2 illegal kills were documented at HK, although no organized attempt to estimate illegal kill was undertaken at either area.

From the scent station data, a substantial increase in the total number of dog tracks was noted at each area in 1984 (Figure 10). This corresponded to a change in baits used at the scent stations from a fatty acid to a can of sardines, which likely attracted more animals. Track counts of dogs were higher at SC than at HK in more years (4 vs. 3). Although the average difference in counts between areas in those years were greater at HK (5 tracks vs. 2 tracks), this result is biased by the large difference in counts between areas noted in 1984 (Figure 10). Upon removing the 1984 count figures, the average differences between areas within years becomes the same (2 tracks vs. 2 tracks). Overall, no consistent pattern was noted between areas, although the number of dog tracks at HK has steadily declined from 1983 to 1986 (Figure 10).

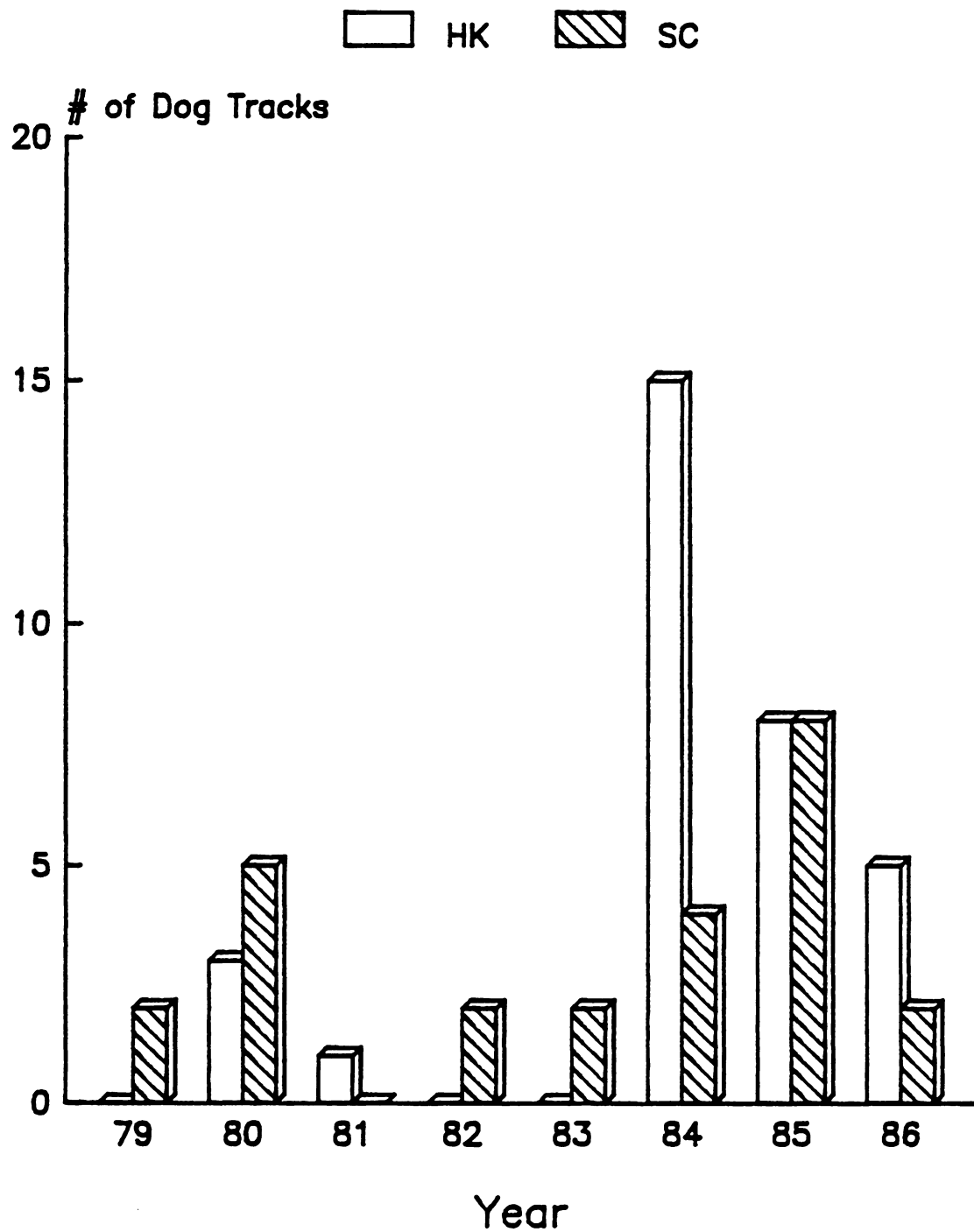


Figure 10. The number of free-roaming dog tracks counted at scent stations at High Knob (HK) and Stony Creek (SC), Virginia, from 1979-86.

Discussion and Conclusions

Relative Deer Abundance

It is assumed that pellet-group density is a good index of relative deer abundance. If the sampling intensity of pellet groups is inadequate to detect changes in deer movements, it also must be assumed that pellet-group sampling was conducted in some fashion to compensate for shifts in habitat (or area) utilization by each respective deer herd. In other words, HK might be hypothetically classified as 75% and 25% "high-use" and "low-use" habitat, respectively, and SC might be classified as 85% "high-use" and 15% "low-use" habitat. Based on the theory of random sampling, the above proportions would describe the proportion of randomly located pellet-group plots in the 2 habitat types on the 2 areas. Thus, in order to make valid comparisons between areas (with the above assumptions), if on 1 area 65% and 35% of the sample plots were located in "high-use" and "low-use" habitat, respectively, so must the other area be sampled with those proportions. Otherwise, it is likely that one area will be more heavily sampled in "high-use" or "low-use" habitat, resulting in the potential of counting greater or fewer numbers of pellet groups.

Further, a factor that controls deer use or non-use of habitat is seasonal forage availability, especially hard mast. Because forage availability within seasons can change over the years, often

dramatically, it is surmized that sampling efforts must adjust to this shifting of habitat use to maintain sampling proportionality, if valid comparisons between areas or over time are to be made. Based on VDGIF oak mast surveys and food habits observations reported herein, substantial differences in hard mast availability were noted between HK and SC in both years, although transects were not relocated or adjusted to counteract this potential bias. Thus, the significantly lower pellet-group density found at HK could have been biased from disproportionate sampling between HK and SC in "high-use" and "low-use" habitats over the 2 sampling periods. The significant area x year interaction effect also could be reflective of disproportionate sampling or indicative of problems inherent in the technique.

Although the relative density of deer at HK is probably somewhat lower than at SC over winter, it is believed that the herd at HK is increasing slightly. This increase seems plausible in view of the dramatic rise in the percentage of the area in stands 0-5 years of age (which naturally increases the amount of digestible energy over the growing season), the low, but steady increase in hunter-harvests in the vicinity, and personal interviews with local hunters in which they reported noticeable increases in deer abundance compared to the past hunting seasons.

Nutritional Assessment

Hunter-Harvest Data

The significantly lighter yearling bucks at HK relative to SC would normally be suggestive of a lowered nutrient availability at HK (most likely digestible energy). However, it is possible that this difference is reflective of a later peak fawning period at HK or other factors. If fawns were born later in the summer at HK relative to SC, and given equal nutrition between areas, it follows that HK fawns would be smaller than SC fawns at the onset of winter. Coming out of winter, the difference in body size for this cohort would still be present between areas. And thus, as growth proceeds over summer, differences in body weights are maintained between areas and reflected in

the yearling bucks during hunting season. More probable, it is believed that the differences in body weights are a reflection of the differences in winter weather severity between areas. If given similar peak fawning periods and nutrition between areas, it follows that fawn body weights between areas would be similar in late fall. This did not appear to be the case. Dressed body weights of fawns in September were 17.1 kg and 18.6 kg at HK and SC, respectively. However, due to the severity of winter at HK, fawns most likely lose substantially more weight than fawns at SC over winter. Indication of this was noticed in the dressed body weights of fawn bucks from the March, 1986, deer collection (20.4 kg HK vs. 24.3 kg SC). Thus, this difference in body weight between areas is believed to be maintained as body growth proceeds over summer and is markedly similar to that exhibited by the area differences in yearling buck dressed body weights.

The significantly smaller and less developed antlers among yearling and adult bucks at HK relative to SC could be due to genetic differences or differences in age structure among the adult bucks between areas. However, it is more plausible that these differences also are indicative of a lowered herd condition at HK in late winter, a time when antler growth commences.

Antler growth is secondary to body maintenance (French et al. 1955) and can be dramatically affected by late winter nutritional status (Verme and Ullrey 1984). To elaborate, it was noted that antler characteristics increased at each area in November, 1986, relative to November, 1985. In September, 1984, the VDGIF oak mast index was low at each area (8.6 acorns/limb HK vs. 7.3 acorns/limb SC), resulting in a shortage of a highly digestible forage in late winter and presumably poor herd condition at both areas. However, in September, 1985, the VDGIF oak mast index was substantially higher at each area (16.4 acorns/limb vs. 43.8 acorns/limb SC). The increased oak mast abundance provided an abundant source of digestible energy and presumably fostered a relative increase in herd condition in late winter, and thus, improved antler development at each area.

September Deer Collection

There was little evidence to suggest differences in physical condition between herds. However,

dressed body weights at HK did tend to be lower than at SC ($P = 0.149$), corroborating the results found in dressed body weights of yearling bucks in November. The similarity in stored fat levels between areas in September was not unexpected. It is known that deer coming out of winter replenish lost muscle tissue over summer (French et al. 1955, Sauer 1984), a time when forage (and most likely digestible energy) is the most abundant (Segelquist and Green 1968). In late summer, lipogenesis begins; and even when deer are energy restricted, it has been shown that fat synthesis occurs (Verme and Ullrey 1984). Thus, any difference between herds among the fat measurements would be least at this time.

Among the blood indices, there was some evidence of nutritional differences between the herds. The significantly lower total protein concentration in HK deer relative to SC deer is indicative of a lowered protein nutritional state. This blood constituent is usually maintained at a fairly constant level, changing only when chronic protein deficiencies are incurred (LeResche et al. 1974). No evidence to corroborate this result was found in blood urea nitrogen concentrations or rumen or fecal crude protein levels, however. It may be possible that the substantially greater quantities of mushrooms, which contain high levels of crude protein (Blair et al. 1984, O'Halloran et al. 1987), found in the SC rumen contents may have elevated the serum concentration of total protein in SC deer. This likely resulted in the significant area difference. The significantly lower total cholesterol concentration in HK deer relative to SC deer is reflective of a reduced energy plane in HK deer (Vogelsang 1977). However, none of the other indices of energy nutrition measured in the blood approached significance between areas.

By far the most significant result associated with this sampling period was the abomasal parasite counts. The significantly greater number of parasites found in HK deer, in the strictest sense, is indicative of lowered herd health, and in the most liberal sense, is indicative of a deer herd approaching carrying capacity as defined by Eve and Kellogg (1977). The significantly lower yearling buck DBWs and antler measurements of hunter-harvested deer at HK is supportive of the liberal interpretation. The pellet-group data in conjunction with the hunter-harvest data could be sugges-

tive of an overall lowered carrying capacity (defined herein as the number of animals a given area can support while maintaining desirable physical characteristics or a healthy physiological condition of the herd) at HK relative to SC. However, the significant year effect found on abomasal parasite counts is noteworthy. It was estimated that HK and SC abomasal parasite counts decreased by 43.0% and 99.0%, respectively, within each area from September, 1984, to September, 1985. It is almost inconceivable that these dramatic decreases are associated with either a decrease in deer density or an increase in herd health. It was noted that acorn production was lower in 1984 than in 1983 at both areas, evidence to suggest that this factor could not have improved the herd condition in 1985 vs. 1984. The increased production of acorns in 1985 vs. 1984 at both areas should not have affected the abomasal parasite counts either, because deer were collected shortly after the onset of acorn drop. Demaris et al. (1983) found no significant trends between herd health and abomasal parasite counts conducted on deer from Mississippi. They also calculated necessary sample sizes to estimate the true mean with 10% precision at the 95% confidence level. Calculated sample sizes ranged among their study areas from 90-1,378. However, Davidson et al. (1982) found a significant ($P < 0.05$) correlation between herd health (measured by a subjective ranking system) and abomasal parasitism. Both sets of investigators collected deer either in December/January or throughout the fall and winter seasons. Because data suggesting otherwise were sparse, questionable, and/or inconsistent with other data, it is believed that the HK deer herd was not experiencing a nutritional deficiency in September relative to the SC deer herd. However, there appeared to be evidence, specifically the abomasal parasite counts, to suggest that the HK deer herd is approaching or at carrying capacity.

March Deer Collections

Late winter is a time when the potential for a declined physiological state in deer is greatest. Seasonal forage quantity and quality are at a minimum during winter (Thorsland 1966, Segelquist and Green 1968, Blair and Halls 1968, Blair and Epps 1969, O'Halloren et al. 1987). Pregnant does have had the extra burden of nourishing at least one, and more likely two, fetus(es), while all deer have had to cope with adverse weather conditions. Thus, any differences in the physiological state

between deer at HK and SC that were caused by any of the above factors would be, theoretically, most noticeable at this time. However, before proceeding it must be noted that the SC area had an abnormally abundant acorn crop in the fall of 1985 (the highest VDGIF oak mast index at SC since the technique's implementation in 1973) and an abnormally harsh winter in 1986-87, while the HK area had an abnormally mild winter in 1986-87.

In March 1986, it was apparent from the substantially lower body weights and stored fat levels that HK deer were in poorer condition compared to SC deer. Of the blood indices, total cholesterol and beta-hydroxybutyrate concentrations tended to be lower at HK relative to SC, indicative of a lowered dietary energy plane. Concentrations of blood urea nitrogen tended to be elevated at HK relative to SC and, in conjunction with the energy and stored fat indices, would normally be indicative of muscle catabolism in HK deer. Counter to this trend, concentrations of nonesterified fatty acids, which usually increase as fat is catabolized, tended to be much lower at HK relative to SC. The lowered nutritional status of the HK deer also was attested to by the lowered number of fetuses/doe and the smaller and lighter fetuses at HK relative to SC. As stated previously, energy nutrition can dramatically affect ovulation rate and fetal development. Thus, it is believed that dietary energy levels were lower in late fall (1985) and over winter (1985-86) at HK relative to SC.

The rumen analyses results at this time were revealing. The preponderance of acorns in the SC rumen contents (reflecting the record acorn crop at SC in the fall) is believed to be largely responsible for the differences documented in the physical, fat, blood, and reproductive measurements between herds. The endosperm of acorns is rich in crude fat (lipids) and is an excellent source of digestible energy (Short 1971). By ingesting large quantities of acorns, SC deer were able to maintain fat levels and overall physical condition, while HK deer reflected the effects of living on a lower nutritional plane over winter (relative to the SC diet). Also, diets high in lipid content result in elevated free fatty acid levels (Maynard and Loosli 1969:100). This phenomena was detected in the elevated nonesterified fatty acid concentrations of SC deer, resulting in a counter relationship to the other energy indices. Although rumen content and fecal chemical analyses indicated a higher

dietary protein and diet quality in HK deer relative to SC deer, these results also were influenced by the abundance of acorns in the SC deer diet. Acorns contain low amounts of crude protein (Short 1971), and on a dry-weight basis, have a large amount of fibrous outer shell relative to the endosperm. This resulted in the decreased rumen and fecal crude protein levels, increased percentages of rumen and fecal acid detergent fiber, and subsequent decreased rumen content digestibility in SC deer. This decreased protein nutrition in SC deer also may have resulted in lower blood urea nitrogen levels at SC relative to HK. And as Kirkpatrick et al. (1975) pointed out, deer on high energy diets tend to have depressed blood urea nitrogen levels. Consequently, potentially false conclusions about muscle catabolism in HK deer in March, 1986, may have been stated. The substantially more developed fetuses at SC, in this year of unusual food supply, most likely reflect the superior dietary energy plane of SC does relative to HK does, and it is probable that SC fetuses are not as well developed in "normal" years.

The effects of winter weather cannot be discounted. It is believed that the 5 times greater snowfall at HK relative to SC, from December 1, 1985, to March 31, 1986, contributed to the differences noted in the physical condition indices. Although no controlled studies on the effects of weather parameters on white-tailed deer biology were found in the literature, it is readily known that severe winter weather has a dramatic effect on white-tailed deer. Moen (1978) reviewed several studies that emphasized the importance of winter weather on the welfare of white-tailed deer. Both he and Verme (1968) emphasized the detrimental effects of not only snow accumulation, but also temperature on the bioenergetics of deer residing of poor quality range. Energy resources are rapidly depleted when deer are forced to travel on accumulated snow (Verme and Ullrey 1984). Often, the energy expended to feed in deep snow exceeds that supplied by the forages eaten (Verme and Ullrey 1984). Most of the studies emphasizing the effects of snow on whitetails were based in the northern regions of North America where snow accumulation is substantial. Little importance of this factor has been mentioned by most researchers in the Southeast; however, Shrauder (1984) mentioned that in localized areas of the Appalachian Mountains in South Carolina winter weather and limited food supplies were responsible for low carrying capacities. Thus, although winter

weather severity at HK is not as harsh as most northern climates, the winter weather is more severe at HK than at SC, and certainly is harsher than in most parts of Virginia.

In March, 1987, however, an almost complete reversal in herd condition occurred between areas. Although deer at HK were in much better physical condition relative to SC, as evidenced by greater stored fat levels at HK, body weights were similar between areas. Among the blood indices, there was no evidence to suggest any differences in energy nutrition between areas, and this was supported by the similarities in food habits. Given equal dietary energy planes between areas, the somewhat higher BUN concentrations in HK deer relative to SC was thought to be suggestive of increased dietary protein nutrition at HK. This belief is corroborated by the slightly higher rumen and fecal crude protein levels at HK relative to SC. The much greater quantity of woody buds in the HK rumen contents relative to SC is thought to explain the higher level of dietary protein nutrition at HK. Although the crude protein composition of woody buds is not known, Bailey (1967) indicated that the buds of witch-hobble (*Viburnum alnifolium*), a deciduous woody shrub found in the Northeast, contained up to 9.2% crude protein, which is higher than that found in other winter forages commonly eaten (see forage quality data for comparison). Reproductively, the substantially greater number of fetuses/doe at HK relative to SC would normally be reflective of better energy nutrition during ovulation in late fall (1986), since little prenatal mortality occurs in deer (Kirkpatrick 1975). It is possible that the slightly higher VDGIF oak mast index at HK compared to SC (11.1 acorns/limb vs. 6.7 acorns/limb) could have indicated a greater availability of digestible energy during the breeding season, resulting in greater ovulation at HK. However, it also was apparent that although SC deer were in poorer physical condition, SC does were able to maintain a similar physiological state as HK does (as evidenced by the similarities in fetal measurements between areas). This similar physiological state probably reflected the diet similarities found between areas.

The abnormally light snowfall at HK in conjunction with the abnormally heavy snowfall at SC, from December 1, 1986, to March 31, 1987, is believed to have had the greatest effect on the

differences found in the stored fat levels at this time. It is probable that the mild winter at HK resulted in a lessened metabolic energy demand, relative to normal winters, and did not require the use of all fat stores. However, at SC, there were 18 times more days with snow accumulation > 15.0 cm (than the previous winter) and the more than 2 times greater snowfall than normal. These occurrences must have resulted in a much greater metabolic energy demand than in "normal" winters, requiring the use of all sources of stored fat.

Upon combining the data over the 2 sampling periods, significant area differences were obtained that are undoubtedly confounded by winter weather severity and an abnormally abundant acorn crop at SC (in 1985), and thus not true reflections of differences in nutritional status and/or habitat quality. However, as was found in September and November, it is apparent that actual muscle bulk (as evidenced by DBW) was lower on HK deer and HK deer had a smaller skeletal size (which might have contributed to some the differences between areas in body weight). It also is apparent that in years of oak mast scarcity (e.g., 1987 collection), energy nutrition appeared to be similar between areas, although protein nutrition might be slightly better at HK (based on woody bud consumption). Although not mentioned previously in the discussion, it is tempting to infer that the significantly lower serum calcium and sodium levels found in HK deer relative to SC deer were indicative of dietary mineral deficiencies. However, as Church and Pond (1982:138) emphasized, serum calcium levels do not usually reflect dietary calcium intake. They pointed out that although serum calcium levels may decline slightly during the onset of dietary calcium deficiency, control by parathyroid hormone, which promotes bone resorption, and calcitonin, which inhibits bone resorption, "...renders this [serum calcium] a relatively useless index of calcium nutrition." More probable, these differences in serum mineral concentrations in deer reflect differences in energy nutrition between areas. To substantiate this, Seal et al. (1978) found significant dietary energy effects on serum calcium ($P=0.005$) and sodium ($P=0.02$) levels in deer fawns fed diets varying in energy (2 levels) and protein (2 levels) content. All diet combinations were supplemented with minerals and had the same calcium to phosphorus ratios. Deer on the lower energy diets (2700 kcal DE/kg dry weight) had lower serum mineral (Ca and Na) concentrations than deer on the

moderate energy diets (3000 kcal/kg). Also, LeResche et al. (1974) pointed out that serum calcium depression during winter months may be related to reduced nutrition and possible hypoproteinemia and decreased vitamin D. Because the largest differences in serum calcium and sodium levels in deer between HK and SC were noted in March 1986, which was when SC deer foraged almost exclusively on acorns (high in energy), it is believed that the lowered serum mineral levels in HK deer in March do not reflect dietary mineral deficiencies. Further evidence to support this belief is presented in the Forage Quality section. Thus, taking into account the substantial effects of increased winter weather severity at HK and the abundance of acorns in the diet of SC deer (and its subsequent influential effects on energy nutrition) in 1986, there do not appear to be any consistent notable differences between the 2 deer herds except for skeletal size, muscle mass, and antler development.

Habitat Assessment

Most of the nutritional assessment results in September or March did not indicate any apparent differences in habitat quality between HK and SC. However, the hunter-harvest data in conjunction with the abomasal parasite counts suggested the possibility of a lowered carrying capacity at HK. Although there is no way of determining an overall quantitative index of habitat quality to corroborate these findings, the significant area differences in soil mineral levels, forage abundance, and forage quality are discussed in terms of their relevance to deer physiology.

Soil Measurements

Zeedyk (1967) emphasized the importance of determining soil fertility and forage abundance and quality when appraising deer habitat. And as stated previously, strong correlations have been documented between soil mineral levels and deer characteristics. The significantly greater soil mineral levels in conjunction with heavier body weights and larger antlers at SC appear to corroborate the findings of other investigators. Although it is believed that the differences documented in

the soil measurements exist between areas, oddities are present. Deciduous hardwood forests typically induce a basic soil pH regime from the decomposition of fallen dead leaves, which are rich in bases (Thompson and Troeh 1978:33). High Knob is almost entirely forested by deciduous hardwood trees, while a small percentage (5.7%) of SC is forested in coniferous stands, which tend to maintain and thrive in more acidic soil. It follows then that both areas should have reflected relatively non-acidic soils, with a greater potential at HK. However, the significantly more acidic soils at HK relative to SC were suggestive of something odd in the soil nutrient regime at HK. After documenting abnormally low soil pH levels in mature oak stands at HK by another investigator (J. Burger, pers. comm.), acid precipitation in conjunction with relatively high precipitation was considered as a factor contributing to this condition. Based on a scale presented by Thompson and Troeh (1978:173), soil pH values at HK and SC would be considered strongly acidic and medium acidic, respectively. Although soil pH is reported to have little or no direct effect on plant growth, soil pH directly affects the amount of bases (Ca, Mg, K) available to plants for uptake (Thompson and Troeh 1978:173), and subsequently, available to animals for metabolic needs (growth, lactation, antler development, etc.) from foraging on these plants.

Forage Abundance

Although quantities of all vegetative classes were significantly greater at HK relative to SC, utilization of the vine and forest grass vegetative classes, as evidenced in the September food habits results, was virtually nonexistent at both areas. Also, the absolute difference between areas in the woody leaves vegetative class is not believed to be of a magnitude to cause any biological differences between herds. The absolute difference between areas in the forb vegetative class was substantial. However, the estimate of this vegetative class at HK was dominated by ferns, a nonpalatable and infrequently consumed forage (Harlow and Hooper 1971). Forty-one percent of the clipped plots at HK containing forbs were dominated by ferns, while only 6.7% of these plots at SC were dominated by ferns. Ferns have relatively large amounts of stalk compared to leaf mass. This results in heavier dry weights relative to equal wet quantities of less stalky leaves. Though the effects of this on the HK forb estimate are not quantifiable, it is probable that the overall differences in the

quantity of readily eaten forbs between areas may not be substantial. It could be inferred that fungi availability was lower at HK relative to SC in September 1985, based on the lower quantities found in the HK rumen contents. However, mushrooms are a very sought after food item (Harlow and Hooper 1971). Their life cycle is very short, which results in periods of abundance and scarcity (O'Halloren et al. 1987). The majority of ingested forages during a single foraging period are "turned over" in approximately 24 hours (Church 1969:89); and thus, it is more likely that the quantities of mushrooms reported herein merely attest to their immediate availability.

Although it is believed that the area similarities in the March woody leaves estimate are accurate, the forb differences between areas are believed to be inaccurate due to error carried over from the September estimate (due to the preponderance of ferns in the clipped plots at HK). A better reflection of the potential abundance of both vegetative categories present in March was exhibited in the percent frequency of occurrence estimates. These estimates tended to indicate that winter forages (mainly rhododendron, mountain laurel, teaberry, and galax) were relatively lower at HK. It could be inferred from the 1987 food habits results that the relative quantities of evergreen woody tree leaves and evergreen forbs consumed was indicative of their availability. From personal observation at both areas, winter supplies of evergreen woody leaves accessible to deer far exceeded their apparent demand. Also, deer tend to select the most palatable (and nutritious) forages available (Zeedyk 1967, Harlow 1984). Thus, because deer at HK were eating more evergreen woody leaves relative to evergreen forbs and SC deer were eating more evergreen forbs relative to evergreen woody leaves in March, this is suggestive of a decreased availability of evergreen forbs (plants) at HK relative to SC, which tends to corroborate the relatively lower percentage of evergreen forbs encountered at HK in September.

Based purely on the VDGIF oak mast survey results on a yearly basis, it might be inferred that HK has the potential for producing more abundant mast crops than SC; but, there was some evidence of a lowered potential to produce "excellent" mast crops at HK relative to SC. This may be a result of the area differences in soil measurements, although no literature on this effect was

found. As stated previously, both areas are dominated by forest cover types with oak components. However, almost half of the HK area is dominated by the yellow poplar-white oak-red oak covertypes, which is composed almost entirely of yellow poplar, whereas nearly 75% of the SC area is dominated by the white oak-red oak-hickory covertypes. In other words, almost 30% more of the SC area is composed of oak dominated covertypes. Although the actual density of mast producing oaks is not known, it is probable that this density is lower at HK relative to SC. The implications of this are worth discussing. Given a similar mast production per tree figure at both areas (as might be inferred from the VDGIF indices) of 25 kg and a density of mast producing oaks figure of 10 trees/ha at HK and 25 trees/ha at SC (as might be the case based on differences between areas in oak dominated covertypes), it follows that the total acorn biomass per ha at HK and SC would be 250 kg/ha and 625 kg/ha, respectively. Although these numbers are purely hypothetical, the relative magnitude in the difference between areas is believed to be plausible. Also, when mast crop yields per tree are substantially different between areas (as was the case in 1985), the relative difference between areas is even further amplified.

Forage Quality

The effects of the lowered soil pH on soil calcium availability at HK were corroborated by the chemical analyses of some of the forages. However, the significantly lower soil phosphorus, magnesium, and potassium levels at HK were not reflected in the forage mineral levels. The inverse relationship found between soil and plant levels of these minerals at HK is not understood based on the discussed effects of soil pH on the availability of bases. Hundley (1956), however, found similar inconsistencies in the mineral content of plants collected on 4 different soils in the Ridge and Valley Physiographic Province. It also is possible that the time of sampling, especially for the September collected forages, could have influenced the mineral content analyses of the forages (J. Burger, pers. comm.). Early fall is a time when some translocation of nutrients (and minerals) from the leaves to the stems begins (Larcher 1980:141), potentially resulting in the inconsistent patterns found among the various mineral/forage combinations between areas. Thus, it is apparent that interpretation of the differences between areas in forage mineral content is difficult. It must be re-

iterated, however, that given the inconsistencies among most of the mineral levels, calcium levels in forages collected at HK tended to be lower in all cases relative to SC. Although it is tempting to infer (using this result in conjunction with the lower serum calcium levels) that HK deer were subjected to deficient dietary calcium levels, all forages at HK contained calcium levels in excess of that determined to be necessary for adequate growth, skeletal development, and antler development of weaned fawns (based on the work of Ullrey et al. 1973). Even though it is not believed that mineral nutrition differs substantially between deer herds, it is worth noting that many researchers have documented the importance of dietary mineral deficiencies and imbalances as determinants of animal condition, fertility, productivity, and mortality (Robbins 1983:30). Robbins (1983:30) further stated that, "marginal deficiencies are easily overlooked as population fluctuations are attributed to more obvious factors, such as severe weather, food shortages, parasites, and infectious agents."

More importantly, the significantly greater amount of lignin in all forages (except galax) collected at HK resulted in significantly lower predicted digestibilities at HK in 2 summer (sassafras and sourwood) and 2 winter forages (rhododendron and mountain laurel). At the individual animal level, it is thought that these differences in digestibility were insignificant. For example, given an animal of equal weight at each area, a forage containing 4 kcal/g (dry-weight) of gross energy with digestibilities of 65% (HK) and 69% (SC), and a daily metabolic energy requirement of 2500 kcal for each animal, it is calculated that the deer at HK would have to consume approximately 960 g of forage (dry-weight), while the SC animal would have to consume approximately 905 g (dry-weight) of forage. White-tailed deer have an extraordinary ability to gather their forage in an efficient manner (Verme and Ullrey 1984); and thus, the extra time spent foraging by the HK deer would be considered insignificant. However, these differences in digestibilities do become significant when metabolic energy requirements differ between areas. Although the metabolic energy requirements of deer between areas is not known, it is conceivable that the greater average winter severity at HK could result in an increased energy demand on HK deer relative to SC deer. Thus, given the same figures as above and metabolic energy requirements of 3500 kcal (HK) and 2500 kcal (SC),

it is calculated that the HK deer would have to consume 1345 g of forage (dry-weight), while the SC deer would still have to consume approximately 905 g (dry-weight) of forage. Although these simulations reflect potentially profound implications, it must be noted that other forages analyzed did not differ significantly in digestibility between areas.

Thus, in terms of overall habitat quality, it is believed that although soil mineral levels are lower at HK relative to SC, quantities of (leafy) forage and their mineral composition do not appear to be biologically significant between areas. More importantly, average yearly total acorn biomass is thought to be substantially lower at HK relative to SC, although empirical data supporting this are absent. There also is some evidence to suggest that forage digestibility is lower at HK relative to SC and is the only other factor differentiating habitat quality between areas.

Extent of Poaching and Free-roaming Dogs

Poaching undoubtedly occurs on both study areas both out of season and during hunting season, and was documented at HK in season. The extent to which poaching is occurring at HK relative to SC, however, is believed to be similar between areas or slightly less at HK. Although there is a lack of literature documenting the sole effects of poaching on white-tailed deer abundance, poaching certainly has a reducing effect on herd density. Based on this, it is intuitive that poaching also indirectly increases the relative amount of digestible energy available per animal and theoretically results in larger and better conditioned deer. Since deer at HK are not in better physical condition relative to SC deer, it is believed that poaching is not a major factor affecting the HK deer herd.

The scent station track counts did not reflect any substantial differences to infer that free-roaming dogs were in greater abundance at either area. There is good scientific evidence to support the belief that free-roaming dogs are not effective predators (Sweeny et al. 1971, Corbett et al. 1972,

Scott and Causey 1973, Gavitt et al. 1974, Causey and Cude 1980), do not cause permanent changes in home ranges (Gipson and Sealander 1977), and do not effect reproduction of adult white-tailed deer (Gavitt et al. 1974, Gipson and Sealander 1977). However, in newly stocked or low-density areas, harassment by dogs may have a significant effect on the establishment or growth a deer herd (Hawkins and Montgomery 1969, Perry and Giles 1970, Corbett et al. 1972, Peery and Coggin 1975:38, Nichols and Whitehead 1978). No studies reporting the effects of free-roaming dogs on the nutritional or physical condition of whitetails or the general effects of feral dogs on deer during periods of severe snow accumulation were found in the literature. Although feral dog abundance may be similar between areas, it is conceivable that the effects of free-roaming dogs during periods of heavy snowfall at HK could be affecting the late winter physical condition of deer at HK relative to SC.

Summary Conclusions

Over the course of this study, a large volume of information was collected on deer and habitat characteristics at both areas. However, as is the case in almost all field studies, cause and effect relationships between potential causative factors and their effects on the subject being studied can seldom be affirmed. Instead, the data obtained in this study provided valuable insight from which inferences were made as to the probable factors contributing to the differences noted between the HK and SC deer herds. Before proceeding, it must be stated that the late winter physical condition of the SC deer herd in a "normal" year was not documented due to the influential effects of an abnormally abundant mast crop (1986 collection) or an abnormally harsh winter (1987 collection). Because the physical condition of the SC deer herd in March 1987 was similar to that at HK in March 1986 and noting that winter weather is normally milder at SC, it is assumed that the SC deer herd would reflect a somewhat better physical condition than the HK deer herd in years of "normal" winter weather. A summary of the major differences found between areas are presented in Table 42. By piecing the data together from all sources and making some reasonable assumptions, a

Table 42. A summary of the major significant differences found between High Knob (HK) and Stony Creek (SC), Virginia, over the duration of the study.

Study Component	Major Differences
Relative Deer Abundance	HK had a lower pellet group density
Nutritional Assessment	
September	HK deer had lower serum concentrations of total protein and total cholesterol HK deer had higher abomasal parasite counts
November	Hunter-harvested bucks had lighter dressed body weights, smaller antler beam diameters, and fewer antler points
March	HK deer had lighter body weights, possibly lower stored fat levels, possibly lower serum cholesterol, beta-hydroxybutyrate, calcium and sodium concentrations, and possibly smaller and lighter fetuses. It must be noted that both March collections were heavily influenced by abnormalities
Habitat Assessment	
Soil Measurements	HK had a lower soil pH and lower mineral and organic matter levels
Forage Abundance	HK probable had lower total acorn biomass
Winter Weather	HK had 3X greater snowfall in "normal" winters

conceivable scenario was thought to have been created to explain the current status of the HK deer herd.

The most significant and consistent results obtained over the course of the study, which were indicative of the nutritional status of the HK deer herd in general, were the yearling buck body weights and antler measurements. This is rationalized by the relatively larger sample size and low variance associated with these measurements. Also, these data were not confounded by sex. Primary factors believed to be affecting the HK deer herd were winter weather severity and the lack of high quality forages in late fall through late winter. The possibility of a lowered forage digestibility as a contributing factor also is considered.

To explain the way in which these factors affect the HK deer herd, the scenario begins in September and assumes that the VDGIF oak mast index did not differ greatly between areas (± 10 acorns/limb) and winter weather patterns at each area are similar to their 10-year norm. Based on the September 1985 kidney fat index and bone marrow data, it is believed that the condition of adult (2.5+ -years-old) animals is similar between areas at this time of year. As fall progresses and acorns become available, deer at both areas begin to consume acorns almost exclusively and begin to build abdominal and subcutaneous fat reserves. However, because it is believed that total acorn biomass is substantially lower at HK, mast crops at HK are depleted more rapidly. Subsequently, as HK deer are forced to consume greater quantities of lesser quality forage while SC deer continue to forage on acorns, it is thought that SC deer surpass HK deer in physical condition upon entering winter.

Although it is apparent that winter forage utilization is similar between areas after acorns are depleted (March 1987 food habits results) and is of insufficient quality to meet energy demands, deer at both areas begin to use stored fat reserves. However, because of the normally higher snowfall at HK and its effects on energy expenditure, it is hypothesized that the metabolic energy requirements for similar sized deer are greater at HK. This results in an increased rate of fat

catabolism at HK relative to SC. Additionally, it is believed that over most winters at HK (and possibly SC), fat stores become depleted, resulting in muscle catabolism. Although it is possible that muscle catabolism may occur in SC deer as well, it most likely occurs at a much later time during winter and over a shorter period of time (due on their better condition upon entering winter and relatively lower metabolic energy requirements). Ultimately, deer are in poorer physical condition at HK, relative to SC, by late winter.

The effects of the decreased late winter physical condition of pregnant does at HK on fawning weights is not known. However, it is well documented that decreased physiological state of the doe can dramatically affect prenatal development (see prenatal development section of Literature Review). For the purposes of this discussion, it is assumed that fawning dates are similar between areas. Thus, it is hypothesized that fawns at HK are lighter at birth relative to SC fawns. From this, it might be hypothesized that fawn survival within 2 weeks after birth might be lower at HK than at SC (based on the probability that HK does are not producing milk at all or are producing insufficient quantities due to their relatively poorer physical condition leaving winter). Of the fawns surviving, most are probably lighter by the end of summer relative to SC fawns. Once weaned, these fawns are subjected to the same factors as mentioned for adult deer from September through March. Fawn bucks at HK entering their first winter are smaller and in relatively poorer physical condition than SC fawns (due to the lack of quality forage in late fall); and by the end of winter, the differences in fawn body weights and physical condition between areas are substantial.

As fawn bucks become yearlings, energy demands for antler development are present for the first time, but are secondary to energy demands for body growth (French et al. 1955). Thus, because 1-year-old bucks are in poorer condition at HK in early spring, muscle anabolism takes precedence over antler formation. However, 1-year-old bucks at SC, being in relatively better physical condition, are able to shunt excess energy intake into antler development sooner and while continuing to put on body weight. From this, it is understandable that yearling buck body weights and

antler characteristics would be significantly lower at HK relative to SC in November (as reflected in the hunter-harvest data).

It is believed, however, that as the HK animal matures, the area differences become less substantial. This is rationalized by the fact that over time, growth rates tend to level off as animals become older, subsequently affording the smaller HK animal the chance to "catch up". Although the scenario presented is undoubtedly an oversimplification of the effects caused by a multitude of factors, some unmeasurable or not realized, interacting to produce the present herd conditions at HK, it is believed that too often, overly complex factors are searched for, while simple, yet powerful factors are ignored.

If the possibility of a lowered forage digestibility at HK, relative to SC, is included in the above scenario, the differences hypothesized could be of even greater magnitude. Also, if this factor is considered independently of the other factors mentioned, its potential effects are profound, yet straightforward. For example, given similar quantities of forages between areas (excluding acorn biomass) and a lowered forage digestibility at HK, it follows that the overall amount of digestible energy available would be lower at HK. Thus, fewer animals per unit of area could be supported at HK relative to SC. It also is intuitive that if the HK deer herd was at or above carrying capacity (as the abomasal parasite count data would suggest), the amount of digestible energy per animal would be insufficient to support better developed animals (as the hunter-harvest data would suggest is the case). Although this concept is appealing, empirical data to support this are absent.

Management Considerations

Although the overall herd size at HK is apparently increasing slightly in response to the substantial increase in timber harvesting in the area (as evidenced by the increase in hunter harvest of antlered bucks), it is believed that herd density is above that conducive to quality physical characteristics. For the purposes of this section, it is assumed that improvement in body weights and antler characteristics is desired. The 2 main causative factors contributing to the HK herd status were winter weather (mainly snowfall) and late fall through late winter forage quality. Considerations which potentially may alleviate their effects are presented separately.

Winter Weather Severity

It was estimated that only 1.3% of the HK area was composed of coniferous overstory covertypes. Although stands of rhododendron and mountain laurel were frequently encountered and were heavily used by deer, both as foraging areas and shelter, during winter months (as seen in food habits analyses and when conducting pellet group counts), the amount of area composed by these stands is not known and should be considered. The proximity of these stands to higher quality forage also is not known and should be considered. These stands represent virtually all of the shelter available for deer to minimize energy expenditures and management practices to enhance

(or at least maintain) their occurrence would contribute to improving the late winter physical condition of the deer.

Abundance of Quality Forage

The summer and early autumn forage base is rapidly increasing at HK because of increasing regeneration cutting. Although these cuts do supply some winter forage in the way of buds, buds do not appear to be consumed in large quantities relative to other forages (as found in the March food habits analyses). Probably the biggest difference between HK and SC is the abundance (total biomass) of acorns. Acorns, by far, are the most energy-rich, naturally occurring forage available to deer. When acorns are abundant deer eat little else (Crawford and Leonard 1965, Segelquist and Green 1968). Management efforts to enhance total acorn biomass should be considered, although acorns are not produced by oaks until 30-40 years of age (Merritt 1980:131). Selective thinning of current oak stands to increase acorn production or complete preservation of all mast producing oaks should be considered. However, because little can be done about improving total mast production in the short run, consideration of a winter forage improvement program is warranted. Not only might this include the maintenance of clearings and seeded roadways, but the planting in strategic locations of a self-maintaining, high quality forage that persists through winter. An example of such a species which has been thoroughly tested in the Southeast and supported by prominent members within the profession is Japanese honeysuckle (*Lonicera japonica*) (Segelquist et al. 1971, Craft and Haygood 1972).

Other Considerations

Other factors affecting the HK deer herd to a lesser degree also can be addressed. The development of an improved monitoring and control system of free-roaming dogs might be warranted. Also, monitoring of acid precipitation and cooperative research with U.S. Forest Service on the seriousness of the problem and its effects on wildlife should be considered. Questions raised, but not answered in this study that might warrant further research include the physical condition of deer in late fall/early winter, mortality rates of different age classes and sexes of deer over winter and the

factors causing mortality, postnatal mortality over summer, and movement patterns of deer during winter.

Future Study Considerations

Problems commonly encountered by all researchers conducting studies are budget and time constraints. Before research projects are begun, cost and time allocations usually are estimated based on the techniques proposed and personnel required to evaluate pre-set objectives. However, one component of this process too often disregarded is determining the number of samples necessary to achieve a certain level of precision and confidence in the results. By calculating the sample size required to estimate the true population mean for a particular variable to be measured, given a set level of precision and confidence, the feasibility and intensity of the research (in terms of cost and time) can be evaluated.

Using the data collected in this study, sample sizes necessary to estimate the true population mean of selected variables with 10% precision at the 95% confidence level were calculated (Table 43). For example, it was determined that to estimate the true population mean of dressed body weights for yearling bucks in November with 10% precision at the 95% confidence level, 6 deer must be collected at each area. On the other hand, to estimate the true population mean of the number of parasites per deer in September with 10% precision at the 95% confidence level, 402 deer (abomasums) must be collected (analyzed) at each area. Further examination of Table 43 reveals that most of the variables measured (a representative subset of all the variables measured) were under sampled at both areas, although some variables were over sampled.

Thus, a general question must be asked. Is a study like this feasible, given 10% precision and 95% confidence levels and the actual budget and time constraints? The answer must be no, if the under sampled variables are considered. However, this sort of post-study analysis is useful in identifying possible data weaknesses and strengths or the practical utility of the variables measured. For example, abomasal parasite counts (in September) and the kidney fat index (in March), which

Table 43. Necessary sample sizes to estimate the true population mean with 10% precision at the 95% confidence level for a subset of the variables measured in this study. Actual sample sizes of these variables are given for High Knob (HK) and Stony Creek (SC).

Variable Measured	Required Sample Size	Actual Sample Size	
		HK	SC
Pellet groups/plot	1669	500	346
September variables			
# of parasites/deer	402	15	16
Hunter-harvest variables			
Dressed body weights (yearlings)	6	32	66
Antler beam diameters (yearlings)	27	32	66
Number of antler points (yearlings)	77	32	68
March variables			
Dressed body weights	23	20	20
Femur marrow fat	4	19	20
Kidney fat index	396	20	20
Serum total protein	6	17	20
Blood urea nitrogen	111	17	20
Serum total cholesterol	20	17	20
Nonesterified fatty acids	299	17	20
Beta-hydroxybutyrate	58	17	20
Fetal length	24	12	13
Fetal weight	145	12	13
Rumen protein	12	20	20
Fecal protein	37	20	20
Soil variables			
pH	14	82	82
Calcium	623	82	82
Phosphorus	1763	82	82
Magnesium	438	82	82
Potassium	85	82	82

Table 43. Continued.

Variable Measured	Required Sample Size	Actual Sample Size	
		HK	SC
Organic matter	138	82	82
Forage chemical components			
Sourwood			
Protein	7	9	14
Lignin	63	9	14
Acid detergent fiber	11	9	14
Calcium	48	9	14
Phosphorus	16	9	14
Magnesium	22	9	14
Potassium	46	9	14
Teaberry			
Protein	3	9	8
Lignin	17	9	8
Acid detergent fiber	4	9	8
Calcium	33	9	8
Phosphorus	12	9	8
Magnesium	18	9	8
Potassium	14	9	8

are commonly used techniques, are highly variable and require relatively large sample sizes to precisely estimate the true population mean. Thus, the practicality of their use may be questionable. Also, since these measurements were under sampled, the results pertaining to these variables also might be questionable. On the other hand, dressed body weights and antler beam diameters of yearling bucks in November vary little from sample to sample, which results in relatively small required sample sizes. And thus, the practicality of their use could be considered good. Also, since these measurements were over sampled, the results pertaining to these variables are most likely valid and precise.

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Appendices

Appendix I. Arithmetic means and standard errors for the number of pellet group/plot count while conducting pellet-group surveys at High Knob (HK) and Stony Creek (SC), Virginia, in March 1986 and 1987. Ranges are in parentheses.

Year	Area	n	Pellet groups/plot	
			$\bar{X}$	SE
1986	HK	250	0.50 (0-9)	0.07
	SC	173	0.54 (0-6)	0.08
1987	HK	250	0.34 (0-5)	0.05
	SC	173	0.65 (0-6)	0.09

Appendix II. Arithmetic means and standard errors by year, area, and age class for dressed body weights of yearling bucks (DBW), antler main beam diameters (MBD), and the number of antler points (NAP) from hunter harvested white-tailed deer at High Knob (HK) and Stony Creek (SC), Virginia in November 1985 and 1986. Ranges are in parentheses.

Year	Area	Age Class	n	DBW (kg)		MBD (mm)		NAP	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
1985	HK	Yearling	17	35.4 (25.4-40.8)	0.9	13.1 (8.0-18.0)	0.7	2.4 (2.0-4.0)	0.2
		Adult	10	-	-	21.2 (15.0-29.0)	1.3	4.9 (2.0-9.0)	0.7 ¹
	SC	Yearling	34	39.0 (31.8-53.1)	0.8	14.1 (8.0-23.0)	0.6 ²	2.8 (2.0-7.0)	0.2 ³
		Adult	18	-	-	22.4 (11.0-34.0)	1.6	6.8 (2.0-14.0)	0.7
1986	HK	Yearling	15	35.4 (30.8-41.3)	0.8	12.0 (7.0-15.0)	0.7	2.1 (2.0-3.0)	0.1
		Adult	7	-	-	23.3 (12.0-31.0)	2.6	6.0 (3.0-9.0)	0.9
	SC	Yearling	32	39.2 (25.4-50.8)	0.9	17.0 (10.0-23.0)	0.6	3.5 (2.0-6.0)	0.3
		Adult	21	-	-	24.2 (19.0-34.0)	0.9	7.3 (4.0-12.0)	0.4

¹ n = 11

² n = 31

³ n = 36

Appendix III. Arithmetic means and standard errors by area, sex, and age class for whole body weight (WBW), dressed body weight (DBW), kidney fat index (KFI), femur marrow fat (FMF), mandibular marrow fat (MMF), and the femur to hindfoot ratio (F/HF) from white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	WBW (kg)		DBW (kg)		F/HF	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	41.2	-	27.7	-	0.523	-
		Adult	4	49.2 (48.1-51.3)	0.8	32.9 (32.7-33.1)	0.1	0.552 (0.547-0.558)	0.002
	M	Yearling	3	47.0 (40.8-52.2)	3.3	32.7 (29.0-39.5)	3.4	0.540 (0.529-0.555)	0.007
		Adult	2	64.6 (63.5-65.8)	1.1	49.2 (48.1-50.3)	1.1	0.552 (0.544-0.560)	0.008
SC	F	Yearling	1	45.4	-	34.0	-	0.553	-
		Adult	6	54.1 (47.2-63.5)	2.3	38.0 (33.6-42.2)	1.3	0.549 (0.528-0.574)	0.007
	M	Yearling	3	47.5 (45.8-48.5)	0.8	34.8 (32.7-36.3)	1.1	0.526 (0.515-0.539)	0.007

Appendix III. Continued.

Area	Sex	Age Class	n	KFI (%)		FMF (%)		MMF (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	21.3	-	88.4	-	89.3	-
		Adult	4	11.8 (8.1-14.2)	1.3	90.9 (79.8-95.7)	3.7	89.6 (83.6-92.9)	2.1
	M	Yearling	3	22.4 (12.4-34.5)	6.5	85.9 (78.7-94.7)	4.7	89.7 (88.0-90.7)	0.9
		Adult	2	38.0 (30.4-45.6)	7.6	89.4 (85.6-93.2)	3.8	90.5 (90.0-91.0)	0.5
SC	F	Yearling	1	18.0	-	90.9	-	91.0	-
		Adult	6	24.1 (8.6-34.5)	3.9	93.5 (81.3-98.7)	3.2	91.3 (88.5-92.8)	0.7
	M	Yearling	3	21.7 (19.4-23.1)	1.2	86.7 (81.4-94.2)	3.9	88.8 (86.8-90.8)	2.0

Appendix IV. Arithmetic means and standard errors by area, sex, and age class for serum total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), and nonesterified fatty acids (NEFA) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	TP (g/dl)		BUN (mg/dl)		TC (mg/dl)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	6.6	-	8.0	-	58.0	-
		Adult	4	6.8 (6.4-7.2)	0.2	10.0 (4.0-17.0)	2.7	55.5 (53.0-61.0)	1.8
	M	Yearling	3	6.7 (6.3-7.4)	0.4	18.0 (12.0-27.0)	4.6	67.0 (61.0-75.0)	4.2
		Adult	2	7.5 (7.0-7.9)	0.5	18.0 (12.0-24.0)	6.0	64.0 (59.0-69.0)	5.0
SC	F	Yearling	1	6.8	-	16.0	-	74.0	-
		Adult	6	7.9 (7.2-8.3)	0.2	14.8 (12.0-19.0)	1.2	72.8 (55.0-93.0)	6.4
	M	Yearling	3	7.3 (7.0-7.7)	0.2	14.7 (10.0-18.0)	2.4	66.3 (64.0-69.0)	1.5

Appendix IV. Continued.

Arca	Sex	Age Class	n	TRI (mg/dl)		NEFA (mM)	
				$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	29.0	-	153.7	-
		Adult	4	56.3 (20.0-103.0)	17.8	119.0 (80.2-136.0)	13.1
	M	Yearling	3	33.3 (20.0-54.0)	10.5	117.6 (71.5-197.5)	40.1
		Adult	2	64.0 (29.0-99.0)	35.0	88.7 (87.0-90.4)	1.7
SC	F	Yearling	1	32.0	-	114.9	-
		Adult	6	38.8 (19.0-62.0)	7.6	88.7 (63.2-125.5)	12.0
	M	Yearling	3	36.0 (32.0-43.0)	3.5	156.4 (64.7-248.1)	91.7

Appendix V. Arithmetic means and standard errors for serum calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	Ca (mg/dl)		P (mg/dl)		Na (mcq/l)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	10.1	-	11.3	-	139.0	-
		Adult	4	9.7 (8.9-10.5)	0.4	5.7 (2.8-7.3)	1.0	137.3 (127.0-146.0)	4.6
	M	Yearling	3	10.5 (9.5-11.4)	0.6	9.1 (8.8-9.3)	0.1	138.7 (135.0-142.0)	2.0
		Adult	2	10.7 (10.3-11.0)	0.4	9.6 (8.2-10.9)	1.4	144.0 (143.0-145.0)	1.0
SC	F	Yearling	1	10.3	-	12.2	-	142.0	-
		Adult	6	10.1 (9.1-10.4)	0.2	8.1 (6.4-9.1)	0.5	141.0 (135.0-145.0)	2.1
	M	Yearling	3	10.8 (9.9-11.4)	0.5	9.8 (9.4-10.5)	0.4	143.3 (142.0-145.0)	0.9

Appendix V. Continued.

Area	Sex	Age Class	n	K (meq/)		GLU (mg/dl)		PCV (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	10.0	-	173.0	-	50.0	-
		Adult	4	9.3 (8.7-9.7)	0.2	162.8 (114.0-201.0)	18.0	46.0 (40.0-54.0)	4.2
	M	Yearling	3	11.9 (8.5-16.2)	2.3	278.3 (12.0-532.0)	128.1	49.3 (45.0-57.0)	3.8
		Adult	2	11.9 (11.5-12.2)	0.4	150.0 (141.0-159.0)	9.0	55.0	-
SC	F	Yearling	1	11.8	-	191.0	-	47.0	-
		Adult	6	10.2 (7.8-14.2)	1.2	193.2 (86.0-322.0)	38.4	42.2 (30.0-50.0)	3.6
	M	Yearling	3	9.7 (6.4-12.2)	1.7	238.3 (155.0-319.0)	47.4	47.0 (44.0-52.0)	2.5

Appendix VI. Arithmetic means and standard errors by area, sex, and age class for testes weights (TW) and corpora rubra counts (CR) of white-tailed deer collected at Ilich Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	TW (g)		CR	
				$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	-	-	0.0	-
		Adult	4	-	-	1.0	0.0
	M	Yearling	3	58.9 (32.0-78.6)	13.9	-	-
		Adult	2	72.1 (61.3-82.9)	10.8	-	-
SC	F	Yearling	1	-	-	0.0	-
		Adult	6	-	-	1.2 (1.0-2.0)	0.2
	M	Yearling	3	41.7 (21.3-72.6)	15.7	-	-

Appendix VII. Arithmetic means and standard errors by area, sex, and age class for rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	CP (%)		ADF (%)		Lignin (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	16.8	-	25.2	-	21.9	-
		Adult	4	19.0 (12.8-25.4)	2.9	30.2 (22.4-36.6)	3.3	24.6 (19.9-28.7)	2.0
	M	Yearling	3	22.9 (14.8-28.2)	4.1	26.2 (23.4-28.2)	1.4	21.1 (19.9-22.5)	0.8
		Adult	2	21.3 (12.2-30.4)	9.1	23.0 (16.0-30.0)	7.0	21.6 (18.6-24.6)	3.0
	F	Yearling	1	23.8	-	19.0	-	19.5	-
		Adult	6	20.4 (15.8-25.4)	1.4	28.6 (15.6-37.0)	2.9	27.0 (16.8-46.3)	4.2
SC	M	Yearling	3	20.6 (16.8-24.2)	2.1	25.7 (25.2-26.2)	0.3	22.8 (22.3-23.5)	0.4

Appendix VII. Continued.

Area	Sex	Age Class	n	DMD (%)	
				$\bar{X}$	SE
HK	F	Yearling	1	66.1	-
		Adult	4	61.0 (53.5-70.1)	3.6
	M	Yearling	3	66.0 (64.2-66.9)	0.9
		Adult	2	68.0 (59.9-76.0)	8.1
SC	F	Yearling	1	71.0	-
		Adult	6	60.8 (52.3-77.6)	3.8
	M	Yearling	3	63.5 (62.0-65.9)	1.2

Appendix VIII. Arithmetic means and standard errors by area, sex, and age class for abomasal parasite counts of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Year	Area	Sex	Age Class	n	# of parasites/deer	
					$\bar{X}$	SE
1984	HK	F	Adult	3	2480 (1420-3500)	601
		M	Yearling	1	1960	-
			Adult	1	1100	-
	SC	F	Yearling	1	1600	-
			Adult	4	1175 (660-2180)	342
		M	Fawn	1	280	-
1985	HK	F	Yearling	1	960	-
			Adult	4	1265 (720-1580)	191
		M	Yearling	3	1480 (1380-1660)	90
			Adult	2	1230 (760-1700)	470
	SC	F	Yearling	1	160	-
			Adult	6	410 (0-1000)	187
		M	Yearling	3	100 (60-180)	40

Appendix IX. Arithmetic means and standard errors for fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ratio (F/P) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in September 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	CP (%)		ADF (%)		F/P	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	1	20.8	-	42.8	-	2.1	-
		Adult	4	15.5 (14.0-16.8)	0.6	47.1 (40.3-51.0)	2.4	3.1 (2.4-3.6)	0.3
	M	Yearling	3	17.6 (12.8-22.4)	2.8	45.1 (38.5-56.9)	5.9	2.8 (1.7-4.4)	0.8
		Adult	2	12.8 (12.6-13.0)	0.2	53.0 (46.3-59.8)	6.7	4.2 (3.6-4.7)	0.6
SC	F	Yearling	1	19.0	-	38.1	-	2.0	-
		Adult	6	17.9 (10.0-26.2)	2.2	44.1 (32.2-57.8)	3.4	2.8 (1.2-5.8)	0.6
	M	Yearling	3	16.9 (14.0-19.6)	1.6	40.0 (36.1-44.1)	2.3	2.4 (1.8-3.2)	0.4

Appendix X. Arithmetic means and standard errors by area, sex, and age class for whole body weight (WBW), dressed body weight (DBW), kidney fat index (KFI), femur marrow fat (FMP), mandibular marrow fat (MMF), and the femur to hindfoot ratio (F/HF) from white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1986. Ranges are in parentheses.

Area	Sex	Age Class	n	WBW (kg)		DBW (kg)		F/HF	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	32.4 (31.3-33.6)	1.1	25.2 (23.6-26.7)	1.6	0.568 (0.542-0.595)	0.027
		Adult	5	44.5 (40.4-50.8)	2.0	31.6 (28.1-35.4)	1.2	0.552 (0.520-0.584)	0.010
	M	Fawn	3	26.9 (25.4-28.6)	0.9	20.4 (19.1-21.8)	0.8	0.530 (0.510-0.554)	0.013
SC	F	Fawn	3	28.7 (25.9-31.3)	1.6	21.8 (19.5-23.6)	1.2	0.553 (0.541-0.560)	0.006
		Adult	4	50.7 (46.7-61.2)	3.5	35.3 (32.7-42.2)	2.3	0.544 (0.519-0.564)	0.010
	M	Fawn	2	31.1 (29.0-33.1)	2.0	24.3 (22.7-25.9)	1.6	0.535 (0.524-0.546)	0.010
		Adult	1	54.4	-	41.3	-	0.586	-

Appendix X. Continued.

Area	Sex	Age Class	n	KFI (%)		FMF (%)		MMF (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	12.2 (8.6-15.7)	3.6	93.3 (92.1-94.4)	1.2	79.4 (72.2-86.6)	7.2
		Adult	5	9.2 (5.9-11.6)	1.0	89.1 (82.4-95.1)	2.8	81.2 (70.2-89.0)	4.0
	M	Fawn	3	6.0 (4.0-10.1)	2.0	84.8 (80.1-87.7)	2.4	79.8 (66.7-87.4)	6.6
SC	F	Fawn	3	51.6 (41.4-70.9)	9.7	94.2 (91.6-97.2)	1.6	91.2 (89.5-93.7)	1.3
		Adult	4	53.1 (28.3-98.4)	16.0	97.2 (96.0-98.5)	0.5	90.1 (86.3-92.3)	1.3
	M	Fawn	2	20.6 (18.3-22.8)	2.3	96.4 (95.6-97.2)	0.8	90.6 (88.0-93.1)	2.6
		Adult	1	8.8	-	93.9	-	92.1	-

Appendix XI. Arithmetic means and standard errors by area, sex, and age class for serum total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), nonesterified fatty acids (NEFA), and beta-hydroxybutyrate (B-HB) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1986. Ranges are in parentheses.

Area	Sex	Age Class	n	TP (mg/dl)		BUN (mg/dl)		TC (mg/dl)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	4.3	0.0	11.5 (11.0-12.0)	0.5	39.0 (35.0-43.0)	4.0
		Adult	5	6.3 (5.4-7.2)	0.3	14.0 (7.0-27.0)	3.5	43.4 (38.0-48.0)	1.9
	M	Fawn	3	6.4 (6.2-6.5)	0.2	12.0 (7.0-17.0)	5.0	44.5 (40.0-49.0)	4.5
SC	F	Fawn	3	5.8 (5.0-6.4)	0.4	12.7 (10.0-16.0)	1.8	59.3 (55.0-66.0)	3.4
		Adult	4	6.6 (6.5-6.8)	0.1	8.3 (4.0-15.0)	2.4	60.8 (52.0-79.0)	6.2
	M	Fawn	2	5.5 (5.2-5.8)	0.3	9.0 (8.0-10.0)	1.0	59.0 (53.0-65.0)	6.0
		Adult	1	5.8	-	11.0	-	57.0	-

Appendix XI. Continued.

Area	Sex	Age Class	n	TRI (mg/dl)		NEFA (mM)		B-HB (mM)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	13.0 (5.0-21.0)	8.0	69.8 (64.7-74.9)	5.1	158.1	0.0
		Adult	5	39.0 (20.0-82.0)	11.1	129.2 (85.5-233.0)	26.5	101.1 (52.3-129.5)	13.7
	M	Fawn	3	23.0 (21.0-25.0)	2.0	115.9 (104.3-127.4)	11.5	115.8 (113.3-118.3)	2.5
SC	F	Fawn	3	114.0 (34.0-253.0)	69.8	273.8 (155.7-474.0)	100.6	201.3 (124.5-295.0)	50.0
		Adult	4	47.0 (17.0-98.0)	18.6	381.6 (166.5-827.4)	152.5	165.3 (114.4-237.8)	30.6
	M	Fawn	2	43.5 (17.0-70.0)	26.5	115.8 (102.8-128.9)	13.0	169.9 (165.6-174.3)	4.4
		Adult	1	23.0	-	188.4	-	104.6	-

Appendix XII. Arithmetic means and standard errors for serum calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV) of white-tailed deer collected at Iligh Knob (HK) and Stony Creek (SC), Virginia in March 1985. Ranges are in parentheses.

Area	Sex	Age Class	n	Ca (mg/dl)		P (mg/dl)		Na (meq/l)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	7.2 (6.5-7.8)	0.7	6.8 (6.0-7.6)	0.8	112.0 (99.0-125.0)	13.0
		Adult	5	9.5 (9.2-9.9)	0.1	7.5 (6.7-8.3)	0.3	142.4 (137.0-146.0)	1.6
	M	Fawn	3	10.4 (10.1-10.6)	0.3	8.8 (8.7-8.9)	0.1	138.5 (138.0-139.0)	0.5
SC	F	Fawn	3	10.7 (10.4-11.3)	0.3	10.5 (9.0-12.4)	1.0	143.0 (142.0-144.0)	0.6
		Adult	4	9.6 (7.7-11.0)	0.7	9.2 (7.8-10.0)	0.5	143.3 (139.0-152.0)	3.1
	M	Fawn	2	10.9 (10.8-10.9)	0.1	10.5 (9.9-11.1)	0.6	142.5 (141.0-144.0)	1.5
		Adult	1	9.1	-	6.2	-	142.0	-

Appendix XII. Continued.

Area	Sex	Age Class	n	K (meq/l)		GLU (mg/dl)		PCV (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	7.1 (5.9-8.3)	1.2	245.0 (133.0-357.0)	112.0	46.0 (39.0-53.0)	7.0
		Adult	5	8.9 (7.5-10.0)	0.4	162.8 (107.0-206.0)	18.7	51.8 (47.0-57.0)	1.7
	M	Fawn	3	10.0	0.0	207.5 (186.0-229.0)	21.5	53.0 (51.0-55.0)	2.0
SC	F	Fawn	3	9.2 (7.8-10.0)	0.7	251.0 (231.0-272.0)	11.8	52.3 (46.0-58.0)	3.5
		Adult	4	9.5 (7.9-10.0)	0.5	176.5 (8.0-306.0)	67.0	44.3 (22.0-54.0)	7.5
	M	Fawn	2	9.5 (9.0-10.0)	0.5	340.5 (279.0-402.0)	61.5	49.5 (49.0-50.0)	0.5
		Adult	1	8.6	-	292.0	-	48.0	-

Appendix XIII. Arithmetic means and standard errors by area, sex, and age class for testes weight (TW), corpora lutea counts (CL), fetal counts (FC), fetal crown to rump length (CRL), and fetal weight (FW) from white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1986. Ranges are in parentheses.

Area	Sex	Age Class	n	TW (g)		CL		FC	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	-	-	1.0	0.0	1.0	0.0
		Adult	5	-	-	2.2 (1.0-4.0)	0.5	1.6 (1.0-2.0)	0.2
	M	Fawn	3	6.0 (5.7-6.5)	0.3	-	-	-	-
SC	F	Fawn	3	-	-	0.0	0.0	0.0	0.0
		Adult	4	-	-	2.0	0.0	2.0	0.0
	M	Fawn	2	10.2 (6.7-13.7)	3.5	-	-	-	-
		Adult	1	23.2	-	-	-	-	-

Appendix XIII. Continued.

Area	Sex	Age Class	n	CRL (cm)		FW (kg)	
				$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	23.4 (23.2-23.5)	0.2	0.45 (0.42-0.47)	0.02
		Adult	5	20.0 (15.2-26.3)	2.1	0.31 (0.11-0.63)	0.10
	M	Fawn	3	-	-	-	-
SC	F	Fawn	3	-	-	-	-
		Adult	4	31.0 (29.5-32.3)	0.6	1.08 (0.95-1.26)	0.07
	M	Fawn	2	-	-	-	-
		Adult	1	-	-	-	-

Appendix XIV. Arithmetic means and standard errors by area, sex, and age class for rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1986. Ranges are in parentheses.

Area	Sex	Age Class	n	CP (%)		ADF (%)		Lignin (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	22.5 (19.2-25.8)	3.3	30.1 (27.8-32.4)	2.3	26.6 (25.9-27.2)	0.7
		Adult	5	20.8 (19.0-23.4)	0.9	31.8 (29.6-35.0)	1.0	26.1 (23.4-28.5)	0.9
	M	Fawn	3	21.4 (20.2-23.0)	0.8	30.9 (30.4-31.4)	0.3	26.3 (25.2-27.5)	0.7
SC	F	Fawn	3	15.1 (12.2-18.2)	1.7	39.5 (34.4-44.2)	2.8	29.3 (27.3-31.2)	1.1
		Adult	4	15.3 (12.0-17.8)	1.4	39.9 (31.4-45.2)	3.3	29.6 (26.3-32.0)	1.2
	M	Fawn	2	14.7 (14.0-15.4)	0.7	32.7 (26.8-38.6)	5.9	26.6 (23.6-29.6)	3.0
		Adult	1	17.2	-	39.4	-	28.3	-

Appendix XIV. Continued.

Area	Sex	Age Class	n	DMD (%)	
				$\bar{X}$	SE
HK	F	Yearling	2	59.0 (56.6-61.3)	2.3
		Adult	5	60.6 (57.4-62.3)	0.9
	M	Fawn	3	61.3 (60.6-62.0)	0.4
SC	F	Fawn	3	52.4 (49.2-55.6)	1.8
		Adult	4	50.7 (45.0-57.6)	2.7
	M	Fawn	2	59.0 (51.9-66.1)	7.1
		Adult	1	55.2	-

Appendix XV. Arithmetic means and standard errors for fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ration (F/P) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1986. Ranges are in parentheses.

Area	Sex	Age Class	n	CP (%)		ADF (%)		F/P	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Yearling	2	17.8	0.0	54.9 (52.7-57.0)	2.2	3.1 (3.0-3.2)	0.1
		Adult	5	17.5 (16.6-18.8)	0.4	53.2 (49.1-55.9)	1.1	3.0 (2.9-3.2)	0.1
	M	Fawn	3	17.2 (14.8-19.8)	1.4	53.7 (49.5-58.0)	2.5	3.2 (2.5-3.9)	0.4
SC	F	Fawn	3	12.8 (12.4-13.2)	0.2	52.9 (50.8-56.8)	2.0	4.1 (3.9-4.4)	0.2
		Adult	4	13.4 (12.4-14.6)	0.5	53.0 (49.2-59.5)	2.3	4.0 (3.4-4.8)	0.3
	M	Fawn	2	15.7 (13.8-17.6)	1.9	52.1 (50.2-54.0)	1.9	3.4 (3.1-3.6)	0.3
		Adult	1	4.6	-	75.9	-	16.5	-

Appendix XVI. Arithmetic means and standard errors by area, sex, and age class for whole body weight (WBW), dressed body weight (DBW), kidney fat index (KFI), femur marrow fat (FMF), mandibular marrow fat (MMF), and the femur to hindfoot ratio (F/HF) from white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1987. Ranges are in parentheses.

Area	Sex	Age Class	n	WBW (kg)		DBW (kg)		F/HF	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	24.5	-	18.6	-	0.533	-
		Yearling	1	35.1	-	26.8	-	0.548	-
		Adult	4	46.5 (39.5-52.2)	2.6	32.4 (26.8-36.7)	2.1	0.560 (0.548-0.573)	0.006
	M	Fawn	4	22.3 (19.5-27.2)	1.8	17.1 (14.5-21.3)	1.6	0.558 (0.540-0.595)	0.012
		Yearling	3	41.1 (33.1-48.1)	4.4	27.7 (23.6-34.0)	3.2	0.558 (0.548-0.571)	0.007
SC	F	Adult	6	43.1 (38.1-49.2)	1.6	29.9 (27.7-33.1)	0.9	0.557 (0.539-0.573)	0.005
		Yearling	1	36.7	-	28.6	-	0.554	-
	M	Yearling	1	36.7	-	28.6	-	0.554	-

Appendix XVI. Continued.

Area	Sex	Age Class	n	KFI (%)		FMF (%)		MMF (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	13.5	-	85.1	-	92.8	-
		Yearling	1	14.3	-	92.1	-	88.0	-
		Adult	4	30.4 (20.1-51.9)	7.4	97.9 (97.6-98.4)	0.2	90.6 (88.2-92.5)	1.0
	M	Fawn	4	9.9 (6.7-15.5)	2.0	90.1 (89.0-91.9)	0.7	86.4 (81.1-90.5)	2.8
		Yearling	3	8.6 (8.0-9.6)	0.5	83.9 (81.1-87.6)	1.9	76.9 (69.4-81.2)	3.7
SC	F	Adult	6	12.4 (5.9-28.8)	3.5	86.5 (61.7-96.5)	5.4	81.7 (46.2-93.1)	7.3
	M	Yearling	1	4.9	-	64.9	-	62.9	-

Appendix XVII. Arithmetic means and standard errors by area, sex, and age class for serum total protein (TP), blood urea nitrogen (BUN), total cholesterol (TC), triglycerides (TRI), nonesterified fatty acids (NEFA), and beta-hydroxybutyrate (B-HB) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1987. Ranges are in parentheses.

Area	Sex	Age Class	n	TP (mg/dl)		BUN (mg/dl)		TC (mg/dl)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	5.2	-	26.0	-	52.0	-
		Yearling	1	5.5	-	11.0	-	42.0	-
		Adult	4	6.2 (5.3-6.8)	0.3	11.5 (4.0-19.0)	3.1	43.5 (30.0-63.0)	7.0
	M	Fawn	4	5.4 (5.2-5.5)	0.2	13.5 (6.0-21.0)	7.5	52.0 (47.0-57.0)	5.0
		Yearling	3	5.1 (4.8-5.8)	0.3	11.3 (4.0-19.0)	4.3	39.3 (32.0-52.0)	6.4
SC	F	Adult	6	6.0 (5.4-6.2)	0.1	6.8 (2.0-11.0)	1.4	41.8 (33.0-47.0)	2.1
		Yearling	1	5.3	-	10.0	-	42.0	-
	M	Yearling	1	5.3	-	10.0	-	42.0	-

Appendix XVII. Continued.

Area	Sex	Age Class	n	TRI (mg/dl)		NEFA (mM)		B-HB (mM)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	18.0	-	74.6	-	145.7	-
		Yearling	1	12.0	-	109.6	-	108.3	-
		Adult	4	9.0 (3.0-20.0)	3.9	153.2 (105.8-231.1)	28.0	108.9 (68.5-158.1)	23.6
	M	Fawn	2	19.0 (12.0-26.0)	7.0	109.8 (53.1-166.6)	56.8	84.7 (80.9-88.4)	3.7
SC	F	Yearling	3	13.3 (10.0-20.0)	3.3	137.4 (73.4-231.1)	47.9	115.4 (104.6-122.0)	5.4
		Adult	6	12.5 (8.0-21.0)	2.1	117.1 (34.5-308.4)	40.2	102.9 (61.0-134.5)	10.8
	M	Yearling	1	12.0	-	157.5	-	98.4	-

Appendix XVIII. Arithmetic means and standard errors for serum calcium (Ca), phosphorus (P), sodium (Na), potassium (K), glucose (GLU), and packed-cell volume (PCV) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1987. Ranges are in parentheses.

Area	Sex	Age Class	n	Ca (mg/dl)		P (mg/dl)		Na (meq/l)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	10.4	-	9.6	-	140.0	-
		Yearling	1	9.7	-	11.2	-	145.0	-
		Adult	4	10.0 (9.0-10.8)	0.4	8.1 (6.8-9.8)	0.7	143.8 (134.0-153.0)	3.9
	M	Fawn	2	10.4 (10.1-10.6)	0.3	8.8 (8.7-8.9)	0.1	138.5 (138.0-139.0)	0.5
SC	F	Yearling	3	9.7 (8.4-10.4)	0.7	9.3 (6.5-13.2)	2.0	144.0 (140.0-147.0)	2.1
		Adult	6	9.4 (8.2-10.4)	0.3	8.1 (5.4-11.0)	0.7	143.0 (140.0-149.0)	1.3
	M	Yearling	1	10.1	-	9.1	-	141.0	-

Appendix XVIII. Continued.

Area	Sex	Age Class	n	K (mcq/l)		GLU (mg/dl)		PCV (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	10.0	-	127.0	-	57.0	-
		Yearling	1	10.0	-	219.0	-	62.0	-
		Adult	4	9.0 (7.5-10.0)	0.6	124.8 (96.0-141.0)	10.7	52.5 (42.0-60.0)	3.8
	M	Fawn	2	10.0	0.0	279.0 (271.0-287.0)	8.0	51.0 (49.0-53.0)	2.0
SC	F	Yearling	3	9.0 (8.3-9.5)	0.4	190.0 (137.0-290.0)	50.0	45.0 (35.0-53.0)	5.3
		Adult	6	9.6 (8.0-10.0)	0.3	185.3 (71.0-241.0)	27.0	48.2 (44.0-54.0)	1.7
	M	Yearling	1	9.0	-	237.0	-	41.0	-

Appendix XIX. Arithmetic means and standard errors by area, sex, and age class for testes weight (TW), corpora lutea counts (CL), fetal counts (FC), fetal crown to rump length (CRL), and fetal weight (FW) from white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1987. Ranges are in parentheses.

Area	Sex	Age Class	n	TW (g)		CL		FC	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	-	-	0.0	0.0	0.0	0.0
		Yearling	1	-	-	1.0	0.0	1.0	0.0
		Adult	4	-	-	2.0	0.0	2.0	0.0
	M	Fawn	4	5.5 (3.9-6.9)	0.9	-	-	-	-
SC	F	Yearling	3	-	-	0.7 (0-1)	0.3	0.7 (0-1)	0.3
		Adult	6	-	-	1.2 (0-2)	0.3	1.2 (0-2)	0.3
	M	Yearling	1	21.7	-	-	-	-	-

Appendix XIX. Continued.

Area	Sex	Age Class	n	CRL (cm)		FW (kg)	
				$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	-	-	-	-
		Yearling	1	11.5	-	0.06	-
		Adult	4	23.4 (22.0-24.9)	0.8	0.50 (0.38-0.65)	0.06
	M	Fawn	2	-	-	-	-
		Yearling	3	24.9 (22.8-27.0)	2.1	0.57 (0.43-0.71)	0.13
SC	F	Adult	6	21.9 (11.2-26.2)	2.8	0.48 (0.06-0.68)	0.12
		Yearling	1	-	-	-	-
	M	Yearling	1	-	-	-	-

Appendix XX. Arithmetic means and standard errors by area, sex, and age class for rumen crude protein (CP), acid detergent fiber (ADF), lignin, and predicted dry-matter digestibility (DMD) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1987. Ranges are in parentheses.

Area	Sex	Age Class	n	CP (%)		ADF (%)		Lignin (%)	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	20.9	-	32.0	-	16.2	-
		Yearling	1	18.5	-	34.0	-	14.6	-
		Adult	4	18.9 (16.4-21.8)	1.4	37.3 (32.6-42.6)	2.1	17.9 (13.8-22.6)	1.9
	M	Fawn	4	20.0 (18.9-21.4)	0.5	32.8 (31.8-34.2)	0.6	15.2 (14.6-15.8)	0.3
		Yearling	3	18.1 (14.8-22.6)	2.3	36.4 (31.6-41.4)	2.8	16.1 (13.8-18.4)	1.3
SC	F	Adult	6	16.7 (15.5-18.0)	0.4	37.2 (35.6-38.6)	0.5	16.2 (15.0-17.6)	0.4
	M	Yearling	1	18.8	-	35.0	-	17.0	-

Appendix XX. Continued.

Area	Sex	Age Class	n	DMD (%)	
				$\bar{X}$	SE
HK	F	Fawn	1	66.5	-
		Yearling	1	65.8	-
		Adult	4	60.8 (51.3-67.2)	3.4
	M	Fawn	4	66.9 (66.2-67.4)	0.3
SC	F	Yearling	3	63.0 (55.8-69.4)	4.0
		Adult	6	63.3 (60.8-64.7)	0.7
	M	Yearling	1	63.2	-

Appendix XXI. Arithmetic means and standard errors for fecal crude protein (CP), acid detergent fiber (ADF), and the fiber to protein ration (F/P) of white-tailed deer collected at High Knob (HK) and Stony Creek (SC), Virginia in March 1986. Ranges are in parentheses.

Area	Sex	Age Class	n	CP (%)		ADF (%)		F/P	
				$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
HK	F	Fawn	1	17.2	-	54.2	-	3.2	-
		Yearling	1	18.0	-	52.4	-	2.9	-
		Adult	4	11.3 (4.6-15.2)	2.4	59.4 (56.6-64.8)	1.9	6.6 (3.8-12.7)	2.1
	M	Fawn	4	14.9 (6.5-18.6)	2.8	56.2 (55.2-57.6)	0.5	4.6 (3.0-8.9)	1.4
		Yearling	3	10.1 (9.5-10.6)	0.3	50.6 (48.2-53.4)	1.5	5.0 (4.5-5.6)	0.3
SC	F	Adult	6	10.7 (4.2-17.0)	1.7	52.1 (48.2-55.2)	1.0	5.9 (2.8-12.1)	1.3
		Yearling	1	12.6	-	50.8	-	4.0	-
	M	Yearling	1	12.6	-	50.8	-	4.0	-

Appendix XXII. Arithmetic means and standard errors by land form and area for soil pH, calcium (Ca), phosphorus (SE), magnesium (Mg), potassium (K), and organic matter (OM) of soils collected at High Knob (HK) and Stony Creek (SC), Virginia in September/October 1986.

Land Form	Area	n	PPM											
			pH		Ca		P		Mg		K		OM (%)	
			$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Cove	HK	13	4.5	0.1	103.4	25.7	1.3	0.4	16.2	3.0	36.6	3.1	5.4	0.5
	SC	9	6.0	0.4	737.3	189.2	6.4	3.0	45.6	14.2	36.8	4.5	7.4	1.9
Flood Plain	HK	3	4.6	0.03	68.0	14.4	1.0	0.5	11.3	1.4	32.0	3.6	3.8	0.3
	SC	8	5.2	0.4	483.0	132.6	2.6	0.4	45.0	12.2	41.4	6.4	5.2	1.4
Ridgetop	HK	14	4.6	0.03	30.0	1.7	0.7	0.4	7.1	0.3	26.4	1.8	3.8	0.2
	SC	9	5.4	0.4	616.0	177.2	1.6	0.6	27.1	6.6	46.3	8.2	5.2	1.3
Shoulder	HK	16	4.7	0.03	44.3	7.4	0.6	0.3	8.9	1.0	34.3	3.4	4.2	0.3
	SC	15	5.8	0.3	705.6	147.6	3.3	2.1	22.1	4.3	34.1	4.1	3.6	0.4
Side Slope	HK	36	4.7	0.1	133.3	30.2	1.2	0.4	24.0	4.4	40.4	2.7	4.4	0.2
	SC	41	5.7	0.2	678.1	80.2	1.7	0.3	29.6	4.1	40.3	3.4	5.0	0.5

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