CLIMATIC FACTORS
INFLUENCING HUNTER SIGHTINGS OF DEER
ON THE BROAD RUN RESEARCH AREA

by

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INTRODUCTION

The white-tailed deer (Odocoileus Virginianus Zimmerman) is the most sought after big game animal in the eastern United States. It is one of our greatest natural assets and one of the valuable forest recreation resources. Probably no other game animal generates greater interest and controversy among more people. The ever-increasing demand placed on all natural resources requires sound management programs designed to insure the perpetuation, as well as the maximum utilization, of the game resource.

In game management, the behavior of both game and hunter are of concern to the wildlife manager who must regulate the harvest of a game species. This study was designed to supply new information about the interactions of hunters, white-tailed deer, and climatic conditions. The overall influence of climatic conditions on the magnitude of deer-to-hunter contacts was examined.

An important part of modern deer herd management is the determination of total population trends. In order to recognize and analyze these trends, various inventories become the tools of management. Of these inventories, an annual compilation and analysis of annual deer harvest is of great importance. Factors affecting harvest vary among states and regions for a number of reasons. Hunting season regulations are the primary means to control this annual harvest, but weather conditions immediately before and during the season certainly are important, especially as they affect the contacts between hunters and deer. On occasion, such variables may be the deciding factors as to whether a successful harvest is realized in
accordance with management objectives.

Before judgements can be made about population trends based on harvest data, the factors which were influential in each year's harvest must be considered and, if possible, quantified. With sufficient data, the relation of hunter-to-deer contacts to specific weather variables can be studied. The relative importance of these variables as they influence deer-to-hunter contacts can then be determined. The significant weather variables may be helpful in explaining some of the causes of year to year fluctuations in annual deer harvest.

Wildlife management has been defined by Giles (1969) as the art and science of changing the characteristics and interactions of habitats, wild animal populations, and men in order to achieve specific human goals by means of the wildlife resource. One of the most effective ways of manipulating a deer herd population is through the use of the hunting season as a management tool. Hunting can be used to increase, decrease, or stabilize a population level. Decision makers must determine the specific number of animals to be removed in order to meet stated management objectives. It would seem, therefore, that any factor, in this case weather, affecting deer harvest would be of concern to wildlife managers.

Many authors have related weather factors to animal behavior and movements in the course of various investigations. A few have speculated on local weather conditions as they affect and influence hunter activity, movements, access and pressure. In none of the
cases observed has data been of sufficient quality or quantity to allow any definite conclusions to be drawn other than that a relationship does exist. Fewer still have attempted to collect and quantitatively analyze data pertaining to the interaction involving hunters, deer activity, and weather variables.

The management implications and conclusions which follow from this study will focus mainly on Virginia, but may apply more widely to other areas of similar topographic and climatic conditions. If the results of the proposed research indicate a close relationship between certain weather variables and deer-to-hunter contacts, then it is possible that they could contribute to the improvement of the wildlife management decision process. The results might provide insight into the degree of kill that can be explained by weather factors thus providing managers with a useful tool for more accurately appraising deer herd trends. Knowledge of the importance of weather as related to hunter contacts may serve to explain some of the year-to-year fluctuation existing in annual deer harvest.

With these possible results in mind, the following objectives were established:

1. To identify the significant climatic variables related to contacts occurring between hunters and white-tailed deer on the Broad Run Research Area in Southwestern Virginia.

2. To determine, by means of mailed questionnaire, the influence of weather factors on the deer hunter.
THE STUDY AREA

Location

This study was conducted on the approximately 8000 acre tract known as the Broad Run Research Area located on the New Castle District of the Jefferson National Forest in Craig County, Virginia. The area, situated approximately 5 air miles south of New Castle, Virginia, and approximately 25 air miles north of Roanoke, Virginia, on the northwestern slopes of North Mountain, is within the large physiographic division known as the Appalachian Valley.

History

The purchase and ownership history of the area is available from the New Castle Ranger District office of the Jefferson National Forest; a complete account was given by Quillen (1959).

An historical account of early farming land abuses over the study area was given by Seneca (1961), and Bachant (1963). Seneca (1961) mentioned the absence of sound silvicultural practices and adequate fire protection until 1935.

The fire history of the area was given by Quillen (1959), Bachant (1963), and Seneca (1961). Information indicates that the area was subjected to frequent fires during dry periods. The worst recorded fire occurred during the summer of 1930 when practically all of the area was burned.

An account of past and present timber harvest practices was given by Bachant (1963).

Geology

Whelan (1962) reported that the study area is located in what is
commonly referred to as the ridge and valley province which is an integral part of the large physiographic region known as the Appalachian Highlands. Whelan (1962) discussed the geology of the entire ridge and valley province. The most complete geological history of the area was given by Edmundsen (1950). The area has dry, infertile, shaley soils with low water-holding capacity and low pH values (Seneca 1963). Quillen (1959) referred to the large percentage of ericaceous plants on the area, adding that they are indicators of acid soils.

Climate

The general climatic pattern for the ridge and valley region depends primarily upon two factors: latitude and topography. Elevation is the principal factor changing the pattern (Whelan 1962).

The weather station nearest the study area is located in Roanoke County at Catawba Sanitorium. The station, at an elevation of 1900 ft., is situated 3 miles west of the study area and across the Broad Run Mountain.

The following climatic data were compiled from United States Weather Bureau publications entitled "Climatic Summary of the United States", United States Department of Commerce, Washington, D. C., and from the Virginia Polytechnic Institute Cooperative Extension Service publication entitled "A Handbook of Agronomy", Virginia Polytechnic Institute, Blacksburg, Virginia. All data were recorded at the Catawba Sanitorium Station and are based on 50 years of record.

The region has a mean annual temperature of 54.5°F., with a January and February mean of 37°F. The average maximum temperature
for July and August is 72°F. The mean maximum temperature for July is 83.9°F.; the mean minimum, 61.5°F.

The average date for the first killing frost is October 21. The average date for the last killing frost is April 22. The average length of the growing season (number of days without killing frost) is 181 days.

The highest degree of record is 102°F.; the lowest of record is -10°F.

There are 12 mean days annually with a maximum of 90°F. or more. The mean annual number of days with a minimum of 32°F. or less is 98.

The mean annual precipitation is 42.50 inches distributed unevenly over the year. The months of July and August contribute an average of 9.07 inches. Average precipitation for the six warm months of the year, April through September, is 24.17 inches.

The annual snowfall averages 18.30 inches with most occurring during the months of January and February.

The mean annual number of days with 0.10 inches or more precipitation is 79. The mean annual number of days with 0.50 inches or more precipitation is 27.

The following data, because they are not recorded at the Catawba Sanitorium Station, were taken from the official United States Weather Bureau Station located at Woodrum Field in Roanoke, Virginia. The ground elevation of this station is 1149 feet. It is located approximately 25 miles southwest of the Broad Run area and all data are based on 15-17 years of record. It has been determined that their data would not differ significantly had it been taken at the Catawba Sanitorium
Station (Crockett, pers. comm.).

Mean sky cover ranges from 6.4 in February to 4.8 in October. Mean yearly sky cover is 5.9. Sky cover is expressed in a range of 0 for no clouds to 10 for complete sky cover. Cloudy days outnumber clear and partly cloudy days which occur in about equal numbers. The mean annual relative humidity at 7:00 A.M. is 76 percent. Thus, the regional climate may be characterized as cool and moist, having a moderate amount of snowfall with cloudy weather predominating.

**General Ecology**

Quillen (1959) reported on the general ecology of the Broad Run Area stating that previous fires and logging have produced erosion that has led to the shallow, infertile soils. The sheltered coves have collected the best soil and have access to more moisture than any other area. The flats vary in quality directly with the intensity of past fires and logging. Edaphics and physiography of the area have been treated by Seneca (1961) and Bachant (1963). Bachant states that the elevation of the Broad Run Area varies from 1,500 feet along Craig Creek to 3,100 feet along the ridge of North Mountain. The approximate mean elevation is 2,300 feet. Soils and edaphic conditions on the study area are representative of much of the forested land in southwestern Virginia (Seneca 1961). The physiographic history of the ridge and valley province is provided by Fenneman (1938).

**Forest Cover Types**

The ridge and valley province contains forest vegetation typical of two large forest regions: the central forest region and the northern forest region.
The central forest region is characterized by the oak-chestnut association within the ridge and valley province. The chestnut, of the oak-chestnut association was almost entirely eliminated by blight and has been replaced by oaks. The study area contains only central forest vegetation (Whelan 1962). Whelan (1962) classified the principal forest types occurring on the study area according to topographic position as follows and discussed these types in detail:

1. dry slope and ridge forest, including chestnut oak, scarlet oak, black oak, bear oak, and pitch pine-table mountain pine.
2. moist slope and cone forest, including northern red oak, cove hardwood, and yellow poplar.
3. valley floor forests, characterized mainly by oak with white oak being the most characteristic species.

Seneca (1961) described the floral conditions existing on the westerly and easterly exposures of the area, and reported on the vegetative type, pH, mesic and xeric conditions, topographic features, and ecological conditions found in the coves, flats, and ravines. Quillen (1959) designated six types for the study area due to difficulty incurred in attempting to place the timber types of the area in standard Society of American Foresters categories.

Timber and Wildlife Management Practices

The Broad Run Study Area was subdivided into four compartments consisting of approximately 2000 acres each. Compartment boundaries were established on the Broad Run Area to access treatment effect in the form of timber and wildlife management practices. Silviculture practices and wildlife habitat improvement practices were reported by
Seneca (1961). Quillen (1959) discussed the general management plans, timber sales, timber harvesting, and timber stand improvement practices. Bachant (1963) reported in detail on the wildlife habitat improvement practices and on the timber cutting schedule, acreage to be cut, and expected yields. Construction, location, costs, size and treatment of the 25 agricultural clearings and 10 water holes existing on the area were discussed by Quillen (1959).

Deer Herd Density and Distribution

Concerning the presence and distribution of deer in Craig County, Wooley (1940) noted that deer range in Craig County was the best that he had encountered. He reported that the white-tailed deer was not extirpated from Craig County but that native deer were there before restocking operations began in 1938 to reestablish deer in counties west of the Blue Ridge. It is logical to assume that the present Broad Run herd had descended from a few native deer plus some from the Fort Lewis release that may have crossed North Mountain. Following the release, the 5-year closed season up to 1938 was extended to 1946 at which time a 2-day season was initiated (Quillen 1959). Seneca (1961) reported that as in the case of most animal populations, the distribution of deer on the study area is neither random nor uniform but clumped, with deer tending to congregate at the lower elevations along Craig Creek during the winter months.

Using fall and winter pellet group counts within agriculture clearings, Quillen (1959) estimated the Broad Run deer population to be approximately 130 animals. He indicated, however, that this population estimate is higher than he believed to exist on the area. Seneca (1961)
estimated the population by total acreage for the management area based on the winter 1961 pellet group count as $117 \pm 48$ (2 standard errors). Seneca believed that illegal killing of deer in the late 1940's put a drain on the population until numbers were reduced to the level of his population estimate.

**Winter Deer Concentrations**

Seneca (1961) reported that there is no apparent indication that deer move to the lower elevations along Broad Run and Craig Creek until severe weather conditions occur. He stated that the exact time deer move to this area and the duration of their stay varies from year to year and is regulated by the severity of the winter snows. He observed that during intermittent periods of relatively good weather during the winter months, deer left the lower elevations and ranged over the entire study area. He believed that deer congregated at these lower elevations because of two reasons:

1. the area offers protection from severe weather in the form of Virginia pine
2. patches of Japanese honeysuckle offer abundant food in a small area as it occurs abundantly in patches along the creek.

Spot light counts, taken when snow was 6 inches or more in depth along the Broad Run Creek road, revealed deer feeding in honeysuckle patches or taking refuge in heavy cover supplied by Virginia pine. Handley (1945) stated that Japanese honeysuckle was widely used as an emergency browse species, especially when snow covered the ground.
LITERATURE REVIEW

Climate

Wolf et al. (1949) stated that the term climate embraces a concept of the entire assemblage of meteorological conditions of an area or region over a long period of time. In one sense, climate is a generalization of weather. They state that climate is usually expressed in statistical terms in the forms of averages, frequencies, and extremes of such phenomena as temperature, precipitation, drought and the like.

Climate is "an average of weather conditions" as defined in some encyclopedias, meteorological glossaries, and textbooks. But Wolf (1949) thinks that climate, as so defined, provides little guidance toward recognizing relationship between climate and plant and animal responses in local areas. Only the values for each weather element can be averaged. These averages are seldom correlated with biotic phenomena and rarely are placed in a cause and effect relationship.

Climate is defined by Humphreys (1942) as the "history of the weather of an area" and by Landsberg (1947) as "the collective state of the atmosphere at a given place over a given area within a specified period of time." As so defined by Landsberg, relationships to biotic phenomena may be sought, for these concepts recognize the extreme conditions which influence significantly critical periods in the lives of plants and animals. Wolf et al. (1949) stated that averages are used only as statistical tools and are almost always useless in explaining relations between weather and biological phenomena. They explained that in seeking the relation between weather regions and living organisms over a long period of time, more knowledge of the actual sequence
of weather types occurring in plant and animal habitats appears desirable and necessary.

Weather Bureau data do not reflect local weather phenomena nor were they designed to do so. The Weather Bureau does not attempt to measure local variations, but emphasize the larger, more generalized weather conditions necessary to its primary objective of forecasting weather. The publication of Weather Bureau summaries may have some merit in biological studies of local areas but the fact that these summary data do not reflect local conditions has been noted in some detail by Wolf et al. (1949). They stated, "It may be held as it has by some, that these data are the best measurements we have. But the problem still persists as to whether or not the differences in biotic communities are related to the particular differences in climatic phenomena which are measured by Weather Bureaus. Briefly, the best may not even be pertinent." This emphasized the need for more reliable and critical studies of actual habitat conditions in problems related to forestry, conservation, agriculture, and ecology.

Weather Factors Affecting Deer

The weather in some way affects the behavior of every terrestrial organism every minute of its life (Wolf et al. 1949). The influence of changes in microclimate on white-tailed deer movements touch on one of the least understood relationships of deer to their environment. Sometimes it is possible to give reasonable answers concerning deer movements due to gross climatic differences, or learned activity which has become traditional (Severinghaus and Cheatum 1956).

Deer are subjected to a variety of weather conditions, some of
which cause predictable behavioral responses. Deer will try to escape adverse conditions by bedding down to conserve energy, traveling to a more favorable habitat, or changing their activity pattern so they are least vulnerable to the elements when conditions are most hazardous. The type of reaction varies with the weather condition. There is a paucity of information on seasonal activity patterns in wild mammals including deer. Therefore, the review presented herein is brief, but includes what little is known of seasonal activity and the influence of climatic factors on activity.

The magnitude and nature of weather factors which resulted in changes in deer activity and distributions have fascinated students of the white-tailed deer. Behrend (1966) reported that the most extensive movements occur where seasonal climatic changes are pronounced, due either to high elevations or northern latitude. He stated that while few studies have been made on the effect of weather on deer activity, many biologists have recorded their observations during the course of other studies. The results are interesting, but often confusing. Behrend stated that activity in the higher animal is the result of a complex of interacting environmental and physio-psychological factors which may be very difficult to document accurately, let alone explain.

Peterson (1969) stated that deer distribution is influenced chiefly by weather and topography, and from much qualitative information it appears that extremes of snow, wind and temperature can alter normal deer distribution and activity. Montgomery (1963) reported that differences in the time relative to sunset at which evening activity began in central Pennsylvania may have been related to differences in
temperature, cloud cover, relative humidity or a combination of these weather factors. Progulske and Duerre (1964) found that 85.28 percent of the variation in their deer spotlight counts was caused by interaction of weather factors. Banasiak (1957) noted a decrease in deer activity under the following conditions:

1. high winds and low temperatures
2. storms
3. breaking snow crusts
4. when sinking depths are more than 18 to 24 inches. (A sinking depth is when snow becomes so deep that deer find it difficult and exhausting to move about.)

Considerable variation in seasonal movements, home range and changes in distribution occur over the range of the white-tail. Behrend (1966) reported that deer activity during the winter proved to be exceedingly variable, and followed no discernable pattern over time. From late October through November, activity closely coincided with the intensity of the rut, and except for storms, the reaction of deer appeared to be independent of weather. He found only temperature, wind-chill, and snow depth to be even broadly correlated with deer distribution. The lack of positive association between other weather factors is certainly not conclusive, but he thought it very unlikely that factors other than storms and wind influence activity significantly. Behrend stated, however, that one generalization appears possible: deer tend to move farther and/or distribute themselves in different habitats where changes in climatic conditions are more pronounced, and move little or not at all where the climate is mild and more stable.
Hahn (1949), working in Texas, observed that temperature, atmospheric pressure, and wind had no appreciable effect on movements. He stated, "There is, however, a considerable negative correlation between temperature and relative humidity, if either is highly correlated with deer activity the other must also be correlated with activity." Progulske and Duerre (1964) reported that temperature and relative humidity showed positive correlations with deer activity, whereas cloud cover, precipitation, and dew showed negative correlations. Since Hahn stated that temperature and relative humidity were significantly correlated (negatively) to deer activity, it is difficult to understand how they could have both been correlated positively with deer seen. Cronemiller and Fischer (1946) who observed numbers of deer in California and southern Oregon, stated that the effectiveness of the counts in this area appeared to be more closely associated with the time of day rather than with weather.

Many sportsmen believe that the number of deer killed during an open hunting season is related closely to prevailing weather. Fobes (1945) stated that the number of legally killed deer during a hunting season is dependent upon such factors as:

1. deer population
2. number of hunters
3. length of season
4. hunting conditions.

He believed hunting conditions, regulated primarily by the weather element, were the single most important factor. Banasiak (1957) reported annual harvests in Maine have fluctuated between levels of 35,000 and
42,000 since 1948, seemingly dependent upon winter severity and hunting conditions. During the 1954 deer hunt in Texas, the weather throughout the season was mild. According to the hunters, deer activity was light. The weather, the phase of the moon and degree of the rut probably were the factors involved (Carney and Parker 1954). Van Etten (1965) reported that more deer were seen by hunters in a square mile enclosure on "good" days than at other times and in Oregon, Lightfoot (1962) reported kill varied in a positive relationship to weather conditions in areas of low hunter density, but not in areas of high hunter density.

Temperature

Temperature is an important factor in the physical environment of both plants and animals and its interaction with humidity and with vegetation probably has a greater effect on terrestrial organisms than any other climatic element (Allee et al. 1949).

Behrend (1966) reported that in the Adirondacks, of the measured weather variables examined, only maximum daily temperature proved to be significantly positively correlated to winter deer activity. He found it accounted for 44 percent of the variation in activity and stated that this positive correlation was in general agreement with other observations of white-tail deer on northern ranges. Progulske and Duerre (1964) reported that temperature exerted the strongest influence of all weather factors on all deer behavior during night hours. In Texas, Halloran (1943) found that morning and evening activity of white-tail was positively correlated with temperature, and indicated that more deer were seen on evenings of higher temperature than evenings of low temperature.
Hammerrstrom and Blake (1938) reported that white-tailed deer began concentrating in swamps with the onset of lower temperatures; 20°F seemed the critical level triggering the phenomena. They felt, however, that protection from wind also was important in determining use of swamps since actual temperature was lower there than in surrounding uplands. Allee et al. (1949) suggested that crowding of animals, which occurs during heavy snows and low temperatures, may be important to group survival. It has been demonstrated that air temperatures are modified in certain micro-habitats by animal aggregations. Day (1963) found deer activity to be reduced to a minimum during very cold periods (-22°F to 26°F) and stated that fresh tracks were seldom seen far from bedding areas when such temperatures prevailed. Silver and Colovos (1957) indicated that deer actually seem to attempt to conserve body heat by lying down, erecting hair, and remaining essentially motionless. Tester and Heegon (1965) found January movements of white-tails to be considerably greater in warmer periods than during periods of extreme cold. Townsend and Smith (1933) agreed and added that it was usual to see deer in greater numbers on comparatively warm days whether cloudy or clear; windy days were no exception. Banasiak (1961) observed that, within deer yards, activity increased on warm days.

Verme (1965) and Severinghaus and Cheatum (1956) reported that on cold nights (-20°F to -30°F.) few deer were bedded while most walked slowly along trails, whereas on warmer nights most deer were bedded. They suggested that the reduction in activity under more moderate temperatures might "... indicate less need for exercise to maintain body heat and ward off chilling." Conversely, Silver and Colovos (1957)
reported that in periods of extreme cold (-30°F. to -32°F.) penned deer appeared to make every effort to avoid heat loss by lying down and remaining nearly motionless. Under such conditions the deer remained uninterested in food, even when the food was warmed.

Fobes (1945) reported the years with higher deer kills were those when November temperatures were normal or above. He stated that it was usual to see deer in greater numbers on comparatively warm days and the increased activity possibly resulted in the greater kill.

**Snow**

Snow is generally conceded to be the most potent factor affecting seasonal movements and distribution of deer (Behrend 1966). Day (1963) is cited by Behrend as having extensively surveyed the literature for white-tailed deer, and found most authors considered snow the foremost factor influencing distribution. Cook and Hamilton (1942) stated that winter deer concentrations in central New York are in response to definite environmental stimuli of which snow is of considerable importance. Behrend (1966) reported that with 13 to 14 inches or more snow, bedding occurred in the most sheltered type, dense conifer crowns, while with below 10 inches, as much or more bedding occurred in hardwood and hardwood-conifer type. Bed and track counts showed that activity was somewhat less on days with or immediately following a snow fall than on days not associated with snow and that severe ice and snowfall definitely depressed activity.

In reference to the minimum depth of snow affecting the mobility of white-tails, Day (1963) found varying reports in the literature, with estimates ranging up to 24 inches. Patui (1965) reported that during
fall and winter months in the Adirondacks, deer distribution appeared to be affected principally by the character and depth of snow cover. An effective depth of 14 to 16 inches appeared to restrict distribution and accelerate the trend toward concentration in sheltered areas. Hepburn (1959) studied the phenomena in Ontario and found that the steepest decline in mobility occurred between 10 and 16 inches of snow.

Gill (1956), Hosley (1956) and Severinghaus and Cheatum (1956) reported that in the northern portion of the white-tails range the important effect of depth and duration of snow was to restrict the animals ability to reach food. Gill stated that soft snows of greater than 18 to 20 inches progressively accentuated the importance of food availability and Cook and Hamilton (1942) reported that in New York when accumulated snow on the ridges had made travel difficult, the herd resorted entirely to the lower slopes and valleys for feeding.

Evidence of the importance of hunting conditions (snow) and possibly deer behavior, on hunting success and total harvest was gained from a comparison of the accumulated daily kill for 1955 and 1956 in Maine. Although the 1956 total kill exceeded the 1955 harvest by 12 percent, the number of deer killed was essentially the same during both years for the first 17 days of the season. After November 10, approximately 4,500 more deer were killed in 1956 than in 1955. The most obvious difference in hunting conditions during the above period was snowfall amount and duration on the ground. An average of 9.8 inches of snow fell in 1956 compared to 1.4 inches in 1955 (Banasiak 1957). White (1967) reported that deer harvest in New Hampshire was influenced by many variables, one of the most important being the effect of snow.
During the 1965 deer season, general hunting conditions were very good. Snow was frequent and present over most of the area and 32 of the 51 deer were taken with snow on the ground (Godzyk 1966). Laramie and White (1964) reported that over a 7 year period in New Hampshire the bare ground success rate was 29.85 deer killed per 1000 hunter days while with a snow cover it increased to 48.18. From 1956 through 1962 a steady decline in harvest occurred. The failure of the herd to recover was largely due to the hunting conditions being "too good." Snow was on the ground 50% to 63% of the season dates (White 1967). Gwynn (1961) reported that in 1960 an above average snowfall in eastern Virginia possibly concentrated the hunters' efforts on deer. He stated that the snow did not arrive until the fourth week of the season, but probably helped to increase the harvest at that time. He indicated that the 1962 season had snow during the latter part of the season. The effect of the snow was generally considered to have provided good hunting conditions, allowing deer hunters to readily find fresh tracks and to get dogs on the trail with a minimum of lost time (Gwynn 1964a). Banasiak (1957) reported that weather provided unfavorable conditions during the first part of the 1956 deer season in Maine. He stated, however, that the poor beginning was off-set by much colder weather and a good tracking snow during the latter part of November.

Rain

Ruff (1963a) wrote that changes in weather caused fluctuations in the intensity of feeding activities and that records of daily catches in a live trapping operation pointed to the probability that deer move about and feed more intensively preceding a period of rain or snow.
Townsend and Smith (1933) observed practically no deer on rainy days and stated that heavier showers seemed to drive deer to the shelter of the woods. Carhart (1946) agreed and stated that on a rainy day deer will not move about, but are likely to bed in a protected spot and let the storm pass.

Day (1964) indicated that the lower deer kill during the 1963 season in Vermont was due to the rainfall which persisted throughout most of the 16 day season. He stated that the extremely rainy season caused a reduction in both hunter and deer activity and resulted in a 20 percent drop in kill from the previous season. Fobes (1945) stated that heavy downpours usually drive deer to cover, however, when clearing weather prevails, deer move about much more. Behrend (1966) reported that summer observations indicated that deer do not avoid activity during brief periods of rain, even heavy rain, but prolonged precipitation does depress activity. Mechler (1970) found the amount of precipitation on the first day of the season to be the most significant weather variable of the 10 variables studied. He found precipitation to be negatively correlated to deer kill.

Wind

Siegler (1968) reported that deer will normally bed down during windy and cold days to "wait out" the storm. He believed this action to be an energy-conserving mechanism. Townsend and Smith (1933) stated that it is well known that during the hunting season deer tend to skulk on windy days, but during other times it seems not to affect them. Halloran (1943) reported observing his highest deer counts in open country when there was little or no wind. When there was distinct air
movement, the deer tended to spend more time in the brush. Palmer (1951) wrote that deer often are nervous and restless on windy days and Cook and Hamilton (1942) reported that deer are notably averse to wind. Behrend (1966) stated that wind, acting in concert with cold winter temperatures, may depress deer activity and that wind chill rather than either low temperature or wind alone is the climatic factor of most importance in influencing deer distribution and activity. His results seemed to indicate that if shelter is indeed sought to mitigate the effects of severe weather, the principal adverse factor is wind chill. Such observations as the above show a distinct aversion to cold wind and a strong tendency for deer to seek sheltered spots under such conditions.

Other Weather Factors

Relative Humidity

Odum (1953) stated that relative humidity is an artificial ratio, and as such does not exist in the environment. However, humidity, or the actual amount of atmospheric moisture, plays an important role in influencing the activities of organisms and controlling their distribution. Allee et al. (1949) reported that the amount and distribution of atmospheric moisture frequently affects the distribution of animals, and Hahn (1949) reported seeing more deer, and found them to be more active on cloudless days of low relative humidity. Hahn concluded that the best counts of deer were made when the relative humidity was below 70 percent and the sky was not more than 50 percent overcast. Bailey (1960) reported that relationships between deer activity and relative humidity were important. Behrend (1966) stated, however, that the
humidity pattern over the year is not correlated with deer activity and humidity is of little importance except as it may effect day-to-day activity during the warm months.

**Barometric Pressure and Sky Cover**

Behrend (1966) reported no marked trends in deer activity with changes in cloud cover or barometric pressure. But deer were often found to be more active just prior to or during the early stages of a storm. This is in agreement with Barick (1952) who found that deer in North Carolina appeared to feed more heavily just prior to low pressure storms.

Halloran (1943) reported seeing more deer in Texas when the sky was overcast. Chapman (1939) found that more deer were feeding on cloudy rather than clear nights and that daytime activity was influenced by sky conditions, deer being active throughout the day when cloudy, but inactive between 10:00 A.M. and 5:00 P.M. on clear days. Only Barick (1952) reported that more deer were active on clear nights rather than cloudy ones.

**Weather Influence on Habitat Preference of Deer**

In the central Adirondacks, wintering areas are largely restricted to spruce slopes at lower levels and to coniferous swamps (Severinghaus and Cheatum 1956). Severinghaus and Cheatum reported that fall or early winter migrations appear largely to be responses to weather conditions which affect the animals' physical comfort; at these times deer seek areas which provide adequate shelter from harsh winter conditions. They cite reports which indicate that Vermont deer winter in protected valleys, with southern or southeastern exposures, which offer protection
from the prevailing wind. Severinghaus reported watching 30 deer move from one slope that was being swept by a cold west wind to another slope completely protected from the wind. Krull (1964) reported that during severest mid-winter weather in New York, deer used an uncut shelter area more than a clear-cut area where food was plentiful. Hosley (1956) reported that during severe winters in Pennsylvania, deer concentrated in conifer cover at low elevations. Tester and Heegen (1965) found a similar situation in Minnesota. There, deer concentrated in cedar bogs during cold weather and ranged into adjacent uplands only during warm periods. Banasiak (1961) observed that deer in southern Maine roam over much of their summer and fall range except during cold, windy, or stormy weather when they seek coniferous shelter.

Day (1963) reported that the densest coniferous cover was used for bedding in extremely cold periods and that during the unusually rainy 1963 season in Vermont, deer retired to swamps and thickets.

In the Adirondacks, an area characterized by cold climate, deep snow, and a northern forest, the principal wintering areas were reported to be evergreen swamps where deer begin to congregate as soon as the snow becomes deep enough to make travel on the hardwood slopes difficult (Cook and Hamilton 1942).

Behrend (1966) reported that within the wintering area he studied in the Adirondacks, few differences were found in temperature or relative humidity between forested and exposed locations. He stated the trend toward concentration of deer in coniferous shelter types was found to be most closely associated with increasing frequency of occurrence of severe wind chill (1200 or greater). He reported that in the
forest, wind and snow depth both were consistently less in conifer type. He thought that once deer concentrations were established in coniferous shelter as a result of wind chill, distribution was then most closely associated with changes in sinking depth of snow.

In areas with less severe winters, winter use of coniferous shelter is very limited and deer are found in a variety of cover types during all seasons. Whitetails in the southern United States occupy essentially the same range year-round (Chapman 1939). In the south, the combination of topography and even scanty woods affords adequate protection from wind, and the exposure of the slope insures rapid disappearance of each snowfall (Cook and Hamilton 1942). Peterson (1969) reported that the upper portions of south and west slopes probably are the most densely occupied areas during cold weather because they are warmest, have the least snow, and protect deer from the wind.

**Hunter Effect on Deer Activity and Distribution**

Behrend (1966) observed that human activity appeared to have little effect on deer activity as measured by track counts. At all seasons deer activity levels appeared to be independent of the magnitude of human activity. Montgomery (1963), however, thought that people working on his study area may have caused deer to remain bedded in the woods during the day, presumably explaining the high activity at night when there was little disturbance. Peterson (1969) held the opinion that hunters may cause deer to seek the best protective cover available. Behrend (1966) found deer responded less vigorously to disturbance by humans and vehicles in summer, than any other season. A broad trend of less-pronounced response occurred from March through July but reversed
from July through the winter months. In reference to the Broad Run Area, Virginia, Seneca (1961) speculated that until more hunters move into areas away from the access road and clearings, the kill will not increase appreciably. He reported that deer in the study area tended to move to higher elevations under hunting pressure and hunters seemed reluctant to hunt the higher elevations.

Severinghaus and Cheatum (1956) stated that opinions differ as to whether the white-tailed deer is essentially nocturnal, diurnal, or crepuscular but that most deer feed during early morning and late afternoon, with a preference for evening. They pointed out, however, that this is an average condition, and that some deer could be seen feeding during daylight hours, while some feed at night, particularly in areas where they are harassed by man during hunting seasons. Merriam (1886) believed that while deer are generally thought to be nocturnal, their daily activity was greatly modified by environment, resulting in nocturnal activity in areas much frequented by man, and diurnal activity in more remote areas. Townsend and Smith (1933) found much evidence during summer observations in the Adirondacks to support Merriam's view. Considerable day-time activity was observed in some areas; little in others. They concluded that, where undisturbed, deer may be more crepuscular than nocturnal, but that if degree of disturbance is too great, they desert the locality. In central New York where, unlike the Adirondacks, considerable human activity occurs, Cook and Hamilton (1942) found that deer in winter remained bedded during the day, and commenced to feed approximately 2 hours before sunset.
Weather Effect on Hunters and Harvest

In Colorado, weather is reported to be one of the most important factors contributing to the success of a hunting season, as well as causing the movement of hunters (Hunter 1957). White (1968) indicated that heavy pressure in New Hampshire on the first day may not in itself cause an unusually large kill, but may do so when combined with excellent hunting conditions. Peterson (1969) held that the distribution of hunters is affected by weather, topography, vegetation density, and area accessibility. Swift (1937b) believed weather conditions to be very important in determining hunter distribution and found most Wisconsin hunters returned home during bad weather. Those who remained in the field seldom traveled more than 1/4 mile from a major road.

Peterson (1969) stated that manipulating hunting pressure is a problem of interpreting complex interactions between hunter habits, equipment and environmental factors. White (1968) reported that the presence of snow has a recognizable effect on hunter success and a pronounced influence on harvest. He stated that ideal conditions are considered by the average New Hampshire hunter to consist of 3 to 4 inches of quiet powder snow. Tracks are then more obvious and a hunter's chances are further improved by the stealth with which he may proceed through the woods. Experienced native New Hampshire hunters are well aware of the likelihood of late-season snow and many wait till then to do their hunting (Laramie and White 1964).

After snow, a warm spell and resultant thaw is often beneficial but as soon as freezing takes place, quite hunting becomes impossible. The freshness of tracks can be readily determined, however, and "drive
"hunting" in groups is the usual method under such conditions (White 1968).

Yeager and Denney (1959) stated that a good tracking snow with no threat of a blizzard, gives the western mountain hunter a feeling of security. It makes for easier and more effective hunting. They felt that the best game kills were made under such conditions.

Fobes (1945) believed a requirement for obtaining good deer harvests was moderate rain or snow to keep the forest floor moist and provide quiet hunting conditions in Pennsylvania. Gwynn (1961) described the weather of the 1960 season in western Virginia as generally favorable with temperatures in the 60's. Footing was dry and noisy during the first two days and these conditions were considered unfavorable to hunter success. However, rain and cooler weather occurred at mid-week, thus providing excellent hunting conditions. Fobes (1945) stated that precipitation, either rain or snow appeared largely to determine the number of deer killed in any one season. Seasons deficient in precipitation had reduced deer kills. Dry weather resulted in hunters being active, but the noise produced by their walking on a dry forest floor alarmed deer and resulted in a low kill. Day (1964), however, stated that although some hunters claim to enjoy rainy weather and feel it improves chances of success, the majority do not, and most stay close to their homes, cars, camps and motels. Schultz (1957) reported that an important factor working against the hunter was the poor weather during the 1957 season in West Virginia. During the first and second day, high winds reduced much deer movements. On the third day snow and fog prevented hunter access and movement and the deer were seeking heavy
thickets for shelter. There was even less success on the last day of the season than during previous days. A continuous rain occurred all day. Schultz held the opinion that the weather was the most important factor preventing the 4 day total of 1957 from exceeding the previous year's kill. Banasiak (1957) reported extremely unfavorable hunting conditions during the 1956 Maine deer season. The poor beginning was off-set, however, by colder weather and tracking snows during the end of the season. Hunter success improved at the end of the season due to changes in deer behavior, hunter activity and distribution, and greatly improved hunting conditions. Porath (1970) reported that a light snow provides good tracking, whereas a heavy snow hinders movements of hunters by creating difficult road conditions and may make some hunting grounds inaccessible. White (1968) concurred and claimed snow can contribute to a reduced kill in certain situations where the average weekend hunter is more concerned about getting stuck than hunting. Closing of some roads due to inclement conditions may cause an influx of hunters into more accessible areas, resulting in increased kill there. In southern states snow and extremely cold weather seldom occur but rainy weather may be a problem since muddy, impassable roads develop. He also stated that many hunters attracted by a good deer population are desirable but their numbers decline as the weather turns colder.

The detrimental effect of snow on hunter activity was reported by Fobes (1945) who observed a decline in hunting activities in Maine when snow depths reached 8 to 9 inches and by Hunter (1957), Yeager and Denney (1959) and Kimball (1955) who reported that in Colorado many hunters will avoid an extended season because of the great deal of snow and cold
weather expected. In Colorado, one foot of snow was sufficient to send hunters from high elevations to lower elevations where weather was milder.

In summary, weather conditions appear to markedly affect hunter activity, distribution, and the resulting harvest. Weather conditions may not influence the kill in areas of high hunter density but a primary problem seems to be maintaining adequate hunter density in areas under conditions of deep snow, heavy rain, and cold temperatures.
METHODS AND PROCEDURES

The research method involved compiling, tabulating, and analyzing data associated with daily sightings of deer by hunters on the Broad Run Research Area, Craig County, Virginia. The objective was to identify those weather variables which appeared to be significantly related to daily deer sightings. The independent variables included day of the season, hunting pressure, hunting season characteristics, and weather during the hunting season. H. S. Crawford of the United States Forest Service and J. B. Whelan of the Virginia Cooperative Wildlife Research Unit supplied the hunter check station data.

Data Collection

In 1957 a 9-mile access road was constructed through the Broad Run Research Area. The road was built to serve for logging, fire suppression, wildlife and timber management activities and as a hunter-access route.

In 1958 a main hunter-contact station was established at the southwest end of the Broad Run Area. The station was located on the access road, approximately 3/4 of a mile from Virginia Route 311. Since 1959, all hunters entering or leaving the area by the access road have been processed at this point. The operation of the station has been a cooperative effort, shared by U. S. Forest Service wildlife biologists, Virginia Cooperative Wildlife Research Unit personnel, and Virginia Polytechnic Institute and State University wildlife graduate students.

Seneca (1961) held the opinion that the only reliable means of obtaining hunter pressure and success data on the Broad Run Research Area was by personal contact and interview with each hunting party.
During each deer hunting season the station has been opened at 6:00 A.M. or whenever the first hunter arrived in the morning and was operated until 7:00 P.M. or until the last hunter left the area. During this time a record was kept on each party entering the area via the check-station cabin.

In order to control traffic during the hunting season and during periods of bad weather, and to discourage poaching throughout the year, the access road has been gated at each end. The Broad Run Creek road gate has remained closed the entire length of the season for all hunting seasons to eliminate the possibility of error in the hunter survey. Gating the road has made vehicular access to the area possible only by way of the main check-station gate. Thus, all hunters enter and exit through the check-station.

The main weakness of the present method of obtaining data is that some hunters come into the areas on foot via the Broad Run Creek road and from private land that joins the management area. The number of hunters that gain entrance by the above method is unknown, but is believed to constitute less than 25% of the total number of hunters using the area (Seneca 1961). Not only are these hunters not tallied, but their kills, sightings, and hours hunted are unknown.

From 1959 to 1964 all information was recorded on a standard 5 x 7 card form (Fig. 1). Number in the party, time entered and vehicle license number were recorded. The card was then filed by the station operator. As the hunting party left the area, hunters were again stopped at the station, their cards were retrieved from the file and additional questions were asked of him.
Fig. 1. Broad Run Check Station data collection form utilized from 1959 through 1964.

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Broad Run Check Station Data

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<tr>
<th>Year</th>
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Hunting Time, Game Seen and Killed By Compartments

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<th>Compt. C</th>
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Information recorded included:

1. time out
2. total time hunted per individual
3. total man-hours hunted
4. time spent, game seen and game killed by compartment while traveling on the access road
5. time spent, game seen and game killed by compartment while actually hunting
6. time spent, game seen and game killed by compartment during other activities (mainly camping).

After recording this information, the data card was permanently filed under the appropriate date.

In 1965, use of the 5 x 7 data card was discontinued. From 1965 through 1967, all hunter pressure-success data were recorded on the first page (Fig. 2) of a three page questionnaire designed to gain socio-economic information on the hunters using the Broad Run Area.

In 1968, Robert Hooper of the U. S. Forest Service Experiment Station, Blacksburg, completely redesigned the hunter pressure-success data collection form to facilitate the transfer of data from the field form to IBM data punch cards.

Deleted from this redesigned form were:

1. vehicle license number
2. time of entry
3. time of departure
4. number in hunting party.
Fig. 2. Broad Run Check Station data collection form utilized from 1965 through 1967.

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**BROAD RUN QUESTIONNAIRE**

Department of Forestry and Wildlife  
Virginia Polytechnic Institute  
Blacksburg, Virginia

Date entered: _______________  Date departed: _______________

Time entered: _______________  Time departed: _______________

Vehicle license number: __________  Interviewer: _______________

Number of persons in vehicle: ___  Questionnaire number: __________

A SEPARATE QUESTIONNAIRE SHOULD BE COMPLETED FOR EACH HUNTER. ALL OF THE QUESTIONS APPLY ONLY TO THE HUNTER BEING INTERVIEWED.

1. Have you been previously interviewed during this hunting season:

   Yes / /  No / /  

   If so, how many times have you been approached? ___

2. TIME SPENT, GAME SEEN AND KILLED BY COMPARTMENTS.

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Time needed for tabulation of total man-hours hunted, total man-hours of road time, game seen by compartment, and game killed by compartment was greatly reduced through use of this new form.

The climatic data for each of the 7, 12-day deer seasons (1964 through 1970) considered in this study were compiled from United States Weather Bureau publications entitled "Climatic Summary of the United States," and from official weather records obtained from the United States Department of Commerce, Environmental Data Service, Asheville, North Carolina. From the deer management literature, a list was developed of the weather variables that might influence the number of deer seen per day. Appendix Table I lists these weather variables and the location at which they were recorded.

The weather station nearest to the Broad Run area was the Catawba Sanitorium Station located 3 miles west of the study area on the opposite side of Broad Run Mountain. The three useful climatic variables obtained from this station were: temperature, 24-hour precipitation, and snow and sleet. At the station, precipitation was observed and recorded daily at 8:00 A.M., temperature at 5:00 P.M. Three weather variables not recorded at the Catawba Station but considered essential to the study were: relative humidity, barometric pressure, and sky cover. These three variables were therefore taken from the official United States Weather Bureau Station located at Woodrum Field in Roanoke, Virginia. This station is located approximately 25 miles southwest of the study area.

Data relating to wind speed were taken from records provided by the United States Forest Service Weather Station at New Castle, Virginia.
This station is located approximately 5 miles north of the study area. New Castle, because of its proximity to the study area and because of the topographic similarity between the two areas, was considered to be the best source from which to obtain those data.

Data Tabulation

Only hunter pressure-success data collected at the checking-station during the 12-day deer season for the seven years, 1964 through 1970, were used in this study. Although data have been collected since 1959, deer season length prior to 1964 was restricted to only 1 week. Also, the method of checking station operation and data collection has been uniform only since 1964, and many of the data records for the years 1959-1964 were in such poor condition they were almost impossible to interpret accurately. All data collected prior to the 1964 season was therefore deleted.

From the original field data collection sheets, totals for each day of each season were obtained and transferred to a yearly data summary sheet. These included total man-hours spent in the area, hunting time, road time, and camping time, if any. Number of hours per deer seen per day was derived by dividing total man-hours hunted per day by number of deer seen per day. This variable was then recorded on the data summary sheets. Also recorded on the summary sheets were the dates of Thanksgiving, and days for either-sex hunts during a particular season. It was felt that knowledge of these dates would be important as they may influence hunting pressure throughout any particular season.
Weather data for the 7, 12-day seasons, 1964 through 1970, were transferred from United States Weather Bureau and United States Forest Service Weather record forms to yearly climatological data summary sheets.

Weather variables considered of value to the study, but not recorded on official weather forms, were derived from the existing records and recorded on summary sheets. Derived variables were: previous 24-hour precipitation, days since last precipitation, and barometric pressure trend.

**Data Analysis**

All data identified as possibly being related to hunter sightings of deer in the Broad Run Area were tabulated on IBM data sheets and key-punched on data cards. Data were verified by comparing the punched data with the original data.

A preliminary data analysis was undertaken to determine which variables best describe the number of deer sightings by hunters. All data were analyzed using the IBM System 360 computer. The computer was located on the campus of Virginia Polytechnic Institute and State University. The computer program utilized for the preliminary data analysis was the general plot including histogram (BMDOSD). This BMD program is one of the "package" programs prepared by the UCLA Medical Center to assist with the analysis of statistical and mathematical research problems. A complete description of this and other programs are listed by Dixon (1967).

The BMDOSD program provides a method for plotting a one-page graph which has 50 units vertically and 100 units horizontally. The data
points are automatically scaled to conform to these dimensions. A scale is printed both vertically and horizontally.

Five analyses utilizing BMD05D were necessary for the preliminary analysis. Eighty-four data points (the number of days being analyzed) for each independent variable were plotted against a dependent variable. A new dependent variable was chosen for each analysis. It was assumed that any significant relationship between the dependent and independent variables would be displayed by the computer generated plots. A summary of the dependent and independent variables utilized in the five computer runs is presented in Table 1.

Early in the study it was realized that it would be beyond the scope of this study, and impossible to ascertain the influence of weather variables on deer movements, deer activity levels, and the subsequent probability of deer being sighted by hunters. The influence of weather variables on deer activity was therefore considered only from the standpoint of the literature review.

The objective of the data analysis was therefore to define, other than through the activity of the animals themselves, what weather variables significantly influenced the number of deer sighted. It was hypothesized that the number of deer sighted was a function of day of the season, hunting pressure on a particular day, and weather factors directly preceding and during a particular day.

The use of the dependent variable, hours to see a deer, was an attempt to standardize the effect of day of the season and hunting pressure on the number of deer seen. It was hoped that by using hours to see a deer as the dependent variable, the resultant computer-generated
TABLE 1. Variables utilized in preliminary data analysis through BMD05D (general plot including histogram).

### Dependent Variables

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of hours per deer seen</td>
</tr>
<tr>
<td>2</td>
<td>Number of deer seen per day</td>
</tr>
<tr>
<td>3</td>
<td>Number of hunters per day</td>
</tr>
<tr>
<td>4</td>
<td>Total man-hours hunted per day</td>
</tr>
<tr>
<td>5</td>
<td>Average number of hours hunted per day</td>
</tr>
</tbody>
</table>

### Independent Variables

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>2</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>3</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>4</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>5</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>1</td>
<td>minimum daily temperature</td>
</tr>
<tr>
<td>2</td>
<td>maximum daily temperature</td>
</tr>
<tr>
<td>3</td>
<td>average daily temperature</td>
</tr>
<tr>
<td>4</td>
<td>total daily precipitation</td>
</tr>
<tr>
<td>5</td>
<td>previous 24 hour precipitation</td>
</tr>
<tr>
<td>1</td>
<td>snow on ground</td>
</tr>
<tr>
<td>2</td>
<td>barometric pressure</td>
</tr>
<tr>
<td>3</td>
<td>relative humidity</td>
</tr>
<tr>
<td>4</td>
<td>days since last precipitation</td>
</tr>
<tr>
<td>5</td>
<td>wind speed</td>
</tr>
<tr>
<td>1</td>
<td>sky cover - sunrise to sunset</td>
</tr>
<tr>
<td>2</td>
<td>sky cover - midnight to midnight</td>
</tr>
<tr>
<td>3</td>
<td>day of season</td>
</tr>
<tr>
<td>4</td>
<td>number of hunters per day</td>
</tr>
<tr>
<td>5</td>
<td>number of man-hours hunted per day</td>
</tr>
<tr>
<td>1</td>
<td>hours hunted per deer seen</td>
</tr>
<tr>
<td>2</td>
<td>number of man-hours hunted per deer seen</td>
</tr>
</tbody>
</table>
plots would more closely represent the relationships, if any, that existed between the number of deer seen and the weather variables. Those weather variables which displayed very little or no relationship to the dependent variable were deleted from later analyses.

It was felt that linear correlation existed between several of the independent weather variables. To determine if correlation among independents actually existed, all weather variables were entered into a BMD02R multiple regression analysis program utilizing number of deer seen per day as the dependent variable. The printout of a correlation matrix (Table 2), an optional output for this program, was called for. The correlation matrix was then used to determine those weather variables between which a high degree of correlation existed. If two independent variables were shown to be highly correlated only one of the two was utilized in future analyses.

Analysis of Number of Deer Seen Per Day

Computer runs utilizing BMD02R were required for the analysis designed to identify those weather variables significantly influencing number of deer contacted per day.

Prior analyses had shown that a strong relationship existed between day of the season and number of deer seen per day. However, it did not logically seem that this was a cause-and-effect relationship. Instead, day of the season appeared to affect the number of deer seen per day through hunting pressure. Two measures of hunting pressure were available in this investigation: number of hunters per day and total man hours hunted per day. Based on preliminary data plots, both appeared to be strongly related to number of deer seen per day and both
TABLE 2. Matrix of correlation coefficients of all weather variables on which data were collected.

<table>
<thead>
<tr>
<th>Variable Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.000</td>
<td>0.771</td>
<td>0.940</td>
<td>0.143</td>
<td>0.174</td>
<td>0.054</td>
<td>1.000</td>
<td>0.274</td>
<td>-0.424</td>
<td>-0.227</td>
<td>0.362</td>
</tr>
<tr>
<td>2</td>
<td>1.000</td>
<td>0.941</td>
<td>0.124</td>
<td>0.109</td>
<td>0.102</td>
<td>-0.308</td>
<td>0.087</td>
<td>0.159</td>
<td>-0.227</td>
<td>0.136</td>
<td>0.247</td>
</tr>
<tr>
<td>3</td>
<td>1.000</td>
<td>0.145</td>
<td>0.154</td>
<td>0.081</td>
<td>0.184</td>
<td>0.251</td>
<td>0.189</td>
<td>0.229</td>
<td>-0.374</td>
<td>0.187</td>
<td>0.318</td>
</tr>
<tr>
<td>4</td>
<td>1.000</td>
<td>0.316</td>
<td>0.164</td>
<td>0.189</td>
<td>-0.043</td>
<td>0.128</td>
<td>-0.168</td>
<td>0.413</td>
<td>-0.333</td>
<td>0.178</td>
<td>0.251</td>
</tr>
<tr>
<td>5</td>
<td>1.000</td>
<td>0.026</td>
<td>-0.335</td>
<td>-0.079</td>
<td>-0.040</td>
<td>-0.323</td>
<td>0.316</td>
<td>0.026</td>
<td>-0.335</td>
<td>-0.079</td>
<td>-0.040</td>
</tr>
<tr>
<td>6</td>
<td>1.000</td>
<td>-0.442</td>
<td>-0.432</td>
<td>-0.389</td>
<td>-0.323</td>
<td></td>
<td>1.000</td>
<td>0.300</td>
<td>0.164</td>
<td>0.107</td>
<td>0.168</td>
</tr>
<tr>
<td>7</td>
<td>1.000</td>
<td>1.000</td>
<td>-0.209</td>
<td>0.629</td>
<td>0.636</td>
<td></td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

1. minimum daily temperature
2. maximum daily temperature
3. average daily temperature
4. total daily precipitation
5. previous 24 hour precipitation
6. days since last precipitation
7. wind speed
8. relative humidity
9. barometric pressure
10. sky cover - sunrise to sunset
11. sky cover - midnight to midnight
were considered to be valid indices of hunting pressure per day. A simple linear regression analysis revealed a high correlation between the two independent variables ($R = 0.96$). Due to the high correlation existing between the two variables, use of either as a measure of hunting pressure per day would have accounted for about the same amount of variation in the dependent variable. Number of hunters per day was chosen as the measure of pressure because it was considered easier to interpret and would be the more practical variable to use should the study be repeated.

Because it was felt that the influence of day of the season upon the dependent variable was included in the influence exerted by number of hunters per day, day of the season was not utilized as an independent variable. Number of deer seen per day was therefore felt to be a function of number of hunters per day and weather.

In the analysis, number of hunters per day was forced into the regression first with all weather variables left free to enter. Through this method, significant weather variables were entered into the regression after the influence of number of hunters per day had been accounted for. In this analysis, the $F$ level for inclusion of a variable was set as low as possible to reduce the chance of deleting a weather variable which might provide even slight explanation of the number of deer seen per day. A summary of independent variables utilized in this analysis is presented in Table 3.

**Analysis of Deer Seen Per Hunter Per Day**

Following the analysis of total number of deer seen per day, it was decided to utilize number of deer seen per hunter per day as a
TABLE 3. Independent variables utilized in the analysis of number of deer seen per day.

<table>
<thead>
<tr>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$ - average daily temperature</td>
</tr>
<tr>
<td>$X_2$ - total daily precipitation</td>
</tr>
<tr>
<td>$X_3$ - previous 24 hour precipitation</td>
</tr>
<tr>
<td>$X_4$ - barometric pressure</td>
</tr>
<tr>
<td>$X_5$ - relative humidity</td>
</tr>
<tr>
<td>$X_6$ - days since last precipitation</td>
</tr>
<tr>
<td>$X_7$ - wind speed</td>
</tr>
<tr>
<td>$X_8$ - sky cover sunrise to sunset</td>
</tr>
<tr>
<td>$X_9$ - number of hunters per day</td>
</tr>
</tbody>
</table>
dependent variable. The use of this dependent variable seemed reasonable under the assumption that one of the major goals of game management is the maximization of recreational benefits derived by the individual hunter. Under this assumption, any weather variable significantly influencing deer seen per hunter per day would also influence individual hunter satisfaction. The dependent variable was derived by dividing the total number of deer seen per day by number of hunters per day.

Two analyses utilizing BMD02R were necessary. Independent variables used in the analyses are listed in Table 4. All weather variables were left free to enter. Number of hunters was not utilized as an independent variable as it had been incorporated into the dependent variable.

**Analysis of Number of Hunters Per Day**

Based on the results of preliminary data plots of number of hunters versus deer sighted per day (Fig. 3), it was assumed that as the number of hunters per day increased, number of deer seen per day would increase. Also revealed by preliminary data plots was what appeared to be a close relationship between day of season and number of hunters per day (Fig. 4). Thus, day of the season and weather appeared to operate through number of hunters per day in influencing number of deer seen per day. Hence, the hypothesis: number of hunters per day was a function of day of the season and weather.

The objective of the data analysis thus became to determine the degree of influence day of season had on the number of hunters per day. After accounting for the influence of day of the season, those weather variables, if any, which significantly influenced the number of hunters
TABLE 4. Independent variables utilized in the analysis of deer seen per hunter per day.

<table>
<thead>
<tr>
<th>$X_1$</th>
<th>average daily temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_2$</td>
<td>total daily precipitation</td>
</tr>
<tr>
<td>$X_3$</td>
<td>previous 24 hour precipitation</td>
</tr>
<tr>
<td>$X_4$</td>
<td>barometric pressure</td>
</tr>
<tr>
<td>$X_5$</td>
<td>relative humidity</td>
</tr>
<tr>
<td>$X_6$</td>
<td>days since last precipitation</td>
</tr>
<tr>
<td>$X_7$</td>
<td>wind speed</td>
</tr>
<tr>
<td>$X_8$</td>
<td>sky cover sunrise to sunset</td>
</tr>
</tbody>
</table>
Fig. 3  
Increase in deer seen with number of hunters per day on Broad Run Research Area (1964-1970).
Fig. 4. Change in average number of hunters per day with day of the season on Broad Run Research Area, (1964-1970).
per day and therefore indirectly affected the number of deer sighted per day could be identified.

The method chosen to account for the influence of day of the season in the equation,

\[ \text{number of hunters per day} = f (\text{day of the season, weather}) \]

was to first generate through the use of one of the BMD Regression Analysis package programs (BMD05R) a polynomial regression of the form,

\[ Y = \beta_0 + \beta_1 x + \beta_2 x^2 + \ldots + \beta_k x^k + e \]

where \( k \) is some positive integer, to describe the influence of \text{day of season} upon \text{number of hunters per day}.

Due to the number of inflection points in the curve describing the relationship of \text{number of hunters per day} to \text{day of the season}, an 8th degree polynomial was called for in the program. Having obtained this polynomial and determined that an 8th degree term was sufficient in describing the relationship which existed between \text{number of hunters per day} and \text{day of the season}, multiple step-wise regression analysis (BMD02R) was utilized to determine, after the effect of \text{day of the season} had been accounted for, which weather variables, if any, significantly influenced the \text{number of hunters per day}.

The BMD02R program computes a sequence of multiple linear regression equations in a step-wise manner. At each step, one variable is added to the regression equation. The variable added is the one which makes the greatest reduction in the error sum of squares. Equivalently, it is the variable which has the highest partial correlation with the
dependent variable partialed on the variables which have already been added; and equivalently, it is the variable which, if added, would have the highest F value. In addition, variables can be forced into the regression equation. Non-forced variables are automatically removed when their F values become too low.

In this case, the 8th degree term describing influence of day of the season was forced into the regression equation first, all weather variables were then left free to enter. Thus, influence of day of the season would be accounted for first in the regression, then any significant weather variable would then be entered. All non-forced weather variables would be removed when their F values become too low. Independent variables utilized in the analysis are presented in Table 5.

A second analysis of number of hunters was performed utilizing an alternate method to account for the influence of day of the season on number of hunters. All days on which approximately the same degree of hunting pressure was experienced were grouped for analysis. From an examination of the raw data plots of number of hunters by day of the season, (Fig. 4) it was evident that the first day of the season, Saturdays, holidays, and the last day of the season experience approximately the same number of hunters, and this number was much larger than the remaining days of the 12-day season. These most-heavily hunted days were therefore grouped for one analysis. All other days, those on which a much smaller number of hunters were present, were grouped for a second analysis. Through study of preliminary data plots, number of hunters per day was found to increase linearly by year. Year was therefore forced into the multiple stepwise regression analysis first as an
TABLE 5. Independent variables utilized in the analysis of number of hunters per day.

<table>
<thead>
<tr>
<th>Variable (X)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₁</td>
<td>day of the season</td>
</tr>
<tr>
<td>X₂</td>
<td>day of the season squared</td>
</tr>
<tr>
<td>X₃</td>
<td>day of the season cubed</td>
</tr>
<tr>
<td>X₄</td>
<td>day of the season to the fourth</td>
</tr>
<tr>
<td>X₅</td>
<td>day of the season to the fifth</td>
</tr>
<tr>
<td>X₆</td>
<td>day of the season to the sixth</td>
</tr>
<tr>
<td>X₇</td>
<td>day of the season to the seventh</td>
</tr>
<tr>
<td>X₈</td>
<td>day of the season to the eighth</td>
</tr>
<tr>
<td>X₉</td>
<td>average daily temperature</td>
</tr>
<tr>
<td>X₁₀</td>
<td>total daily precipitation</td>
</tr>
<tr>
<td>X₁₁</td>
<td>previous 24 hour precipitation</td>
</tr>
<tr>
<td>X₁₂</td>
<td>barometric pressure</td>
</tr>
<tr>
<td>X₁₃</td>
<td>relative humidity</td>
</tr>
<tr>
<td>X₁₄</td>
<td>days since last precipitation</td>
</tr>
<tr>
<td>X₁₅</td>
<td>wind speed</td>
</tr>
<tr>
<td>X₁₆</td>
<td>sky cover - sunrise to sunset</td>
</tr>
</tbody>
</table>
independent variable. Any non-forced weather variable significantly influencing number of hunters per day would be entered after the influence of year was accounted for. Two runs utilizing BMD02R were necessary for this analysis. Independent variables utilized in these two analyses are presented in Table 6.

Only variables significant at the 90 percent confidence level were included in the regression equation; all other variables were removed when their F values became too low. The large alpha level insured that variables which might be related to number of hunters per day would be detected. It also reduced the chance of rejecting a variable that through interaction with another variable, might provide explanation of the number of hunters per day.

Following the analysis of number of hunters per day, it was felt that extreme weather conditions might influence the average hours expended per hunter per day. Average man hours hunted per day were calculated for the 84 days in the study. The averages were then classed by day of the season and class averages were calculated. Within each of the classes, days exhibiting extremes in weather conditions were identified from the weather data. Average man-hours hunted under extreme weather conditions were then visually compared to the class average and to the other six values for that day class. Any large deviation from day class average which appeared to be weather related would then be more closely examined. Average for individual days, day classes, and corresponding weather extremes are presented in Appendix Table II.
TABLE 6. Independent variables utilized in the analysis of number of hunters per day (days classed by hunting pressure).

| $X_1$  | - year                                      |
| $X_2$  | - average daily temperature                  |
| $X_3$  | - total daily precipitation                  |
| $X_4$  | - previous 24 hour precipitation             |
| $X_5$  | - barometric pressure                        |
| $X_6$  | - relative humidity                          |
| $X_7$  | - days since last precipitation              |
| $X_8$  | - wind speed                                 |
| $X_9$  | - sky cover - sunrise to sunset              |
Additional Analysis

Finally, each weather variable was plotted against the dependent variable, deer seen per hunter per day. One run utilizing BMD05D was necessary for this analysis. Eight, one page graphs, one for each variable, were generated.

It was felt that most of the 84 days of data utilized in the study exemplified moderate weather conditions with very few hunting days experiencing extremes of any weather variable. Data plotting was performed to determine if deer seen per hunter per day was influenced by the few extremes in weather conditions which did occur from time to time over the 7 years studied. If an extreme weather variable did influence the dependent variable, a significant increase or decrease in deer seen per hunter per day corresponding to that extreme weather condition would be displayed by the data plot. The data plots would also reveal any non-linear relationships existing between the dependent variable and the weather variables.

The influence of hunting pressure was incorporated into the dependent variable. Independent variables utilized in this analysis are listed in Table 4.

The Questionnaire

A mailed questionnaire designed to provide information about the influence of weather factors on the deer hunter was an important experimental procedure utilized in this study. An unstructured preliminary questionnaire was constructed to obtain necessary background information. Each questionnaire consisted of 14 questions and took approximately 20 minutes to complete. It was given to four samples of deer
hunters as listed below:

<table>
<thead>
<tr>
<th></th>
<th>Number of Questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VPI Forestry &amp; Wildlife Graduate Students</td>
<td>8</td>
</tr>
<tr>
<td>2. VPI Forestry &amp; Wildlife Faculty and Staff</td>
<td>3</td>
</tr>
<tr>
<td>3. VPI Custodians (local hunters)</td>
<td>3</td>
</tr>
<tr>
<td>4. Virginia National Guard Members</td>
<td>6</td>
</tr>
</tbody>
</table>

Total Questionnaires 20

The questionnaire consisted of 8 open-ended questions (e.g., In your opinion, what are the worst possible weather conditions for deer hunting?) and the rest structured (e.g., When deer hunting, do other hunters in the woods bother you?: yes, very much; yes, bother me slightly; no, they don't bother me at all). Since a large sample of hunters was desired, a mailed questionnaire was constructed based on experience obtained in the pilot questioning.

Addresses of a random sample of 230 hunters residing in the Montgomery-Giles County area who purchased a big game license for 1970-71 Virginia hunting season were obtained from hunting license stubs on file in the Christiansburg Courthouse. Although there was no guarantee that those individuals purchasing a big game license did hunt deer, it was felt that the majority did. Two hundred and thirty questionnaires were mailed to the Montgomery County-Giles County sample on April 9, 1971. A post card reminder was sent out 2 weeks later to those who had not responded by that time.
The questionnaire developed is presented in Appendix Table III. Of 18 questions, only 3 were open-ended. The questionnaire was pre-tested on wildlife graduate students; the average completion time was 15 minutes.
RESULTS

Preliminary Data Screening

Graphs plotted through use of the BMD05D computer program were generated in an attempt to identify those weather variables which may have been related to number of deer seen per day, number of deer seen per hunter per day and three other independent variables felt to possibly provide insight into the relation of weather to the number of deer-to-hunter contacts occurring per day. A summary of independent and dependent variables utilized in this analysis is presented in Table 1. The raw data plots revealed no obvious relationship between any of the five dependent variables and the 12 weather variables. It had been hoped that through preliminary data screening, the number of weather variables could be reduced. The data plots, however, failed to provide a criteria upon which to choose weather variables for further analysis. None of the variables were deleted based on the results of the plots.

Several weather variables were deleted based on the results of a linear correlation matrix (Table 2). The matrix revealed those variables between which a high degree of linear correlation existed. Deleted from further analysis due to this high degree of correlation were: 1) daily minimum temperature; 2) daily maximum temperature; and 3) sky cover - midnight to midnight.

Number of Deer Seen Per Day

The results of the analysis of total number of deer seen per day is presented in Table 7. The linear correlation coefficient for each of the nine independent variables is shown. The variables that were significantly linearly correlated with the dependent variable at the 90 per
TABLE 7. Correlation coefficients for nine independent variables possibly affecting number of deer seen on the Broad Run Research Area.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Deer Seen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average temperature</td>
<td>- .128</td>
</tr>
<tr>
<td>2. Total precipitation on day of hunt</td>
<td>- .079</td>
</tr>
<tr>
<td>3. Previous 24 hour precipitation</td>
<td>- .009</td>
</tr>
<tr>
<td>4. Days since last precipitation</td>
<td>.045</td>
</tr>
<tr>
<td>5. Wind speed</td>
<td>- .049</td>
</tr>
<tr>
<td>6. Relative humidity</td>
<td>- .017</td>
</tr>
<tr>
<td>7. Barometric pressure</td>
<td>.091</td>
</tr>
<tr>
<td>8. Sky cover - sunrise to sunset</td>
<td>.019</td>
</tr>
<tr>
<td>9. Number of hunters per day</td>
<td>.736 *</td>
</tr>
</tbody>
</table>

* Significant at the 90 percent confidence level.
cent confidence level are indicated (*). The correlation coefficient is a measure of the degree of linear association existing between an independent variable and the number of deer seen per day, however it does not imply a cause and effect relationship. A correlation coefficient of -1.0 represents perfect negative linear association in the sample while +1.0 represents perfect positive linear association in the sample (Ostle 1964). A value of 0.0 is interpreted to mean that no linear correlation exists between the two variables in the sample. It is clear from Table 7 that none of the eight weather variables were found to be significantly linearly correlated to number of deer seen per day. Only the variable pertaining to number of hunters per day was found to be significant at the 90 percent confidence level.

The same eight weather variables plus number of hunters per day were used as independent variables in a multiple linear regression analysis. Number of deer seen per day was the dependent variable. Two of the nine variables were significant in the resulting multiple linear regression equation at the 90 percent confidence level. One of the variables, number of hunters per day, was significant at the 99 percent confidence level. The resulting \( R^2 \) was 0.5706. The two variables and the order they entered the equation were: 1) number of hunters per day, and 2) average daily temperature.

The \( R^2 \) is the coefficient of determination. It is defined as the percentage of the corrected sum of squares that is "explained by" the fitting of the multiple linear regression (Ostle 1964). The \( R^2 \) is frequently referred to by saying that a certain percentage of the variation of the dependent variable is associated with the multiple regression.
For example, the $R^2$ value of 0.5706 can be interpreted by saying that 57.06 percent of the number of deer seen per day is explained by the two significant variables. The resulting multiple linear regression equation was:

$$Y = 12.24118 + 0.26831x_1 - 0.30064x_2$$

where:

$Y$ = number of deer seen per day

$x_1$ = number of hunters per day

$x_2$ = average daily temperature

### Number of Deer Seen Per Hunter Per Day

The results of the analysis of number of deer seen per hunter per day are presented in Table 8. The correlation coefficients of each of the weather variables with deer seen per hunter per day is shown. Number of hunters per day was not utilized as an independent variable as it had been incorporated into the independent variable.

Two of the eight weather variables, total precipitation on the day of the hunt and average daily temperature on the day of the hunt, were found to be significantly linearly correlated to deer seen per hunter at the 90 percent confidence level. Total precipitation was positively correlated to the dependent variable; average daily temperature was negatively correlated.

The eight weather variables were used as independent variables in a multiple linear regression analysis. Number of deer seen per hunter per day was the dependent variable. Two of the eight weather variables were significant in the multiple linear regression equation at the 90
TABLE 8. Correlation coefficients for eight weather variables possibly affecting number of deer seen per hunter per day.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Deer Seen Per Hunter r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average daily temperature</td>
<td>-0.282 *</td>
</tr>
<tr>
<td>2. Total precipitation on day of hunt</td>
<td>0.394 *</td>
</tr>
<tr>
<td>3. Previous 24 hour precipitation</td>
<td>0.019</td>
</tr>
<tr>
<td>4. Days since last precipitation</td>
<td>-0.013</td>
</tr>
<tr>
<td>5. Wind speed</td>
<td>0.025</td>
</tr>
<tr>
<td>6. Relative humidity</td>
<td>0.109</td>
</tr>
<tr>
<td>7. Barometric pressure</td>
<td>-0.147</td>
</tr>
<tr>
<td>8. Sky cover - sunrise to sunset</td>
<td>0.032</td>
</tr>
</tbody>
</table>

* Significant at 90 percent confidence level.
percent confidence level. The two weather variables and the order they entered the equation were: 1) total precipitation on the day of the hunt and 2) average daily temperature on the day of the hunt. Although these two variables were significant, the resulting $R^2$ value was only 0.2726. The multiple linear regression equation was:

$$Y = 0.53870 + 0.29796X_1 - 0.00725X_2$$

where:

$Y = \text{number of deer seen per hunter per day}$

$X_1 = \text{total precipitation on day of the hunt}$

$X_2 = \text{average daily temperature on day of the hunt}.$

**Number of Hunters Per Day**

Number of hunters per day was found to be significantly linearly correlated to number of deer seen per day (Fig. 3). An analysis was performed to determine which weather variables, if any, significantly influenced number of hunters per day, thereby indirectly influencing number of deer seen per day.

The analysis utilizing an 8th degree polynomial to account for the influence of day of the season on number of hunters per day was found to be inappropriate. Multiple regression analysis using the terms of the 8th degree polynomial as independent variables resulted in figures too large to be utilized accurately by the IBM 360 computer system.

To account for the influence of day of the season on number of hunters per day, the 12 days of the hunting season were divided into two classes based on hunting pressure (number of hunters per day). Days of heavy hunting pressure were opening day, Saturdays, and holidays.
The remaining days of the season were classed as low hunter pressure days.

The results of the linear correlation analysis of number of hunters on low hunting pressure days are presented in Table 9. Only one of the nine independent variables, year, was found to be significantly linearly correlated to number of hunters at the 90 percent confidence level. No weather variables were found to be significantly correlated to number of hunters per day on days experiencing low hunting pressure. All eight independent weather variables plus the independent variable year were entered into a multiple stepwise regression analysis. Only one of the nine variables, however, was found to be significant. This variable, year, was significant at the 90 percent confidence level. The resultant $R^2$, however, was only 0.2836. Weather variables showed no significant relationship, at the 90 percent confidence level, with number of hunters on days of low hunting pressure.

The results of the linear correlation analysis of number of hunters per day on days of heavy hunting pressure (opening day, Saturdays, and holidays), is presented in Table 10. Two of the nine independent variables analyzed were found to be significantly linearly correlated to number of hunters per day at the 90 percent confidence level. Year was found to be positively correlated to the dependent variable; total precipitation on the day of the hunt was found to be negatively correlated.

As in the analysis involving days of low hunting pressure, the eight independent weather variables plus the independent variable, year, were entered into a multiple stepwise regression analysis. In
TABLE 9. Correlation coefficients of independent variables possibly affecting number of hunters per day on days other than Saturdays, opening day, and holidays.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Number of Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average daily temperature</td>
<td>-.024</td>
</tr>
<tr>
<td>2. Total daily precipitation</td>
<td>-.183</td>
</tr>
<tr>
<td>3. Previous 24 hour precipitation</td>
<td>-.128</td>
</tr>
<tr>
<td>4. Days since last precipitation</td>
<td>.209</td>
</tr>
<tr>
<td>5. Average daily wind speed</td>
<td>-.003</td>
</tr>
<tr>
<td>6. Average daily relative humidity</td>
<td>.066</td>
</tr>
<tr>
<td>7. Average daily barometric pressure</td>
<td>.031</td>
</tr>
<tr>
<td>8. Sky cover - sunrise to sunset</td>
<td>-.007</td>
</tr>
<tr>
<td>9. Year</td>
<td>.543 *</td>
</tr>
</tbody>
</table>

* Significant at 90 percent confidence level.
TABLE 10. Correlation coefficients for independent variables possibly affecting number of hunters per day on opening day, Saturdays and holidays.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Number of Hunters r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average daily temperature</td>
<td>-.019</td>
</tr>
<tr>
<td>2. Total daily precipitation</td>
<td>-.335 *</td>
</tr>
<tr>
<td>3. Previous 24 hour precipitation</td>
<td>.093</td>
</tr>
<tr>
<td>4. Days since last precipitation</td>
<td>.054</td>
</tr>
<tr>
<td>5. Average daily wind speed</td>
<td>-.046</td>
</tr>
<tr>
<td>6. Average daily relative humidity</td>
<td>-.212</td>
</tr>
<tr>
<td>7. Average daily barometric pressure</td>
<td>.106</td>
</tr>
<tr>
<td>8. Sky cover - sunrise to sunset</td>
<td>.132</td>
</tr>
<tr>
<td>9. Year</td>
<td>.709 *</td>
</tr>
</tbody>
</table>

* Significant at 90 percent confidence level.
this regression, three of the nine variables were found to be significant in the equation at the 90 percent confidence level. One of the variables, year, was significant at the 99 percent level of confidence.

The three variables and the order they entered the multiple linear regression equation were: 1) year, 2) total precipitation on the day of the hunt and 3) average wind speed on the day of the hunt. The resulting $R^2$ was 0.630. Thus, 63 percent of the variation in number of hunters on opening day, Saturdays and holidays was accounted for by the three significant variables. The resulting multiple linear regression equation was:

$$Y = 35.43604 + 15.06803x_1 + -344.79126x_2 + 2.27257x_3$$

where:

$Y$ = number of hunters per day on days of heavy hunting pressure

$x_1$ = year

$x_2$ = total precipitation on day of the hunt

$x_3$ = average daily wind speed.

Average Man Hours Hunted

A visual analysis was performed in an attempt to determine if average man-hours hunted per day was influenced by extremes in weather conditions. The results of this analysis revealed no large weather related deviations of average man-hours hunted on days experiencing weather extremes from the day class average. Average man-hours hunted per day was found to be extremely variable regardless of the day of the season or the prevailing weather conditions. Results of this analysis are presented in Appendix Table II.
**Data Plots**

In order to determine the influence of extremes in the weather variables on number of deer seen per hunter per day, the eight weather variables were plotted against the dependent variable. It was felt that the few extreme weather conditions occurring over the 7 seasons in this study may have resulted in a significant weather-related increase or decrease in number of deer seen per hunter per day on the day of their occurrence. It is possible that the influence of these few weather extremes may have been masked in the overall analysis of a particular weather variable. However, a visual analysis of the resultant data plots revealed no significant weather-related increase or decrease in number of deer seen per hunter on days experiencing weather extremes. Figure 5 is presented as an example of the extreme variability found to exist in all the weather variables when plotted against number of deer seen per hunter per day.

**The Mailed Questionnaire**

Two hundred and thirty questionnaires were mailed to the Montgomery County-Giles County sample on April 9, 1971.

The final response was:

1. Number of questionnaires mailed to Montgomery County-Giles County sample: 230
   
   a. questionnaires returned by post office never reaching the hunter: 9
   
   b. questionnaires returned with major portions incomplete: 11
Fig. 5. Data plot of deer seen per hunter per day with average daily temperature.

$\text{Average Daily Temperature}$

$\text{Deer Seen Per Hunter Per Day}$

$r = -0.282$
All useable responses were coded on data sheets, analyzed on the Epic Monroe calculator and organized into tables.

The response to the questionnaire met expectations; approximately a 50 percent useable return was expected. Many that replied wrote on the cover or on attached letters to better express their opinions.

The questionnaire is presented in Appendix Table III. Much of the results will center about tables which will cite the original question and present their results in summary form. It should be noted that data are from a select user group and no implications will be made for state deer hunters.

Present age and number of years the respondents hunted deer since 1960 are presented in Appendix Table IV. As seen from this table, ages of the respondents are relatively well distributed. A median present age of 37 years was found for the group. A large portion of the sample 39 percent was found to have hunted deer 10 out of the last 10 years. The median number of years hunted deer since 1960 for the sample was seven years.

When asked with how many other men they usually hunt deer, (Question #3), 14 percent replied that they usually hunt alone, 33 percent with a buddy, 29 percent in groups of two to three, and 24 percent hunt with a group of four or more. Question #4 asked the method of deer hunting most often used. Only eight percent were found to hunt deer in organized drives; 23 percent used the walking-stalking method. The
majority of the respondents, 69 percent, stated that they used the still hunting-sitting method. Results of Questions #3 and #4 are given in Appendix Table V.

Question #7a asked hunters if bad weather would prevent them from going on a planned weekend deer hunt. Fifty-five percent or 62 respondents answered "yes" to this question. Those answering "yes" were then asked to check the two weather conditions most likely to prevent their going (Question #7b), and the one weather condition least likely to prevent them from going. Seventy-four percent indicated heavy rain, 63 percent indicated deep snow, and 32 percent indicated severe cold as the conditions most likely to prevent their going. The weather condition least likely to prevent their going indicated by the largest number of hunters was severe cold checked by 28 percent. These results are presented in Appendix Table VI.

Question #8a asked the hunters if bad weather would prevent them from going deer hunting on the first or last day of the season. Fifty-six percent answered "yes." This was almost identical to the results of Question #7a. The 60 respondents answering "yes" then listed the weather condition that they felt would prevent them from going, (Question #8b). The three weather conditions listed most frequently by the hunters were (in descending order): heavy rain, deep snow and severe cold. These results are given in Appendix Table VII.

A large majority, 81 percent, of the respondents felt that their chances of seeing a deer were affected by weather conditions (Question #9a). When those answering "yes" were asked to check the two worst weather conditions for seeing deer, (Question #9b), 79 percent checked
high winds, 57 percent checked heavy rain and 44 percent checked a dry forest floor. Asked to choose the two weather conditions which they felt were best for seeing deer (Question #9c), 90 percent chose a damp forest floor, 79 percent chose no wind, and 70 percent chose moderate temperatures (35° to 45°). These results are given in Appendix Table VIII.

Question #10 gave the hunters the opportunity to list the worst weather conditions in which they had ever hunted deer (Appendix Table IX). The four most frequently listed weather conditions (in descending order) were: severe cold, heavy rain, high winds, and heavy snow. Many hunters listing severe cold indicated temperatures around 0°F. Also, many listing heavy snow indicated depths in excess of 8 inches.

The hunters were then asked in Question #11 to check the four weather conditions which they felt would result in ideal deer hunting weather. The four most frequently chosen weather conditions and percentage of respondents choosing them were: no wind - 80 percent, damp forest floor - 73 percent, cool temperatures - 70 percent, and overcast skies (no rain) - 40 percent. Very few of the respondents felt that either cold or warm temperatures made ideal deer hunting weather. Results of Question #11 are given in Appendix Table X.

The results of Questions #12 and #13 are given in Appendix Table XI. Hunters were asked in Question #12, if they felt weather affected the number of others that will go deer hunting. Ninety percent answered "yes." Question #13 asked if they felt weather conditions greatly affected the total number of deer killed during a season. Seventy-one percent answered "yes"; 23 percent stated that they "really didn't know."
DISCUSSION

Deer Seen Per Day and Deer Seen Per Hunter Per Day

In the analysis of total number of deer seen per day, none of the weather variables were found to be significantly linearly correlated to the dependent variable. The one variable found to be significantly correlated to deer seen per day was number of hunters per day. It is certainly reasonable to assume that as the number of hunters per day increases, the total number of deer seen per day also increases (Fig. 4).

In the multiple linear regression analysis of number of deer seen per day, two variables were found to be significant in explaining the variation in the dependent variable. Number of hunters per day was the first variable to enter the equation, followed by average daily temperature. The resulting $R^2$ value for the equation was 0.5706. It should be noted that with only the single variable, number of hunters per day, in the equation, an $R^2$ of 0.5416 was obtained. Thus, this single variable accounted for 54.16 percent of the variation in the dependent variable. Addition of average daily temperature increased the amount of explained variation by only 2.90 percent, and was therefore shown to have little influence on number of deer seen per day. The prediction equation obtained from the multiple linear regression analysis showed the dependent variable, number of deer seen, to increase with an increase in number of hunters and to increase with a decrease in average daily temperature. The negative association between average daily temperature and deer seen per day may at first seem to disagree with the findings of Halloran (1943), Behrend (1966), Townsend and Smith (1933), and others. They observed deer activity to be reduced to a minimum
during periods of very cold temperatures (-20°F to 20°F.) and to increase as temperatures rose. They stated that it was usual to see deer in greater numbers on comparatively warm days (>30°F).

The average daily temperature for the seven years considered in this study ranged from 20°F to 61°F. The overall mean temperature for all years was 45°F. Differences of temperature within this range probably had little influence on deer activity. It is possible that it was not the deer so much as the hunter's activity which was influenced. With temperatures ranging from 20°F to 25°F, many hunters find it uncomfortable to remain on a stand and instead resort to the walking-stalking method of deer hunting.

The subsequent increase in hunter activity on these "cold" days may have contributed to a comparatively larger number of deer seen during colder temperatures. Under warmer conditions (>50°F.) hunters may find it comfortable to remain on their stand for a large part of the day. If, in fact, a decrease in hunter activity does occur with warmer temperature, this may explain the decrease in number of deer seen occurring with an increase in average daily temperature.

In the analysis of deer seen per hunter per day, two of the eight weather variables were found to be significantly linearly correlated to the dependent variable, however, in neither case was it a strong linear association. These two weather variables were "total precipitation on the day of the hunt" and "average daily temperature."

Total precipitation on the day of the hunt was positively correlated to deer seen per hunter. This positive relationship would at first seem to refute the findings of Townsend and Smith (1933), Carhart
(1946), Day (1964) and Mechler (1970). They reported number of deer sightings to be negatively correlated to precipitation. Townsend and Smith reported observing practically no deer on rainy days and stated that under rainy conditions deer are likely to bed in protected areas and let the storm pass. Hunters also seek sheltered areas under rainy conditions and usually move about very little until the storm subsides.

It is possible that the amount, severity, and duration of rainfall on the nine days experiencing precipitation over the seven years considered in this study was not sufficient to hinder or depress either deer or hunter activity. It is, in fact, possible that the precipitation may have contributed to an increase in the number of deer seen per hunter by dampening the forest floor and thus allowing hunters to move more quietly through the woods.

Average daily temperature was found to be negatively correlated to number of deer seen per hunter per day. The interpretation of this correlation is the same as that for the negative association shown to exist between average daily temperature and total number of deer seen per day by the multiple linear regression equation. It seems reasonable that the causes underlying the negative association of average daily temperature to the two closely associated dependent variables are the same in both cases.

In the multiple linear regression analysis of deer seen per hunter per day, two of the eight weather variables were significant in the final equation. Total precipitation on the day of the hunt was the first variable to enter the equation followed by average daily temperature. Although the two weather variables were significant, the resulting
\[ R^2 \text{ value was only 0.2726. Thus, the two weather variables accounted for only 27.26 percent of the variation associated with the dependent variable. The predictive equation showed the dependent variable to increase with an increase in total precipitation and to increase with a decrease in average daily temperature. These relationships agree with the results of the linear correlation analysis.} \]

In the regression analysis of both total deer seen per day and deer seen per hunter per day, weather variables proved to be statistically significant, however, they accounted for a very small proportion of the variation in the dependent variables. The failure of the weather variables to "explain" a large proportion of the variation in either total deer seen per day or deer seen per hunter per day may have been due to the fact that over the seven deer hunting seasons analyzed in this study, extreme weather conditions did not occur. Snow was non-existent; temperatures of below 20\(^\circ\)F. occurred on only 2 days; average wind speeds of over 12 miles per hour occurred on only 8 days and on only 9 days out of the total 84 did any rain fall. Only two of the 84 days experienced rainfall in excess of 1 inch.

**Number of Hunters Per Day**

In the analysis of number of hunters on days of low hunting pressure, only one variable, year, was found to be correlated linearly to the dependent variable. This significant positive correlation between year and number of hunters per day being anticipated as a steady, year-to-year increase in hunter use has been noted on the Broad Run Research Area.
In the analysis of number of hunters per day on days of heavy hunting pressure, two variables were found to be linearly correlated to the dependent variable. A positive correlation was shown to exist between number of hunters per day and years. As mentioned previously, this association was anticipated.

The negative linear association between total daily precipitation and number of hunters per day tends to support the findings of Fobes (1945), Day (1964), Schultz (1957) and others. They reported that rain and cooler weather may provide better hunting conditions, and that seasons with decided deficiency in precipitation were usually marked by a reduced deer harvest. They felt, however, that dry weather usually resulted in more hunter activity and a larger number of hunters in the woods. Day (1964) stated that although some hunters claim to enjoy rainy weather and feel it improves their chance of success, the majority do not.

In the multiple linear regression analysis of number of hunters per day on days of heavy hunting pressure, three variables were found to be significant in explaining the variation in the dependent variable. These three variables were: year, total precipitation on the day of the hunt and average wind speed on the day of the hunt. The resulting $R^2$ for the regression equation was 0.630. Year was by far the most important variable accounting for 50 percent of the variation in the number of hunters. The two weather variables, although statistically significant were of little importance as each of them accounted for only 6 percent of the variation after year.

The prediction equation showed number of hunters to increase by
year and with an increase in wind speed and to decrease with an increase in total precipitation. The negative association between precipitation and number of hunters agrees with the results of the linear correlation analysis.

The increase in number of hunters with an increase in wind speed refutes the findings of other authors. Furthermore, no linear association was found to exist between the two variables. It was therefore felt that the statistical significance of wind speed in the multiple regression equation may have been chance correlation.

In the analysis of number of hunters per day, it should be noted that weather variables were found to be significant for days exhibiting heavy hunting pressure but not for days exhibiting light pressure. This was the opposite of the anticipated outcome. A possible explanation for these results may be that those hunters who are afield on days other than Saturdays, opening day and holidays may be avid deer hunters, possibly rural residents whose decision to hunt is only affected by the severest adverse weather conditions. However, a larger proportion of the hunters on heavy pressure days are casual hunters whose decision to hunt was more affected by weather conditions.

As in the case of the dependent variables, deer seen per day and deer seen per hunter per day, weather factors were significant in the statistical sense but probably influence the individual's decision to hunt or not hunt very little. Several reasons may be hypothesized to explain these results;

1. Weather conditions occurring over the 7 years analyzed in this study were not severe nor adverse enough to markedly
effect the number of hunters per day.

2. The deer hunting season length West of the Blue Ridge is relatively short (2 weeks). This limited season length does not permit the hunter to wait for ideal deer hunting weather. A great many hunters therefore take advantage of every opportunity to hunt, and do so regardless of prevailing weather conditions.

3. Averages of weather variables are statistical tools. They are seldom correlated with biotic phenomena and rarely are placed in a cause and effect relationship (Wolf et al. 1949). Relationships between climate and animals are more likely to be identified where climate is defined as "the collective state of the atmosphere" for this concept recognized the multi-dimensional aspect of weather and the extreme conditions which influence critical periods in the lives of biological organisms.

The Mailed Questionnaire

Hunters sampled from the Montgomery County-Giles County area were well distributed in age. Twenty-two percent were in the 20-29 age class, 21 percent were in the 30-39 age class, 15 percent were in the 40-49 age class and 21 percent were in the 50-59 age class. A large percentage (39 percent) of the respondents had hunted deer 10 out of the last 10 years; 57 percent had hunted 5 out of the last 10 years.

Deer hunting to the majority of the respondents was a group activity. Only 16 (14 percent) hunted alone. Most individuals hunted with a buddy or a group and probably did so for companionship; group success
and safety reasons may also be important.

The majority (69 percent) of the sample preferred the still hunting-sitting method of deer hunting. Several respondents indicated, however, that with uncomfortable weather conditions such as cold temperatures or drizzle, they change to the walking method.

When asked if adverse weather would prevent their going on a planned weekend deer hunt, (Question #7a) the response was approximately evenly divided; 55 percent answered "yes." It is possible that many of those answering "yes" were older individuals who were reluctant to hunt deer in bad weather. Several respondents in the 50-59 age class stated that when younger, they hunted deer in any condition, but now hunt only in comfortable weather. It is also possible that some of those answering "yes" were casual hunters, whose decision to hunt was more influenced by weather than was the avid deer hunter's decision.

When those answering "yes" were asked to indicate the two weather conditions most likely to prevent their going, heavy rain and deep snow were the two most frequently mentioned.

When the respondents were asked if adverse weather would prevent them from going hunting on the first or last day of the season (Question #8a), the response was again approximately evenly divided with 56 percent answering "yes." When asked to indicate the two weather conditions most likely to prevent their going on the first or last day, heavy rain and deep snow were again the two most frequently mentioned.

The response to both Question #7 and #8, in which respondents were asked to list those weather conditions most likely to prevent their going deer hunting on a planned weekend hunt or the first or last day of
the season, support the findings of Day (1964), White (1968), and Fobes (1945). Day (1964) stated that with heavy rains most hunters stay home or if in the field stay close to their cars or camps. White (1968) claimed that with heavy snow the average weekend hunter is very likely to stay home. The adverse effect of snow was reported by Fobes (1945) who observed a definite decline in hunter activity when snow accumulated to depths in excess of 8 inches.

Eighty-one percent of the respondents felt that their chances of seeing deer were affected by weather conditions (Question #9a). When those answering "yes" were asked to indicate the two worst conditions for seeing deer, high winds and heavy rains were the two most frequently mentioned. These results tend to support the findings of several authors. Townsend and Smith (1933) stated that during hunting season, deer tend to skulk on windy days. Halloran (1943) agreed and stated that deer tend to spend most of their time in the brush during days of high wind. Palmer (1951) wrote that on windy days, deer are usually nervous, restless and tend to be more alert and Schultz (1957) reported that high winds worked against the hunter during the 1957 West Virginia season by reducing deer movements.

Townsend and Smith (1933) observed practically no deer on rainy days and Behrend (1966) reported that prolonged heavy rain can suppress deer activity. Day (1964) indicated that the rainfall which persisted throughout most of the 1963 Maine season was the primary factor contributing to the reduced deer kill.

When those answering "yes" to Question #9a were asked to indicate the three best conditions for seeing deer, a damp forest floor, no wind,
and moderate temperatures were the three most frequently mentioned. A damp forest floor and no wind were probably considered best from the technical aspect of deer hunting while the high ranking of moderate temperatures is probably an indicator of the importance of physical comfort to many hunters.

When the hunters were asked to list the worst weather conditions in which they had personally ever hunted deer, severe cold, heavy rain, and high winds were listed most frequently. Again, the listing of severe cold is probably an indicator of the importance of comfort to the hunter and tends to support the findings of White (1968) who reported that in many southern states, hunter numbers decline as the weather turns colder. The adverse affects of heavy rain and high winds have already been discussed.

Question #11 asked respondents to choose the four weather conditions which they felt would make ideal deer hunting weather. The three most frequently mentioned were no wind, a damp forest floor, and moderate temperatures. These results indicate the difference that exists between the Montgomery County-Giles County sample and most New England hunters as to what constitutes ideal deer hunting conditions. White (1968) stated that ideal conditions are considered by the average New Hampshire hunter to consist of 3 to 4 inches of quiet powder snow. Laramee and White (1964) reported that experienced New Hampshire hunters wait until the late-season snows have fallen to do their hunting. Most New England hunters feel that a good tracking snow makes for easier and more efficient hunting. However, only 26 percent of the respondents indicated snow on the ground to be a factor in ideal hunting conditions.
This may have been due to the fact that the question did not indicate a specific snowdepth. It is possible that the majority of the respondents took "snow on the ground" to mean snow of a depth sufficient to hinder access and hunter movements. Had a depth of 2 to 3 inches been specified, the respondents may have given this weather condition a much higher rank. It is also possible that many hunters do not regard snow on the ground to be an ideal hunting condition due to their lack of experience in hunting under these conditions. They may not realize the advantages one has, since snow on the ground during deer season is a rather rare occurrence in this region.

When respondents were asked if they felt that weather conditions can greatly effect the number of deer killed during the season, 71 percent replied "yes." These results support the findings of Fobes (1945), and indicate that should a lower than predicted kill be realized due to severe weather factors, the majority of hunters would accept bad weather as an explanation for the reduced kill.

It should be noted that although the statistical analysis of the Broad Run data did not show weather to substantially influence either number of deer seen or number of hunters per day, these results were most probably due to the non-existence of severe weather conditions over the years 1964-1970. The questionnaire results indicate, however, that the majority of hunters feel that severe weather has a large influence on hunter behavior and a decided effect on harvest.
SUMMARY AND CONCLUSIONS

Data collected on the Broad Run Area, 1964 through 1970, concerning number of deer seen per day, number of deer seen per hunter per day, and number of hunters per day were analyzed. Weather variables thought to influence and affect the dependent variables were identified and tabulated. Linear correlation coefficients and multiple regression analysis were used to determine significant relationships between these variables and the three dependent variables.

The weather variables studied included: average daily temperature, amount of precipitation on the day of the hunt, amount of precipitation occurring 24 hours prior to the day of the hunt, number of days since last precipitation, average daily wind speed, average relative humidity, average daily barometric pressure, and average daily sky cover, sunrise to sunset.

In the multiple regression analysis of deer seen per hunter per day, two weather variables, average daily temperature, and total daily precipitation, were found to be significant at the 90 percent confidence level. The resulting $R^2$ value, however, was only 0.2726. Average daily temperature was negatively related to the dependent variable; total daily precipitation was positively related.

A single variable, number of hunters per day, was found to account for 54.16 percent of the variation in the number of deer seen per day.

The addition of average daily temperature, the one weather variable found to be significant, increased the amount of variation explained by only 2.90 percent and as such, was felt to lack practical
significance.

Total daily precipitation was significant, but accounted for very little of the variation in the analysis of number of hunters per day. Number of hunters was found to be a function primarily of year and day of the season.

There is no reason to believe that the weather conditions recorded during the seven hunting seasons considered in this study were not typical for the Broad Run Area. Therefore, from the results of the data analysis, it must be concluded that except for severe or extreme conditions, weather probably does not significantly influence the number of deer seen or number of hunters per day. The failure of weather to influence strongly either of these variables was probably due to the fact that:

1. Weather on the Broad Run Area is characteristically comparatively mild; severe or adverse weather conditions were non-existent in the data utilized.
2. The deer season West of the Blue Ridge is relatively short and hunters therefore take every opportunity to hunt.
3. It is rarely possible to detect significant, and meaningful relationship between individual weather variables and biotic phenomena.

In addition to statistical analysis, the influence of weather factors on the deer hunter was examined by mailed questionnaire. The majority of deer hunters felt their chances of seeing or killing a deer are affected by prevailing weather and that the total season's kill is definitely influenced by weather extremes. Approximately 50 percent of the
respondents indicated that heavy rain or deep snow would probably prevent them from going hunting on either a planned weekend hunt or the first or last day of the season. Ideal deer hunting weather was considered by the majority of the respondents to consist of no wind, a damp forest floor, and moderate temperatures. Most also indicated that they preferred an overcast day with no rain. These results indicate that personal comfort, as well as the technical aspects of the hunt, are factors of great importance to the majority of hunters.
REFERENCES


Appendix Table I. Weather variables tabulated for Broad Run Research Area, 1964 to 1970, and the location at which they were recorded.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Average daily temperature. (Catawba)</td>
</tr>
<tr>
<td>2.</td>
<td>Maximum daily temperature. (Catawba)</td>
</tr>
<tr>
<td>3.</td>
<td>Minimum daily temperature. (Catawba)</td>
</tr>
<tr>
<td>4.</td>
<td>Amount of precipitation, in hundredths of inches, on the day of the hunt. (Catawba)</td>
</tr>
<tr>
<td>5.</td>
<td>Amount of precipitation, in hundredths of inches, occurring during the 24 hours prior to the day of the hunt. (Catawba)</td>
</tr>
<tr>
<td>6.</td>
<td>Number of days since the last precipitation.</td>
</tr>
<tr>
<td>7.</td>
<td>Average daily wind speed. (Newcastle)</td>
</tr>
<tr>
<td>8.</td>
<td>Average relative humidity. (Roanoke)</td>
</tr>
<tr>
<td>9.</td>
<td>Average daily barometric pressure. (Roanoke)</td>
</tr>
<tr>
<td>10.</td>
<td>Average daily sky cover in tenths, sunrise to sunset. (Roanoke)</td>
</tr>
<tr>
<td>11.</td>
<td>Average daily sky cover in tenths, midnight to midnight. (Roanoke)</td>
</tr>
</tbody>
</table>
Appendix Table II.  Average man-hours hunted for individual days, day classes, and corresponding weather extremes.

<table>
<thead>
<tr>
<th>Class</th>
<th>(Day of Season)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>1</td>
</tr>
<tr>
<td>Average man-hours</td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>3.11°F</td>
</tr>
<tr>
<td>1965</td>
<td>4.69</td>
</tr>
<tr>
<td>1966</td>
<td>5.70</td>
</tr>
<tr>
<td>1967</td>
<td>5.42</td>
</tr>
<tr>
<td>1968</td>
<td>4.54 P 0.11&quot;</td>
</tr>
<tr>
<td>1969</td>
<td>6.26</td>
</tr>
<tr>
<td>1970</td>
<td>4.37</td>
</tr>
<tr>
<td>Overall Average</td>
<td>4.94</td>
</tr>
</tbody>
</table>

| Year          | 7   | 8   | 9   | 10              | 11              | 12              |
| Average man-hours |     |     |     |                 |                 |                 |
| 1964          | 1.02 | 2.14 | 1.39 P 1.85" | 3.23             | 3.63             | 4.23             |
| 1965          | 1.60 | 1.33 | 4.13  | 3.53             | 3.18             | 2.71             |
| 1966          | 2.28 P 0.77" | 3.08 | 2.21 | 4.30             | 4.26             | 2.92 C 0/10      |
| 1967          | 4.37 | 4.43 W 16 mph | ---- | 2.55             | 3.37             | 4.50             |
| 1968          | 4.18 | 3.41 | 3.71  | 4.04             | 3.68             | 4.61             |
| 1969          | 3.27 | 2.75 C 1/10 | 3.16 | 4.11             | 4.27             | 5.08 C 0/10      |
| 1970          | 4.29 | 1.67 W 14 mph | 3.36 T 17°F | 3.25             | 4.08             | 4.08             |
| Overall Average | 3.00 | 2.68 | 3.00 | 3.57             | 3.78             | 4.01             |

P - Precipitation; T - Temperature; W - Windspeed; C - Cloudcover
Gentlemen:

I am presently conducting research on the influence of weather conditions on deer hunters. I am attempting to find out what you, the deer hunter, consider to be good deer hunting weather, and how you feel weather conditions affect your chances of killing a deer.

WHAT YOU THINK ABOUT DEER HUNTING IS IMPORTANT TO US.

I would greatly appreciate it if you would sit down tonight and complete this questionnaire. Answer the questions carefully, being as accurate as possible; they should only take 15 to 20 minutes to answer.

Your effort in answering these questions will give us additional and much needed information on deer hunting and management in Virginia.

If you forget to answer this questionnaire, we will send you a reminder in two weeks.

Thank you very much for your help.

Sincerely,

Robert L. Curtis
Division of Forestry and Wildlife Sciences, V.P.I.

A self-addressed stamped envelope is enclosed for your convenience.
Appendix Table III. (Continued)

1. What is your present age? ________________ years.

2. In how many of the last 10 years (since 1960) have you hunted deer? (CIRCLE ONE)
   1  2  3  4  5  6  7  8  9  10

3. In the last couple of years, with how many men do you usually hunt deer? (CHECK ONE)
   _____ I usually hunt alone
   _____ I usually hunt with a buddy
   _____ I usually hunt with 2 or 3 other men
   _____ I usually hunt with 4 or more men

4. The deer hunting method I use most often was:
   (CHECK ONLY THE ONE MOST USED)
   _____ walking-stalking
   _____ still hunting-sitting
   _____ organized drives with a group

5. If you don't see a deer after a day's hunt are you:
   (CHECK ONE)
   _____ very disappointed
   _____ slightly disappointed
   _____ not disappointed at all

6. Do other hunters in the woods, other than those in your party, bother you when you're deer hunting?
   (CHECK ONE)
   _____ yes, very much
   _____ yes, but they bother me only slightly
   _____ no, they don't bother me at all

7a. Would bad weather prevent you from going on a planned weekend deer hunts? (CHECK ONE)
   _____ no
   _____ yes

7b. If you answered YES, place a check in front of the 2 weather conditions listed below which are most likely to prevent you from going.
   _____ Heavy Rains
   _____ Severe Cold
   _____ High Winds
   _____ Deep Snow
   _____ Impassable Forest or Access Roads
Appendix Table III. (Continued)

7c. Now, if you answered YES, place a check in front of the one weather condition which is least likely to prevent you from going.

- Heavy Rains
- Severe Cold
- Deep Snow
- High Winds
- Impassable Forest or Access Roads

8a. Is there any weather condition that would prevent you from going deer hunting on the FIRST or LAST day of the deer season? (CHECK ONE)

--- no
--- yes

8b. If you answered YES, please list below those weather conditions that would prevent you from going.

---

9a. Do you feel your chances of seeing or killing a deer are affected by weather conditions? (CHECK ONE)

--- no
--- yes

9b. If you answered YES, please check (✓) below the 2 WORST weather conditions for seeing or killing a deer.

- High Winds
- Heavy Rain
- Dry Forest Floor
- Unseasonably Warm and Sunny
- Clear Cold Day

9c. Now, please check (✓) below the 3 BEST conditions for seeing or killing a deer.

- Damp Forest Floor
- Drizzle
- Heavy Cloud Cover
- No Wind
- Moderate Temperatures (35° to 45°)
- Cold Temperatures (below 25°)

10. Would you please list below the worst weather conditions in which you personally have ever hunted deer.

---

---
11. If you could hunt under any weather conditions you wanted, what weather conditions would make up your ideal deer hunting day?

(Please check (✓) below, 4 weather conditions you would choose to make your ideal deer hunting day.)

(CHECK ONLY 4)

_____ warm temperatures  
_____ moderate temperatures  
_____ cold temperatures  
_____ no wind  
_____ damp forest floor (no snow)  
_____ moderate wind (not over 5 mph)

_____ light rain  
_____ overcast day (no rain)  
_____ clear and sunny  
_____ snow on ground  
_____ snow falling

12. Do you think weather affects the number of other people that will go deer hunting?

(CHECK ONE)

_____ no

_____ yes

If you answered YES, please list below the weather conditions you feel would prevent other hunters from going deer hunting.

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

13. Do you feel that weather conditions during a deer season can seriously affect the total number of deer killed during that season?

(CHECK ONE)

_____ no, I don't feel that weather influences the number of deer killed during a season.

_____ yes, I feel that weather conditions can seriously affect the total number of deer killed during the season.

_____ I really don't know whether weather has any affect or not on total kill.
Appendix Table IV. Present age and number of years hunted deer since 1960.

<table>
<thead>
<tr>
<th>Age class</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>7</td>
<td>--</td>
</tr>
<tr>
<td>0 - 19</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>20 - 29</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>30 - 39</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>40 - 49</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>50 - 59</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>60+</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>107</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Q#2 years hunted deer since 1960

<table>
<thead>
<tr>
<th>Years hunted deer</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>44</td>
<td>39</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Appendix Table V. Hunting group size and method of deer hunting most often used.

<table>
<thead>
<tr>
<th>Hunt with:</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Hunt alone</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>With a buddy</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>With 2-3 others</td>
<td>33</td>
<td>29</td>
</tr>
<tr>
<td>With 4 or more</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>114</td>
<td>100</td>
</tr>
</tbody>
</table>

Q#4 Method of hunting most often used.

<table>
<thead>
<tr>
<th>Hunting method:</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>2</td>
<td>--</td>
</tr>
<tr>
<td>Walking-stalking</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Still hunting-sitting</td>
<td>77</td>
<td>69</td>
</tr>
<tr>
<td>Organized drives</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>112</td>
<td>100</td>
</tr>
</tbody>
</table>
Appendix Table VI. Number of hunters that felt bad weather would prevent their going on a planned weekend hunt, weather conditions most likely to prevent their going, and least likely to prevent their going.

**Q#7a Would bad weather prevent a planned weekend deer hunt.**

<table>
<thead>
<tr>
<th>Prevent you from going:</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>No</td>
<td>51</td>
<td>45</td>
</tr>
<tr>
<td>Yes</td>
<td>62</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td><strong>113</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Q#7b Weather most likely to prevent your going.**

<table>
<thead>
<tr>
<th>Weather that would prevent hunting (If &quot;yes&quot; in Q#7a):</th>
<th># Hunters listing the weather cond.</th>
<th>% Hunters listing the weather cond.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy rain</td>
<td>46</td>
<td>74</td>
</tr>
<tr>
<td>Deep snow</td>
<td>39</td>
<td>63</td>
</tr>
<tr>
<td>Severe cold</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>High winds</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>Impassable forest roads</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><strong>124</strong></td>
<td><strong>200</strong></td>
</tr>
</tbody>
</table>

**Q#7c Weather conditions least likely to prevent your going.**

<table>
<thead>
<tr>
<th>Least likely to prevent hunting (If &quot;yes&quot; in Q#7a):</th>
<th># Hunters listing the weather cond.</th>
<th>% Hunters listing the weather cond.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe cold</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>Heavy rain</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>Impassable forest roads</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>High winds</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>Deep snow</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td><strong>62</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Appendix Table VII. Number of hunters which felt that bad weather would prevent their going hunting on first or last day of the season, and weather conditions most likely to prevent their going.

<table>
<thead>
<tr>
<th>Prevent you from going:</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>6</td>
<td>--</td>
</tr>
<tr>
<td>No</td>
<td>48</td>
<td>44</td>
</tr>
<tr>
<td>Yes</td>
<td>60</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>100</td>
</tr>
</tbody>
</table>

Q#8a Would bad weather prevent your hunting on first or last day?

Q#8b Weather most likely to prevent your going.

<table>
<thead>
<tr>
<th>Prevent your going (If &quot;yes&quot; in Q#8a):</th>
<th># Hunters listing the weather cond</th>
<th>% Hunters listing the weather cond.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy rain</td>
<td>41</td>
<td>68</td>
</tr>
<tr>
<td>Deep snow</td>
<td>38</td>
<td>63</td>
</tr>
<tr>
<td>Severe cold</td>
<td>24</td>
<td>40</td>
</tr>
<tr>
<td>High winds</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Bad roads</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Sleet-Ice</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td></td>
</tr>
</tbody>
</table>
Appendix Table VIII. Number of hunters that felt weather conditions affected their chances of seeing a deer, worst conditions, and best conditions for seeing deer.

<table>
<thead>
<tr>
<th>Chances are affected:</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not answering</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>No</td>
<td>21</td>
<td>19%</td>
</tr>
<tr>
<td>Yes</td>
<td>90</td>
<td>81%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Q#9a Are chances of seeing a deer affected by weather conditions.

<table>
<thead>
<tr>
<th>Weather condition (If &quot;yes&quot; in Q#9a):</th>
<th># Hunters listing the condition</th>
<th>% Hunters listing the condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High winds</td>
<td>71</td>
<td>79</td>
</tr>
<tr>
<td>Heavy rain</td>
<td>51</td>
<td>57</td>
</tr>
<tr>
<td>Dry forest floor</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>Unseasonably warm</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td><strong>Clear cold day</strong></td>
<td><strong>3</strong></td>
<td><strong>3</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>177</strong></td>
<td></td>
</tr>
</tbody>
</table>

Q#9b Two worst weather conditions for seeing deer.

Q#9c Three best weather conditions for seeing deer.

<table>
<thead>
<tr>
<th>Best conditions (If &quot;yes&quot; in Q#9a):</th>
<th># Hunters listing the condition</th>
<th>% Hunters listing the condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damp forest floor</td>
<td>81</td>
<td>90</td>
</tr>
<tr>
<td>No wind</td>
<td>71</td>
<td>79</td>
</tr>
<tr>
<td>Moderate temps. (35° to 45°)</td>
<td>63</td>
<td>70</td>
</tr>
<tr>
<td>Cold temps. (below 25°)</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Drizzle</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td><strong>Heavy cloud cover</strong></td>
<td><strong>15</strong></td>
<td><strong>17</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>263</strong></td>
<td></td>
</tr>
</tbody>
</table>
Appendix Table IX. Worst weather conditions in which respondents had personally ever hunted deer.

<table>
<thead>
<tr>
<th>Weather condition</th>
<th># Hunters listing the condition</th>
<th>% Hunters listing the condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe cold</td>
<td>64</td>
<td>57</td>
</tr>
<tr>
<td>Heavy rain</td>
<td>50</td>
<td>44</td>
</tr>
<tr>
<td>High winds</td>
<td>50</td>
<td>44</td>
</tr>
<tr>
<td>Heavy snow on ground</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Blowing snow</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Sleet</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Dry forest floor</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Warm temperatures</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Fog</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Heavy cloud cover</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix Table X. Weather conditions respondents felt would be ideal deer hunting weather.

<table>
<thead>
<tr>
<th>Weather condition:</th>
<th># Hunters listing the condition</th>
<th>% Hunters listing the condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>No wind</td>
<td>89</td>
<td>80</td>
</tr>
<tr>
<td>Damp forest floor</td>
<td>82</td>
<td>73</td>
</tr>
<tr>
<td>Moderate temps.</td>
<td>78</td>
<td>70</td>
</tr>
<tr>
<td>Overcast (no rain)</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>Clear and sunny</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td>Snow on ground</td>
<td>29</td>
<td>26</td>
</tr>
<tr>
<td>Moderate wind (&lt;5 mph)</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Warm temps.</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Cold temps.</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Light rain</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Snow falling</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix Table XI. Number of respondents that felt weather affects number of others that will go hunting, and affects the total deer kill for a season.

<table>
<thead>
<tr>
<th>Q#12 Do weather conditions affect number of others that will go hunting.</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will affect # of others:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not answering</td>
<td>8</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>106</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q#13 Do weather conditions affect the seasons total kill.</th>
<th># Hunters</th>
<th>% Hunters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affect total kill:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not answering</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Yes</td>
<td>78</td>
<td>71</td>
</tr>
<tr>
<td>Uncertain</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>
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CLIMATIC FACTORS
INFLUENCING HUNTER SIGHTINGS OF DEER
ON THE BROAD RUN RESEARCH AREA

by

Robert Lee Curtis, Jr.

ABSTRACT

Data collected on the Broad Run Area, 1964 through 1970, concerning the influence of weather variables on number of deer seen per day, number of deer seen per hunter per day and number of hunters per day were analyzed. Linear correlation and multiple linear regression analysis were used to determine significant relationships.

In the multiple regression analysis of deer seen per hunter per day, two weather variables, average daily temperature and total daily precipitation were found to be significant. The resulting $R^2$ was only .2726.

A single variable, number of hunters per day, was found to account for 54.16 percent of the variation in number of deer seen per day. The addition of average daily temperature, the only significant weather variable, increased the amount of variation explained by 2.90 percent.

Number of hunters was found to be a function primarily of year and day of the season.

Except for extreme or severe conditions, it was felt that weather did not significantly influence number of deer seen or number of hunters per day.
In addition to statistical analysis, the influence of weather factors on the deer hunter was examined by mailed questionnaire. Most hunters felt their chances of seeing or killing a deer were affected by prevailing weather and that the season's total kill is definitely influenced. Fifty percent of the respondents indicated that deep snow or heavy rain would prevent them from going hunting on either a planned weekend hunt or the first or last day of the season.