A 15-YEAR RESEARCH SUMMARY AND HUNTING HARVEST DATA EVALUATION OF THE BROAD RUN MANAGEMENT AREA

by

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INTRODUCTION

Man's activity has affected wildlife habitat and, therefore, wildlife populations for hundreds of years. In the past, the axe, cow, gun and flame have shifted favor to some wildlife species while depleting the numbers of, and making extinct, other species.

In the forests of precolonial eastern America 800 million acres of forested land provided a wealth of habitat for elk, bear, bison, beaver, turkey, grouse, and squirrel while rabbits, white-tailed deer and bobwhite quail, denizens of forest edges and clearings, were less prevalent (Reeves 1958a).

With the advent of the European settler, forests were leveled, paving the way for an agrarian society. Species like elk and bison, competiters with cattle for grassland, were crowded out of the Old Dominion by 1800 (Reeves 1958a).

Forest game was depleted during the 19th Century as laisse-faire activity by settlers and commercial entrepreneurs—activity such as unrestricted logging, clearing and swamp draining—destroyed much wildlife habitat. With the 20th Century, the concept of conservation of natural resources came to the forefront. Law enforcement put on the brakes to much indiscriminate harvesting. Also, techniques, such as stocking of native and exotic species, fire protection, planting of food patches, and creation of refuges, arose in an attempt to give game species a fighting chance for survival.

Subsequent to the setting aside of government lands for the preservation of our natural environment, the concept of "multiple use" arrived. Here, in addition to wood production, watershed protection,

and recreation, there arose wildlife production as a parallel objective across our forested lands.

Maintaining wildlife production, therefore, has been the reason-for-being for state and federal agencies assigned the task of wildlife conservation. Since the late 1930's, manipulation of forest-game habitat has been increasingly recognized as the best method of encouraging game animal production. Among practices improving forest habitat for various species are harvest cuttings, and seeding, planting, fertilizing and developing of clearings and water holes.

Do such wildlife and forestry practices significantly influence production of forest wildlife? This question poses the thrust of 15 years of experimental study at the 11,422-acre Broad Run Wildlife Research Area in Craig County, Virginia (also known as the Broad Run Management Area). A program of wildlife habitat evaluation was planned at the Broad Run study area in 1956. The following year the Virginia Commission of Game and Inland Fisheries, in cooperation with the U.S. Forest Service, undertook to develop the area, then known as the Cuba Wildlife Unit. The Virginia Cooperative Wildlife Research Unit began evaluating the management techniques to be used there. This unit was formed at the Virginia Polytechnic Institute in 1935 (the first such unit in the nation) to train men as professional wildlife biologists (Reeves 1958b).

The Virginia Unit recognized Broad Run as a fitting site for long-term studies which might uncover correlations between intensive management and wildlife productivity. The result was the instigation of a 10-year (later extended) non-replicated case history study designed to measure animal responses to various management practices on populations.

Since 1956, when the case-history study began, 17 wildlife graduate study projects have been conducted and 17 theses written in which Broad Run served as the research site. Data from this work form the bulk of this thesis. Other data include those gathered at the hunter check station relating to hunter pressure and success; number of game animals seen and harvested, and measurements of those animals killed. Vegetative and ecological succession studies have also been important areas of research. This thesis endeavored to synthesize all pertinent data, conclusions, evaluations, and recommendations incorporated in the 15 years of research at Broad Run, all with the specific objective of evaluating the impact of wildlife and forestry management practices on indigenous wildlife populations.

This synopsis of overall Broad Run research was designed to provide a compact, up-to-date summary to be analyzed not only by members of the U.S. Forest Service and Virginia Commission of Game and Inland Fisheries, whose organizations have invested much time and money throughout the years for the studies at Broad Run, but also by many biologists outside the state who have been interested in the project.

The summary was compiled at a time when further delay may have made the data too voluminous to be feasibly handled.

PROCEDURES

This thesis has been undertaken with 2 aims: to review and summarize literature directly related to wildlife research on the Broad Run Management Area from the project's inception in 1957; and to compile and organize hunter-harvest data on deer, turkey, squirrel, and ruffed grouse. These data were to be tested statistically to determine whether various wildlife and silvicultural practices affected the relative abundance of these species in the compartments so treated.

Theses Reviewed

Each of the 17 theses involving Broad Run Management Area research was first read cursorily to glean general subject matter and to determine how much subject matter would later be organized more succinctly. The investigator then re-read the theses with great care, reviewing the abstracts and summaries first, taking note of the most important conclusions. The results sections of the theses were then combed for even greater detail. A determination had to be made on how much detail was necessary to provide a meaningful synthesis. Peripheral information, such as was found in the methods and procedures sections, was sometimes necessary for inclusion in order to give continuity. The impact of many conclusions would not be apparent if they were presented out of context with what was trying to be determined. This was why this writer always specified the objectives of the thesis writer.

The conclusions were consecutively enumerated under each general category, or topic. This was done to reflect the general breadth of

scientific findings determined at Broad Run, under a certain category, during the 15 years.

The general categories were designated by secondary subheadings, as "browse studies", "mast", "songbirds", "foxes", "wildlife agricultural clearings", "deer", "hunter weather", "wild grapes", and "wild turkey". Sometimes the topics were limited to the work of one author. These topic headings best described the bulk of information gathered during 15 years. For instance, browse studies were not incorporated under "deer" because browse is also a turkey food, and browse (or mast) was the main topic under study by Whelan (1962) and Thompson (1962), with little or no mention made of deer.

The ennumerated conclusions fell into 2 groups--information of interest to any wildlife biologists (i.e. that minimum home range of the immature turkey at Broad Run was 425 acres prior to the hunting season and 552 acres during the hunting season), and information more provincial (Compartment C had the highest turkey density in the fall of 1962).

Data Compilation and Conclusions

This writer spent more than a month going through kill cards and tally sheets that recorded, in raw form, number of hunters, hunter-hours, and species seen and killed for each compartment on the management area. These data were subsequently compiled in tables which also included Hooper's (1967a) data of 1964-1966. Deer was the only game animal on which specific biological data were consistently gathered. This information, cited as "physical characteristics" was compiled and included in appendix tables.

Appendix tables were also used to record arithmetic data on total hunter hours, and total species seen/compartment for each year beginning from 1964, the year this information was first gathered by compartment. These tables also included a total average of hunter hours/species seen/compartment for the 9 years 1964-1972. These averages were included to give the reader a superfical idea of the differences between compartments. However, the analysis of variance test was used to determine if there were significantly more game animals seen in one compartment than another. The test was based on annual averages of each compartment of its hunter hours/animals seen (as opposed to adding 9 years of hunter hours for each compartment and dividing this by the total number of animals seen from 1964 through 1972).

Shortcomings in the mechanics of gathering harvesting data were noted and suggestions on how the data could be gathered more accurately were discussed in the recommendations. Appendix table data were also included to provide future students and researchers continuity of information.

GENERAL DESCRIPTION OF STUDY AREA

Ecology

Biome

Based on the proposition that each continental area has its own special flora, Good, in 1953, mapped the world into 5 biogeographical regions, or floristic kingdoms (Odum 1971). The North American continent (and Eurasia) is incorporated in the Boreal Region.

The Boreal Region in North America is further divided into biomes. Odum (1971:378) defined a biome as "the largest land community unit which it is convenient to recognize." A biome is characterized by a life form which is distributed uniformly as climatic climax vegetation. The Broad Run study area falls within the eastern Temperate Deciduous Forest biome, an area "with abundant and evenly distributed rainfall (30"-60") and moderate temperatures which exhibits a distinct seasonal pattern (Odum 1971:386)." Here, the climax life form is, of course, broad-leafed deciduous trees with conifers, chiefly pine, the subclimax.

Biotic Province

Whelan (1962) introduced Dice's (1943) concept of biotic provinces as applicable to the study area. Dice (1943:5) defines a biotic province as "a considerable geographical area over which the environmental complex produced by climate, topography, and soil is sufficiently uniform to permit the development of characteristic types of ecological association."

The study area falls within the Carolinian Biotic Province which in-

cludes that part of eastern United States called the temperate deciduous forest. Except for a small part of the southeastern coastal plain the entire state of Virginia is included in the Carolinian Biotic Province (Whelan 1962:37).

Smith (1966:338-339) stated the distinguishing characteristic of a biotic province to be a "continuous geographical area that contains ecological associations distinguishable from those of adjacent provinces, especially at the species and sub-species level."

Whelan (1962:17) pointed out that hardwood climax associations are different from place to place within the Ridge and Valley section of the Carolinian Province. On mountain slopes there is a prevalence of oaks. In mountain coves mixed mesophytic species (potential climax of the area) occur. In the mountain valley white oaks dominate.

The vegetation of the Ridge and Valley Province is typical of that found in the central forest region. In it the erstwhile oak-chestnut association has been changed to mostly oak (Whelan 1962:35).

Whelan (ibid.) described the Ridge and Valley Province forest types according to topograhical position as follows (all scientific names of trees and other vegetation are listed in Appendix Table I):

(1) Dry slope and ridge forest--chestnut oak, scarlet oak-bear oak, bear oak, and pitch pine-table mountain pine

(2) Moist slope and cove forests--northern red oak, cove-hardwood, yellow poplar, cove hemlock, white pine, chestnut, and white oak

(3) Valley floor forest--oak, with white oak most characteristic

Both Quillen (1959) and Seneca (1961) discussed the types of taxa to be found on slopes, coves, ravines, and flat places on the study area.

Perpendicular to the northeast-southwest main ridges are secondary ridges which run northwest and southeast. The western exposures, which receive the rays of the late afternoon sun and the prevailing westerly winds, have a thin soil, low in humus and low in relative humidity. The easterly slopes receive early morning sun rays and do not receive prevailing westerly winds. The soil here is thicker with humus and its humidity is higher (Seneca 1961).

Different slopes reflect different ecological conditions. Quillen (1959) described the steep southwestern slopes to be xeric, with an edaphic climax of a pitch pine and table mountain pine-bear oak association. Soil acidity on the slopes is pronounced. Common plants to be found are ericaceous (of the heath family) plants, such as blueberry, huckleberry, and mountain laurel.

The northeastern slopes are of poor soil, but more mesic than the southwestern slopes and composed of mixed oaks with northern red oak prominent (Quillen 1959). Seneca (1961) described the easterly slopes as supporting mostly an overstory type of mixed oak-pine composed of chestnut oak, scarlet and white oak, pitch pine, and Virginia pine. The understory was comparatively sparse (compared to the westerly slopes) and included flowering dogwood and witch hazel.

The sheltered coves contain the richest soil, having access to more moisture than the other sites (Quillen 1959). Therefore, coves are most productive, having an overstory of white oak, hickory, occasional white pine, tulip poplar, and northern red oak (Seneca 1961).

The ravines, with poorer soils, support an overstory of chestnut oak, scarlet oak, white oak, and hickory. The understory in both ravines

and coves include such taxa as Smilax spp., Vitas spp., witch hazel, flowering dogwood, and cucumber (ibid.).

The level areas, flats, have a mesic environment with an overstory type of Mixed Oak-White Oak (ibid., 19). "The flats vary in quality with intensity of past logging and fires," reported Quillen (1959:24). "The better flats exhibit mixed oaks with white oak predominant. The poorer sites in this category show mixed oak-pine association. The badly burned sections of this type have a dense understory of bear oak and laurel." The physiographic features, in descending order of productivity, are as follows: coves, flats, ravines, east slopes, west slopes.

Forest Cover Types

The eastern deciduous forest, in which the Broad Run area occurs, is subdivided into various climax forest community types called associations. An association, as defined by von Humboldt, is a kind of "plant community of definite composition, presenting a uniform physiognomy... (gross appearance of a kind of vegetation)...and growing in uniform habitat conditions (Daubenmire 1968:27)."

These associations, in forestry parlance, are called forest cover types. The Society of American Foresters (1954:2) defines a forest type as: "A descriptive term used to group stands of similar character as regards composition and development due to given ecological factors, by which they may be differentiated from other groups of stands." The normal species should form at least 50% of the composition.

There are 6 associations, or cover types, on the Broad Run study area. The Mixed Oak-Pine type closely resembles the S.A.F. Type 52

(Soc. Am. For. 1954:22), but the other 5 cover types are not standard types as defined by the Society of American Foresters in Forest Cover Types of North America. The study area was cover-mapped in 1958, before the 15-year study was initiated, by means of aerial photographs and photogrammetric techniques. Whelan (1962:15) checked the accuracy of the cover type map in the field and described and quantitatively reported the cover types as follows:

Type 1	Pine-Bear Oak (2,589 acres)	34.7%
Type 2	Virginia Pine	0.8
Type 3	Mixed Oak-Pine (1,413 acres)	18.9
Type 4	Mixed Oak-White Oak	8.1
Type 5	Cove Hardwood (2,481 acres) (oak, hickory, poplar, white pine)	33.3
Type 6	Chestnut Oak-Mixed Oak	2.8

Types 1, 3, and 5 comprise 6,482 acres, or 87% of the vegetation, while types 2, 4, and 6 are of such small contribution to the overall browse on the study area they were not sampled by Whelan because of the expense and time involved (Fig. 1).

Pine-Bear Oak (Type 1)—This forest cover occurs on the poorest sites on the study area. Steep shaly slopes, or sandstone shale slopes at high elevations with infertile shallow soil, and exposure to westerly prevailing winds and the warm afternoon sun results in a forest type dominated by species capable of surviving under xeric conditions, namely pine. The cover type appears to be the most homogeneous on the area.

Overstory—More than 75% of the type is composed of 3 dominant overstory species: pitch pine, scarlet oak, and black oak. Another common canopy tree is chestnut oak.

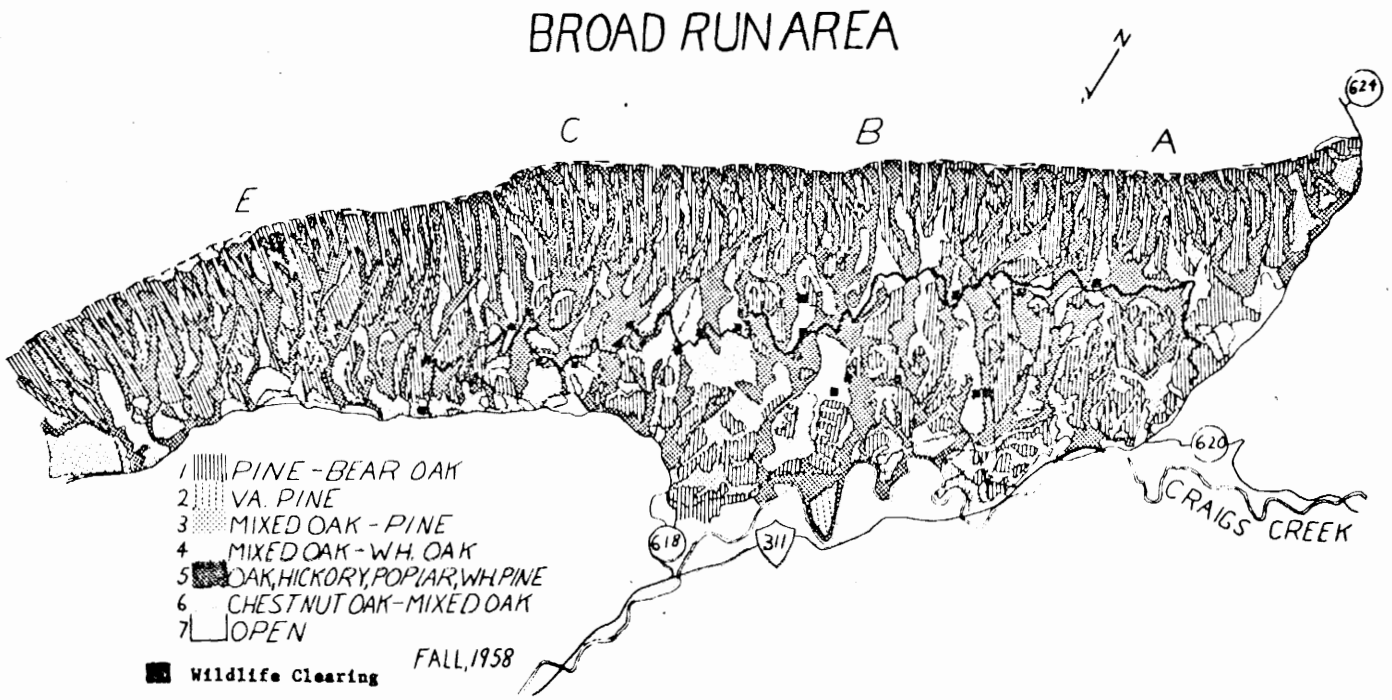

Fig. 1. Forest cover type map of the Broad Run Wildlife Management Area, Craig County, Virginia.

Understory—Some 30 woody species were collected from this cover type with blueberries, huckleberries, red oak, bear oak, and black gum comprising (on 2 series of 15 sampling units) 93%.

Mixed Oak-Pine (Type 3)—Stands of mixed oak and pine are found mainly on 2 types of terrain—the better stands at lower elevations, and often on sites with a small percent of slope to almost flat terrain. Small stands are sometimes found near the tops of easterly exposed slopes. Soils associated with better mixed oak-pine sites usually are colluvial soils, sometimes referred to as "slopewash".

Overstory—More than 90% of the type is made up of 4 dominant overstory species: scarlet oak, black oak, pitch pine, and white oak.

Understory—Some 35 species of woody plants collected indicated blueberries, huckleberries, black gum, sassafras, and red oak, comprising about 90% of the average cover.

Cove Hardwood (Type 5)—The oak, hickory, poplar, white pine forest type (mixed mesophytic) is typical of the flora in this cover. This type often extends a short distance up the easterly and northern exposed slope of a cove. Cover is divided into 2 categories according to elevation: (1) low moist areas, and (2) higher dry. Found on the higher dry and not on the lower moist areas are 3 species: striped maple, northern red oak, and sweet birch.

Overstory—Nearly 70% of this type is composed of 5 dominant overstory species: chestnut oak, scarlet oak, black oak, northern red oak, and white oak. Other dominants include Virginia pine, black gum, hickory, and red maple.

Understory—Some 57 species of woody species make up about 70% of

the average cover. The most prominent are blueberries, huckleberries, black gum, red oaks, and sassafras.

Patton (1963), in his browse study, made a close investigation of the Mixed Oak-Pine type, and determined the relative abundance and frequency of species in Compartments A and B with 49 half-acre sample units. White oak and scarlet oak were most abundant with 32% and 27%, respectively; frequency being 100% each. Pitch pine had a 96% frequency while sourwood frequency was 90% and third most abundant (8%).

Topography and Geology

Rocks and geological formation of the Broad Run Wildlife Research area evolved during the Paleozoic Era, 490 to 190 million years ago. Thick formations of shale, sandstone, and limestone were deposited on the area during the Devonian Period of about 300 million years ago. It was a time when seas spread over continents. During the 30-million-year Permian Period, about 200 million years ago, lands rose higher and higher. The Appalachian Mountains were folded as thick formations of rock were squeezed together during the shrinkage of the earth's surface. Because rock was being bent under such stress, it crumpled into great up-and-down folds which formed mountain ridges and valleys. This upheavel is termed the Appalachian Revolution (World Book Encyclopedia 1958).

Whelan (1962) discussed in great detail the physiography of the Broad Run area. The study area is in the Appalachian Highland, one of the 8 major physiographic regions in the United States. This region embraces 4 provinces extending from the Gulf Coastal Plain to the St. Lawrence River and from the Atlantic Coastal Plain to the Central Lowland.

They are the Piedmont and Blue Ridge Provinces, to the east, known as the "Older Appalachians," and the Appalachian Plateau and Ridge and Valley provinces to the west, known as the "New Appalachians" (Fenneman 1938). The study area is in the Ridge and Valley Province.

The Older Appalachian rocks (igneous and metamorphic) had been uplifted and eroded before the Newer Appalachians emerged from the sea. When they emerged during the Appalachian Revolution, the western part of the New Appalachians upraised in an almost horizontal position (the Plateau) while in the eastern margin 30-40,000 feet of stratified Paleozoic rock was subjected to intense folding and faulting. This crumpling eastern margin, the eastern limit of the Paleozoic interior seas before they emerged, became the Folded Appalachians--the Ridge and Valley Province. This province, extending from southern Tennessee north-eastward to eastern Pennsylvania, is a belt alternatively dominated and interspersed by valleys, ridges, and hills. The upheavel during the Appalachian Revolution resulted in mountains running on a general northeast-southwest line.

Fig. 2 illustrates the geological formation of the study area proper. This aspect was covered in detail by Quillen (1959), Seneca (1961), and Bachant (1963), using information gleaned from Edmundson (1950).

Bachant (1963:35) reported that "both North and Brush Mountains were formed by the Pulaski Fault. This anticlinal fold is interrupted by the Miller Fault which underthrust and interrupted the main ridge line. The Miller Fault is known as Cove Mountain and serves as a physical barrier between Broad Run Management Area and the Brush Mountain Control Area."

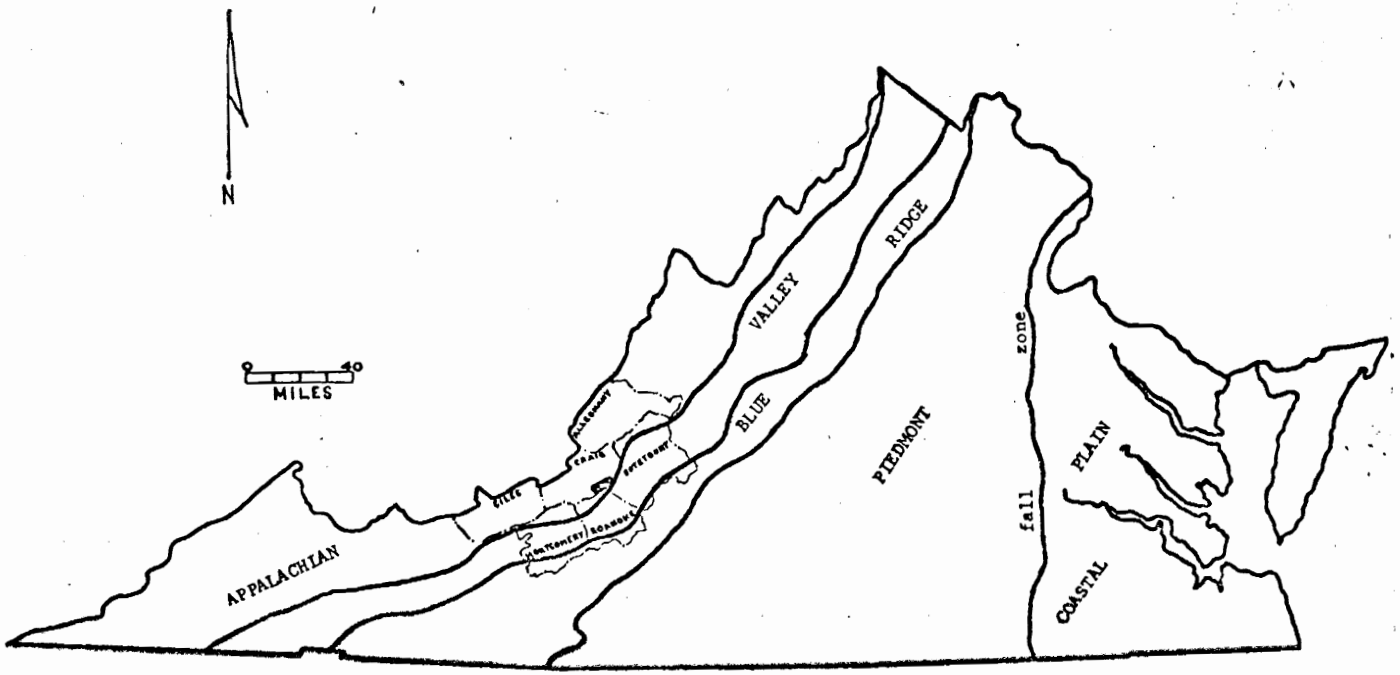

Fig. 2. The physiographic divisions of Virginia, showing the study area located in Craig County.

The parent rock of the Pulaski Fault is derived from 2 formations; Devonian Brallier shale on the lower slopes and Devonian Chemung formation on the ridges and upper slopes (ibid.).

The formations consist of embedded shale and sandstone. The shale of Chemung is softer than Brallier shale (Quillen 1959). "In a large portion of the area these shales are completely exposed or are overlain by only a thin layer of top soil," stated Trumbo (1963:19).

Miller Fault is an upheaval of Cambrian, Ordovician, and Silurian derived rocks. Geologically, the study area and Control Area, divided by Miller Fault, are identical (Seneca 1961).

Edaphics

The study area is included in Virginia's Appalachian Soil Province which is characterized by limestone valleys, mountains, and plateaus (Virginia Academy of Science 1950:350).

Neither the study area's Brallier nor Chemung shales and sandstones or conglomerate rock weather into rich soils. Hundley (1956:22-23) determined pH of 4.7 and 4.6 for 2 Brallier shale areas in adjacent Montgomery County. This fact is re-enforced by the presence on the study area of many ericaceous plants which are acid indicators. About 60% of the study area's soil is derived from Brallier shale (Whelan 1962).

Both Broad Run Management Area and Brush Mountain Control Area have dry, infertile soils of poor water-holding capacity and are representative of much of the forested land in southwestern Virginia. These soils favor growth of the chestnut-oak forest association.

The poor condition of the soil has been aggravated by early logging

practices and fire, but infertility is mostly caused by exposure of western slopes to prevailing winds and extended afternoon sun. These environmental factors have engendered dry, thin soils low in humus content. The slopes with eastern aspects, however, are relatively moist and have thicker soils with more humus because they receive only morning sun and no prevailing winds.

According to the Agronomy Department, Virginia Polytechnic Institute (1953), the 3 most common soil series of the study area are Montevalle (shale), Muskingum (sandstone), and Jefferson (sandstone-shale colluvial material). The Montevalle and Muskingum series belong to the great soil group called the lithosols and lithosolic gray-brown podzolic soils while the Jefferson series is of the yellow podzolic group.

Lithosols are shallow soils with no clearly expressed color profiles, consisting of freshly and imperfectly weathered masses of rock fragments. Lithosolic gray-brown podzolic soils have distinct color profiles, but lack depth and thickness of horizons characteristic of true zonal soils (soils characteristic of a large area or zone). Yellow podzolic soil is a zonal soil with a more distinct color profile and a thicker horizon than the other a soil types of the study area (Whelan 1962).

Jefferson soils are at lower elevations on the study area and limited in extent. These soils have developed in some narrow valleys and coves filled with colluvial matter (rock fragments and soil material at the base of steep slopes as the result of gravitational action). Very different soils are found on surrounding slopes and ridges (ibid.).

The study area lies in the gray-brown podzolic soil (a zonal

order of soils formed in cool-temperate, humid climates, under forests and typified by a highly-leached, whitish-gray A2 horizon) belt of the eastern United States (Kellog 1941). The soils, in general, are light colored, ranging from light gray to grayish-yellow and brown in the surface soils. Yellow, brown, or red prevail in the subsoil.

In 1962 the soils of the study area were classified by soil scientist Charles N. Judy of Fincastle, Virginia, according to great soil groups and their types as follows (Whelan 1962:42):

I. Lithosolic gray-brown podzolic soils: (1) Montevallo shaly silt loam; (2) Muskingum stony loam; (3) Lethew stony very fine sandy loam.

II. Yellow podzolic soils: (1) Jefferson fine sandy loam; (2) Jefferson stony fine sandy loam; (3) Leadvale shaly silt loam; (4) Leadvale-Jefferson complex.

III. Lithosols: (1) Rough stony land; (2) stony colluvium

Both the soils of the Cove Hardwood and Mixed Oak-Pine types were also analyzed and rated from high to low elevations, respectively, for fertility, minerals, organic matter, and pH as follows (ibid. 43-45):

I. Cove Hardwood soil: phosphorus (low), potassium (low to medium), calcium (very low to very high), magnesium (high), organic matter (high), and pH (low).

II. Mixed Oak-Pine soil: phosphorus (medium), potassium (medium to high), calcium (very low to low), magnesium (medium to high), organic matter (high), and pH (low).

"An increase in the percentage of organic matter at high elevations in both forest cover types is most likely the result of a reduced rate of decomposition due to cooler temperatures at the high elevations,"

reported Whelan (1962:42).

In the early 1960s the beginnings of a New Comprehensive Soil Classification system was proposed by the Soil Survey staff of the U.S. Department of Agriculture. Details of this classification are still being worked out. The system is based on soil properties rather than soil genesis (how soils formed or were thought to have been formed), as was the criteria under the old system. The study area belongs to the Ultisol soil order and the Ultsol suborder (Buckman 1969).

Ultisols (L. ultimus, "last") are described as usually moist soils, developing under warm climates with basic solutions less than 35%. Ultisols are formed on old land surfaces, generally under forest vegetation. Buckman et al. (1969:318) stated:

> "Most of the southeastern part of the United States falls in this order (ultisols). The moist, but not wet Ultisols, Udults, extend from the east coast...to end beyond the Mississippi River Valley and are the most extensive of soils in the humid Southeast."

Climate

Latitude, elevation, and topography are important climatic factors. At Broad Run the elevation varies from 1,500 feet above sea level along Craig Creek to 3,100 feet along the ridge of North Mountain. Approximate means elevation is 2,300 feet. Both treatment and control areas receive westerly prevailing winds.

Whelan (1962) and Curtis (1971) obtained climatic data recorded at the weather station at Catawba Sanitorium, Roanoke County, situated 3 miles west of the study area across North Mountain. The data were compiled from U.S. Weather Bureau publications "Climatic Summary of the

United States," United States Department of Commerce, Washington, D.C., and from the Virginia Polytechnic Institute and State University's Cooperative Extension Service publication "A Handbook of Agronomy," Virginia Polytechnic Institute and State University, Blacksburg, Virginia. The most pertinent weather data at Broad Run, based on 50 years of record, were as follows:

(1) Annual mean temperature of 54.5° F.

(2) Average date for first killing frost, October 21; average date last killing frost, April 22; average length of growing season (consecutive days without killing frost), 181 days

(3) Mean annual precipitation, distributed unevenly during the year, 42.50"; annual snowfall average of 18.30", mostly during January and February

Curtis (1971:7) obtained sky cover data from the official U.S. Weather Bureau Station in Woodrum Field, Roanoke, Virginia (elevation 1149, which is situated 25 miles southwest of the study area:

> "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."

SPECIFIC DESCRIPTION OF STUDY AREA

Location

The 11,422-acre Broad Run Wildlife Research Area, part of the Newcastle Ranger District of the Jefferson National Forest, is located in southeastern Craig County about 5 air miles south of Newcastle and about 25 air miles northwest of Roanoke, Virginia. The management area is situated on the southwestern side of North Mountain, its western boundary set off by State Route 311. The 2,013-acre Control Area, situated on the southwestern side of Brush Mountain, is 2 air miles to the southwest of the management area. It is separated physiographically from the study area by Miller Fault.

Management Practices

Compartmentization

In accordance with the basic project plan, the Broad Run Management Area was subdivided into 4 compartments of 2,000 acres each. The compartments are A, B, C, and E. Compartment E has been devoted to a herbicidal project. All of the compartments are similar in size, geographical origin, soils, condition of watershed, slope, elevation, topography, exposure, logging, cover types, and fire history (Quillen 1959).

Each compartment has been treated so each would reflect the effects of wildlife populations resulting from timber cuttings, timber stand improvement (TSI) practices, and the installation of forest-wildlife practices. The general treatment pattern is as follows (Quillen 1959):

Compartment A—Timber sales, TSI operations (2,550 acres)

Compartment B—Timber sales, TSI operations, development of agricultural clearings and water hole improvements for wildlife (2,858 acres)

Compartment C—Development of agricultural clearings and water hole improvements, with no forestry practices (2,037 acres)

Compartment D (Brush Mountain Control Area)—neither wildlife habitat manipulation, nor forest management of any kind (2,013 acres)

Transect Lines

Transect lines were established in each of the 3 management and one herbicidal compartment of the research area. One transect line was set up in the Brush Mountain Control compartment. These lines have been used for collection of data on deer pellet group counts, grouse flushing counts, squirrel leaf-nest counts, typing overstory for cover mapping, mast inventory, and sampling of timber types for species composition and diameter sizes.

These transect lines originated from a Forest Service boundary corner at the lower southwest corner of each compartment; traversing the compartment at an azimuth of 117° to the upper-northeast compartment corner. The transect lines run diagonally to the contours to provide a representative sample to the area.

After transect lines were set up and chained for length, they were permanently marked by a blaze line painted blue. Changes in terrain and cover types were recorded as distances on the line from the starting point. Permanent sampling stations were set up and marked at 10 chain intervals (Quillen 1959:36-37).

Agricultural Clearings and Water Holes

There are 23 agricultural clearings and 10 water holes in the Broad Run Management Area, all of which were completed in 1957. The clearings total 31.7 acres and vary in size from 0.5 to 3.3 acres (averaging 1.3 acres). The water holes range in size from about 15' x 15' to 60' x 30' and in depth from 2' to 5'.

Agricultural clearings and water holes comprise 5.7% of the land area in Compartment B and 5.5% in Compartment C. There are 4 water holes, or one water hole/714 acres in Compartment B, and 6 water holes, or 1/340 acres, in Compartment C. There are 13 clearings, or 1/200 acres (5.8% of the total area) in Compartment B, and 10 clearings, or 1/204 acres (5.1% of the total area) in Compartment C (Fig. 3).

The clearing sites, selected from flat areas containing relatively poor stands of timber, were bulldozed, fertilized, and seeded with Kentucky bluegrass, white Dutch clover, and Kenland clover. Wheat and rye grains were sown at a rate of one bushel/acre. Mast and fruit trees—sawtooth oak, English dogwood, apple, and honey locust—were planted on the periphery of some clearings.

Because the research program was imposed on the developed area, 2 clearings were originally included in Compartment A, but the clearings have now reverted to brush and early succession (McGinnes 1972: pers. comm.). Fig. 3 includes the original 25 clearings.

In the 15 years since the clearings were made, game managers have continued to rejuvenate them. About 1/3 of each clearing is seeded every 3 to 6 years rotationally. In some cases brush has been allowed to grow

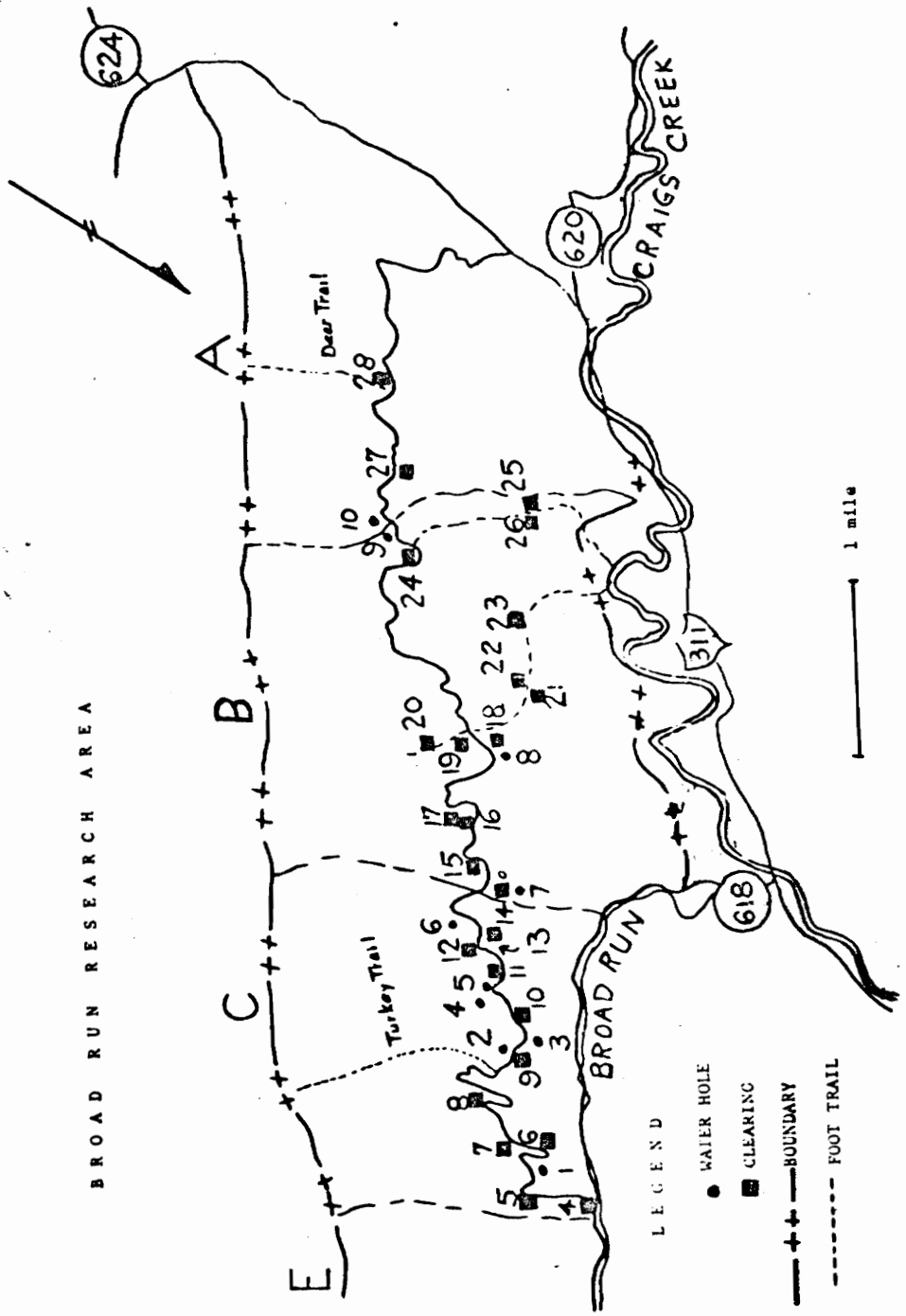

Fig. 3. Compartmentization of Broad Run Wildlife Research Area.

up on the peripheries of clearings considered too large. Prior to spring reseedings, portions of the clearings were disced and fertilized. The clearings were reseeded with ladino and white Dutch clover, both of which persist for about 3 years. Also planted was a mixture containing such annuals as millet, rape, soybeans, cowpeas, and lespedeza. Clover was also put in the mixture so it would emerge after the annuals disappeared. During the last 5 years autumn olive has been planted on the edges of some of the clearings. Chestnut and apple trees have also been planted on clearing edges in recent years, but have not done well. Signs and sightings have confirmed that these plantings have been used by deer and turkey for food (Guthrie 1972: pers. comm.).

Pond sites were situated in seeps, where sedges and/or rushes grew. Sites were picked where clay would provide a relatively impervious substratum.

The water holes were built to supply water during dry periods of summer and fall. In the summer of 1958, 7 water hole edges were seeded to Kentucky 31 fescue and Italian ryegrass and multched (Quillen 1959). Since this time water holes have received no maintenance. Although they get low during dry periods, the ponds have continued to remain at sufficient depths to furnish water for game (Guthrie 1972: pers. comm.).

Access Road

In August 1957 a 9¼-mile access road crossing the Broad Run study area was completed. It serves for logging, suppression of fire, and hunter access. The road has gates at each end for controlling hunter traffic (Quillen 1959).

Silviculture

Timber cutting and timber stand improvement were undertaken at the Broad Run Wildlife Research Area from 1959 through 1964 (Table 1). Cuts, restricted to Compartments A and B, were performed according to normal U.S. Forest Service operating procedures. Of the 4,900 acres available for forest management in these compartments, only 1,000 acres were operable. Inaccessible areas and roads made up 945 acres in Compartment A and 815 acres in Compartment B (Seneca 1961).

According to Seneca (1961), the expected cut from these 1,000 acres was to be 205 M.B.F. (thousand board feet) of sawtimber and 5,600 cords of pulpwood. All accessible areas within the 2 compartments were to be treated as similar as possible by acreage and cover type. About 200 acres were to have been cut a year.

During the 6-year span beginning in 1959, actual acres cut totaled 973—11 cuts in Compartment A totaling 470 acres, and 14 cuts in B totaling 503 acres (Table 1). The yield in sawtimber totaled 224.4 M.B.F., nearly 20 M.B.F. more than predicted, while cords of pulpwood cut totaled 8022, about 2400 more cords than projected. The acreage cut each year varied widely. In 1959, 121 acres were treated; in 1960, 55 acres; in 1961, 77 acres; in 1962, 93 acres; in 1963, 105 acres; and in 1964, 522 acres.

A grand total of 4131.2 M.B.F. were cut at Broad Run. Hardwood pulp provided 83% of this total while pine pulp comprised 13%; pine sawtimber 2% and mixed oak and yellow poplar-white oak-red oak each comprised nearly 1% of the total board feet cut.

Table 1. Timber sales record, Broad Run Wildlife Research Area, Jefferson National Forest, Newcastle District, 1959-1964.

Year	Compartment	Acres	Sawtimber M board feet Hardwood	Sawtimber M board feet Pine	Number of cords Hardwood	Number of cords Pine	Total M board feet
1959	A	62*	14.3	2.2	228	13	137.0
	B	15*	—	—	197	3	100.0
	B	44*	—	—	242	68	119.5
1960	A	10*	—	—	123	8	73.5
	A	19	—	—	194	—	97.0
	B	22*	—	—	281	—	140.5
	B	4*	—	—	52	—	26.0
1961	A	9*	—	—	42	—	22.5
	B	68*	7.3	29.8	364	145	291.6
1962	A	93	5.7	3.5	337	17	186.4
1963	A	105*	16.3	12.8	401	96	277.6
1964	A	38	—	—	40	201	120.5
	A	85	—	—	682	244	463.0
	A	21	9.0	2.0	82	—	52.0
	A	9	—	—	58	—	29.0
	A	19	—	—	86	15	50.5
	B	120	17.8	25.3	472	178	368.1
	B	23	—	—	241	13	127.0
	B	15	—	—	109	31	70.0
	B	10	—	—	75	—	37.5
	B	16	—	—	212	—	106.0
	B	47	—	—	470	—	235.0
	B	51	—	—	776	32	404.0
	B	21	—	—	408	—	204.0
	B	47	—	—	786	—	393.0
Total		973	70.4	154.0	6958	1064	4131.2
			224.4		8022		

*intermediate cuts

On TSI everything was cut down to 2" d.b.h. level with the ground. For clearcuts mature stands had to be more than 100 years old. Some 358 acres represented intermediate cuts (Todd 1972, pers. comm.).

"In the intermediate cuts we removed, or killed off, all trees competing with desired crop trees," Todd stated. "The objective is to get a faster growing merchantible stand." The intermediate sections are being cut on an 80-year rotation.

Todd admitted there had been no definite rules established for timber cutting at Broad Run. Nearly all cutover areas are adjacent the road (Fig. 4).

"We did this for the simple reason that the local loggers were more apt to buy these areas because they were so accessible," Todd said.

The Forest Service personnel at Newcastle set the boundaries to the sections that were to be treated and local loggers themselves actually cut the timber. Stream channels were not protected.

"Under our present guidelines, we wouldn't have cut over the stream channels since doing so can damage the watershed," Todd noted. "Also, if we had it to do over, the cuts would have been spaced differently, dispersed more into the interior. Now our guidelines call for leaving protection along the streams, providing timber strips to grow on the banks."

Todd forsees the Forest Service doing more silvicultural work at Broad Run, from 1974 to 1984. "There will possibly be work done on the cutover areas and some release work," he said.

Todd said 244 acres of the clearcut areas were planted in white and shortleaf pine. Nearly all of the replanting was done in Compartment B. About 3 acres were replanted in Compartment A.

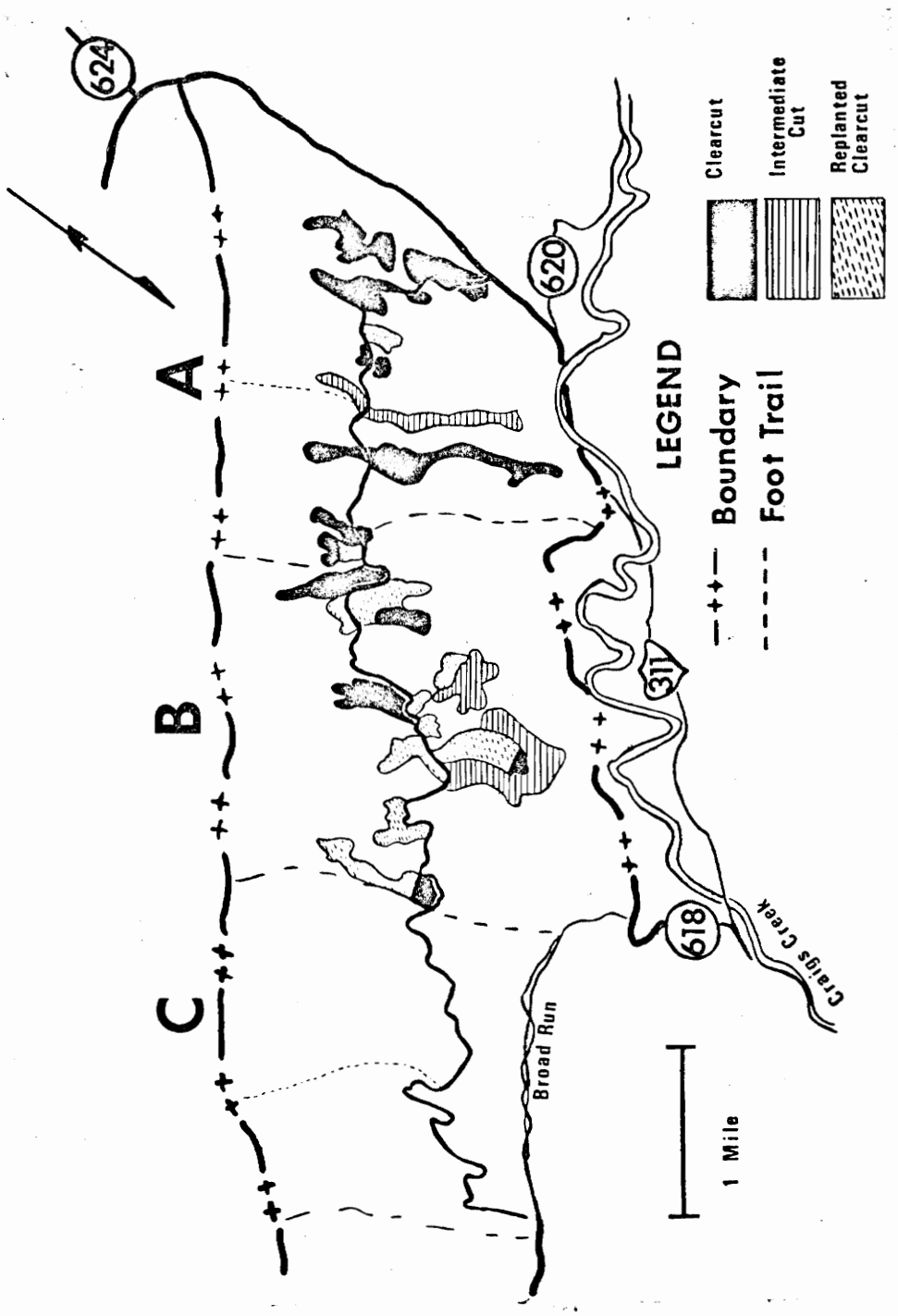

Fig. 4. Cutover sections of the Broad Run Wildlife Research Area.

Miscellaneous Management

No special law enforcement or regulatory steps have been undertaken at Broad Run or Brush Mountain Control Area. No steps have been taken to provide artifical food or cover in either area (Guthrie 1972, pers. comm.). Dog control was practiced to a minimal degree several years ago, but no such control now exists (McGinnes 1972, pers. comm.).

History

Fires and Logging

Fire and logging history of the study area was thoroughly covered by Quillen (1959), Seneca (1961), and Whelan (1962). A thumbnail history of logging, as applicable to the study area, was presented by Whelan (1962:36):

> "The peak of the lumbering industry in southern United States occurred about 1909. After that time a gradual decline began and has continued until present. Nearly all the large-scale timber cutting operations were completed by 1930. Portable sawmills became very active after 1930; these sawmills, capable of operating profitably in small timber, began cutting economically immature trees. The final result of the early "high-grading" timber operations followed by the cutting of immature trees has been the reduction of many acres of forest land to a low level of productivity. Repeated burnings of cutover forest land to increase the amount of livestock forage has also contributed greatly to the deteriorated condition of today's forests; especially our eastern deciduous forest."

Craig County, in which the study area is situated, was high-graded at the turn of the century and most of the merchantable timber was removed between 1900-1915, according to Wooley (1940).

The lack of fire protection as well as poor silvicultural practices resulted in frequent fires following logging operations during the first

third of this century. The worst recorded fire broke out during the dry summer of 1930 when almost all the study and Control areas were burned (Quillen 1959).

Both North and Brush Mountain areas came under Forest Service protection in 1935. The first purchase in the Broad Run unit was made in 1936 and in the Control unit in 1937 (Quillen 1959). No fire of any serious consequence occurred from 1930 to 1935.

The first 2 fires of consequence on the study and Control areas since 1935 were recorded by Quillen (1959):

1945—5 acres near Route 211 in Compartment 11-A, Morganville (just west of Route 311; access road entrance).

1958—One acre near Route 311 in Compartment 11-A, ½-mile east from the start of transect line 11-A.

1963—On April 21 the upper slopes of North Mountain in Compartment A and a small portion of Compartment B were burned (Todd 1972, pers. comm.). The fire burned 1700 acres on the back side of North Mountain and burned over the crest into the study area for a mile. The fire consumed relatively few acres, perhaps 100 acres, or less (McGinnes 1973, pers. comm.).

Timber Sales and TSI (Prior to 1959)

According to Quillen (1959), merchantable saw timber was harvested nearly as fast as it was produced before the Broad Run study area came under Forest Service jurisdiction in 1935.

"The pine pulpwood market started around 1936; the hardwood pulp market did not open until about 1943 in this area," Quillen (1959:62)

noted.

Prior to 1959 all cutting in the study area (totaling 209.5 M.B.F.) took place in Compartment B. Some 73.5 M.B.F. were cut from 2 areas in 1952; the remainder cut out of 3 areas in 1955. Hard pine cuts totaled 91.5 M.B.F.; white oak, 53 M.B.F.; mixed oak, 38 M.B.F., and white pine, 27 M.B.F. Total acreage cut during these 2 years was 248 M.B.F. (Quillen 1959).

Deer

Prior to 1938, deer on the Broad Run study area were though to be descendants either of native stock or of deer that had crossed North Mountain, after the Fort Lewis release of 1928 in Roanoke County.

Quillen (1959) stated one cabin owner on Craig Creek, who lived adjacent the study area, reported there were a few deer near the study area in 1933. Woolley (1940) reported native deer still at North Mountain in 1937.

According to Woolley (1940), the deer season was closed in Craig County for 5 years beginning in 1938. Until then Craig had been the only county west of the Blue Ridge to allow deer hunting with dogs.

In 1938 deer stocking operations began in Craig County. No deer had ever been stocked on the study area. In September 1938 3 deer were released on the Barbours Creek area, in the northwestern section of the county, about 7 miles northwest of Newcastle. In February 1939 20 Michigan deer were released in this wildlife area (Woolley 1940). Woolley (1940) received reports from the District Ranger, Game Warden and several local woodsmen who estimated the county deer herd in 1939 to be be-

tween 75 and 100 animals. Woolley (1940) estimated about half these deer were on the north side of Brush, North, and Lick Mountains, and were scattered in the coves and hollows of all these mountains. All these deer were thought to have emanated from the Fort Lewis release.

The 5-year closed season of 1938 was extended to 1946, at which time a 2-day season began.

Woolley (1940) noted Craig County's deer range to be the best he had encountered. Seneca (1961:17) wrote:

> "Because the area was composed of sprout and seedling growth following logging operations and repeated burnings, deer increased until the late 1940s. Then illegal killings of deer prevailed and vast numbers...on the study area were slaughtered. The drain on the population continued until members were reduced to about their present level."

The deer population in 1957 was estimated at one animal/100 acres, or about 75 to 80 head on the study area (Hooper 1967a). Using 1958 fall and winter pellet group counts within the agricultural clearings, Quillen (1959) estimated the Broad Run population to be about 130 animals, but he thought this to be too large.

Seneca (1961) estimated the management area deer population to be 117 ± 48. This estimate was based on winter 1961 pellet group counts.

"Although specific data are wanting," reported Hooper (1967a), "those of us familiar with the area feel that increases in herd size have been small. Dogs and poaching are thought to be rather serious problems and may be factors limiting deer populations."

Quillen (1959) found 9 illegal kills in one winter. Seneca (1961) found that 40% of the known kills from 1957-1960 were illegal. Best estimate of deer herd trends is hunter-pressure data (Appendix Table

II).

Since 1957, deer hunting has been allowed on the research area. From 1957-1963, there was a one-week season; from 1964 to the present, a 2-week season has existed. During this span 9,088 hunter-visits have resulted in 203 deer being harvested (Appendix Table II).

Turkey

A small turkey population has always existed on North, Cove, and Brush Mountains (Bachant 1963). Mosby and Handley (1943) were also of this opinion. Because of repeated burnings and heavy logging, habitat on the study area, until the last 10 years, has not been favorable for wild turkeys. What may have been the reasons for small early turkey populations? The study area has never been considered optimum turkey range. Poor soils have meant below-average mast crops and, 15 years ago, most of the trees on the study area were in the young pole stage (Quillen, 1959).

The turkey population was estimated to be between 7 and 22 birds in a single flock during the winter of 1957-58 (Quillen 1959:99). Reported McGinnes and Ripley (1962:171):

> "By June 1958, we had accurate records on 4 broods consisting of five hens and 26 poults. On September 17, 1958, 47 different turkeys were counted; we are certain that by late fall 1958 there were no less than 28 birds on the area. During the summer of 1959, we again observed 4 broods, but by 1960 there was a sharp increase, and no less than 11 broods were observed using the Broad Run area."

Seneca (1961) estimated the 1960 fall population to be between 100 and 125 birds. He reported turkeys used both agricultural clearings and waterholes. His population estimate was based on broods observed (11)

and estimated adult:immature ratio at 1:8.8. Gobbling counts also increased from 2 calls along the census route in 1956 to 9 in 1960.

Sight observation data from 1957 to 1960 indicated a ten-fold increase in the wild turkey population on the study area.

"The estimated fall population of 50 birds represents a decrease from the 1960 population estimate," wrote Bachant (1963). "The population on the Control Area apparently has remained stable."

Bachant (1963) estimated turkey densities by compartments. No attempts had been made up to this time to record the distribution of gobbling males in the study area. He estimated average cumulative summer range for family flocks at about 500 acres. Snow track counts showed estimated average range of 4 family flocks to be about 1700 acres in 1962. Total estimated population on the research area in 1962 averaged one bird/170 acres. Bachant (1963) opined harassment by dogs and poaching pressure perhaps to be the two most important limiting factors influencing the area's population. However, he said, increased protection was partially responsible for the increase in turkey population.

Hooper (1967a) believed turkey distribution had changed little from 1963 to 1967:

> "The significance of this is that much of the cutting (of timber) has been completed since Bachant's work in 1962. In addition, my estimate of the 1966 turkey population (about 100) agrees with earlier estimates. Gobbler counts and gobbler territory distribution has also remained stable since 1962...The turkey population has increased greatly since 1957...The actual effect of clearcutting on turkeys is not known, but it's my opinion that distribution has not changed drastically and numbers have at least maintained at the level when less than half of the cutting on the area was completed."

Land-Use Farming

Like most of the southwestern Appalachians, North and Brush mountains have had small mountain homesteads at the heads of the coves and on the main ridges. While there are no remains of homesteads within the study area, remnants of rock walls and stone piles indicate old fields. Today, agricultural lands border the study area only in the valley bottoms (Bachant 1963).

HUNTING SEASONS, CRAIG COUNTY-BROAD RUN

Operation and Facilities

To enable wildlife biologists to get a handle on game populations for research study and to provide hunters recreational opportunity, the Broad Run Management Area and Brush Mountain Control Area were opened to annual hunting beginning in November 1957.

To implement this phase of the study program, 2 problems were obvious at the outset: one, the handling of hunter access into the area, and, 2, devising means of obtaining from hunters accurate information on the type and number of game observed, and hunting pressure and success.

The 9-mile road through the management area has been the primary means of access for hunters into the Broad Run area. The road was completed 3 months before the 1957 deer season opened. However, during the 1957 and 1958 seasons the new access road was closed to private vehicles (Seneca 1961). The new road needed time to settle. Precipitation, at that time, had made it impassable for ordinary vehicles. Quillen (1959) reported 1.21" of rain during the 6-day season in 1957 and .14" fell on opening day of the 1958 season. During these seasons 2 special mobile runs each day took hunters (in vehicles with 4-wheel drive) into the area at 5:00 A.M. and brought them and their game out at 7:00 P.M. These special mobile runs were supplemented by regularly scheduled mobile runs through Broad Run and to the Brush Mountain area.

Although these regularly scheduled mobile runs were one source of hunter contact each hunting season (until they were abandoned after 1963), the principal means of collecting hunter data has been the access road

check station, established in 1958 at the McAfee Gap end of the Broad Run area. The check station cabin is located on the access road, about 3/4 of a mile from Virginia Route 311. In 1964, with the first of the 2-week seasons, an additional facility to the cabin aided living and working conditions for operators.

Since 1959, all hunters entering and leaving the area by the access road have been processed at the main contact station. The operation of the station has been a cooperative effort shared by U.S. Forest Service wildlife biologists, Virginia Cooperative Wildlife Research Unit personnel, Game Commission biologists, and Virginia Polytechnic Institute and State University graduate students. The check station has operated each day of each season, either from the arrival of the first hunter, or from 6:00 A.M. until 7:00 P.M., or until the departure of the last hunter.

Because the gate at the north end of the access road--the Broad Run Creek road gate--has remained closed each hunting season, most hunters visiting Broad Run have had to enter and exit past the check station. This practice has helped insure that data from every hunter were obtained, thus minimizing the possibility of error in the hunter survey.

Shortcomings have existed in these methods of obtaining data. The check station and mobile run data collection process has not provided information from hunters who gained access to the study area on foot by way of Broad Run Creek Road, or from private land bordering the lower elevation of the study area. Bachant (1963), for instance, stated that 5 of the 9 deer killed on the study area in 1962 had been removed by hunters who used these unattended routes. (Data, however, were later collected on these animals from local game checking stations.)

"The number of hunters who gain entrance into the area in the above manner is unknown, but is believed to constitute less than 25 percent of the local number of hunters on the area," stated Seneca (1961:78).

McGinnes (1972 pers. comm.) felt the problem of unchecked hunters is not as great now as it once was. "There used to be local people who would drive jeeps around the closed gate near the Creek road, but this no longer happens," he said. "Also, we no longer have as much pressure from the bottom (entering from private land) any more. Nearly all hunters now use the access road."

Seneca (1961) noted information on game killed on any part of the management area, if not collected at the main checking station, could be obtained at a local state checking station. McGinnes (1972 pers. comm.) said such data used to be obtained from Abbott's store on Route 311.

Another possible weakness in data gathering may have been the mobile runs. On each day of the deer season, from 1957-1963, mobile runs were carried out once daily, on a prescribed schedule, through the management and control areas. These runs checked on pressure and success of those hunters who hunted Brush Mountain and Broad Run by routes other than ones past the main check station. Standard pressure and success cards were distributed with a map of respective areas, a pencil for filling out the card, and a tack for attaching the card to a conspicuous post or tree. This material was either given to the hunter personally, or put under the windshield wiper of his automobile. A record was kept of where the cards were distributed and they were picked up on the mobile run the next day (Quillen 1959).

Bachant (1963) indicated a high percentage of card returns in 1962,

but only 2 cards were issued because of flooding in the Broad Run Valley and little hunter pressure on the Control Area. The largest number of cards (39) ever distributed on the Mobile Runs occurred the last year of their issuance, 1963. The reasons were given to be "the result of clear weather and passable road conditions (Virginia Cooperative Wildlife Research Unit 1963:16)."

The daily mobile run began at 10:00 A.M. each day and cards were distributed to hunters or parked cars along Virginia Routes 618, 621, and 620 (bordering Brush Mountain), and west on Routes 311, and 624 (Fig. 3). Quillen (1959) noted there was greater efficiency in obtaining hunter data information from the main contact station than from the mobile runs. He said best results in data gathering came from personal interviews with hunters. Seneca (1961) concurred.

"Reliance on the hunter to supply the data and leave it in a conspicuous place will not give the desired degree of accurate returns," Quillen (1959:132) concluded.

After 7 seasons only 68% of the hunter pressure and success cards distributed on the mobile runs had been returned (Table 2). This may have been one reason why the mobile runs were discarded after the 1963 season. "There just was not enough hunting pressure to merit the effort of making these runs," McGinnes (1972 pers. comm.) stated.

Another flaw in obtaining hunter information has been in data recording.

Recording The Data

During the 16 years of hunting on the management and control areas,

Table 2. Percentage of returns from distribution of hunter pressure and success cards collected at Broad Run Management Area and Brush Mountain Control Area, 1957-1963.

Year	Means of dispersal	Number Distributed	Number Returned	Percent Returned
1957*	Broad Run Contact Sta.	10	9	90
	Broad Run Mobile Run	11	8	73
	Brush Mtn. Mobile Run	2	0	0
1958*	Broad Run Contact Sta.	141	141	100
	Broad Run Mobile Run	27	12	44
	Brush Mtn. Mobile Run	4	4	100
1959**	Broad Run Contact Sta.	119	119	100
	Broad Run Mobile Run	10	8	80
	Brush Mtn. Mobile Run	1	1	100
1960**	Broad Run Contact Sta.	149	149	100
	Broad Run Mobile Run	22	16	73
	Brush Mtn. Mobile Run	1	1	100
1961***	Broad Run Contact Sta.	122	122	100
	Broad Run Mobile Run	13	11	85
	Brush Mtn. Mobile Run	1	1	100
1962***	Broad Run Contact Sta.	331	331	100
	Broad Run Mobile Run	1	1	100
	Brush Mtn. Mobile Run	1	1	100
1963#	Broad Run Contact Sta.	187	186	99
	Broad Run Mobile Run	17	13	76
	Brush Mtn. Mobile Run	19	10	53
All Years	Broad Run Contact Sta.	1059	1057	99
	Broad Run Mobile Run	101	69	68
	Brush Mtn. Mobile Run	29	18	62

* Data taken from Quillen (1959:134)
** Data taken from Seneca (1961:78)
*** Data taken from Bachant (1963:76)
\# Data taken from Virginia Cooperative Wildlife Research Unit (1963:17)

certain hunter information has been considered essential for research analysis. These data have tried to help answer the following questions: What game exists? Are the game populations increasing, decreasing, or stable? What has been the hunting pressure and its effect on these game populations? Also, most important, have wildlife management and/or silvicultural practices affected game populations, and, if so, in what way? Information needed to help answer these questions has depended on quantitative eye witness reports from hunters about game seen, time spent seeking game (hunting pressure) and harvesting success.

During the first 2 seasons, 1957 and 1958, colored $4\frac{1}{4}$ x $5\frac{1}{2}$ pressure and success cards, and blue kill cards (Figs. 5 and 6) were used to collect information. A pressure and success card was kept on each hunting party entering Broad Run by way of the contact station. Recorded on the card when the party entered were number in the party, time entered, the date, and vehicle license number. As the party left the area data on hours hunted, game seen, and game killed were recorded and filed.

These cards were issued in 3 colors—green, for use in Broad Run only; yellow, for use in the Brush Mountain Control Area, scheduled run only; and brown, for general distribution in either of the areas at any time other than the above mentioned. A blue kill card was filled out for each game animal killed, and information recorded, such as age and sex, for all game species and, for deer, number of antler points, beam diameters, tarsus length, and female reproductive tracts. Crops of grouse and quail, and wings of grouse and gizzards of quail were collected and recorded (Quillen 1959).

During the last 4 years sex and age-of-deer information continued

Pressure and Success

Area _____ Date _____ Card No. _____

Number of hunters in party _____

Number of hours hunted _____

GAME SEEN - Numbers

Deer _____

Grouse _____

Squirrel _____

Rabbit _____

Quail _____

Turkey _____

Bear _____

Fox _____

Bobcat _____

Dog _____

Other _____

GAME KILLED - Numbers

Deer _____

Grouse _____

Squirrel _____

Rabbit _____

Quail _____

Other _____

VCWRU Form #3

Fig. 5. Hunting pressure and success card information requested of Broad Run and Control Area hunters, 1957-1960.

VCWRU Form #4

Kill Record

Area _____ Grid _____ Date _____

Species _____ Weapon used _____

Sex _____ Age _____ Weight _____

Std. Measurements: T. L. _____ Tar _____ Tail _____

Material preserved _____ Tag No. _____

Deer:

Points: L ____ R ____ Beam Diameter: L ____ R ____

Turkey:

Beard length _____ Spur length: L ____ R ____

Remarks: _____

_____

_____

Fig. 6. Kill card information requested of Broad Run and Control Area hunters, 1957-1960.

to be recorded. Also noted were live and dressed weights, total body length (from the tip of the nose to the base of the tail, following the body contour), shoulder height (from the tip of the hoof to the shoulder blade), and dressed and undressed heart girth. Rumen samples (including weight and volume of rumen contents, and weight of rumen and reticulum--with contents and empty) were taken and used by Dr. James Whelan of the Virginia Cooperative Wildlife Research Unit and Richard Harlow of the U.S. Forest Service for nutritional study. Hair samples were taken in 1968 and 1970 and tested for sulfur content (used as an index to habitat quality). In 1971, Whelan tested samples of deer hair for mercury content, but he did not find the amount significantly different from the amount of mercury normally found in deer hair (Whelan 1972: pers. comm.). In 1971 no information was recorded on deer antlers, nor were weights recorded in 1972.

Seneca (1961) stated standard hunter pressure and success cards and kill cards were again used during the 1959 and 1960 seasons. Curtis (1970) stated that from 1959 through 1964 all hunter information was recorded on a standard white 5 x 7 card form (Fig. 7). This card also requested such information as total time hunted/individual, and game seen and killed. Although space was allotted for this information to be recorded by compartment, such data did not begin to be kept until 1964 (Virginia Cooperative Wildlife Research Unit 1965:16).

Other information sought for the first time in 1964 was hunter time on the road, and camping and recreation time. In previous years only the total time spent on Broad Run by the hunter had been recorded. Curtis (1970) noted checking station operation and data collection methods have

Broad Run Check Station

Year _____ Date _____ No. hunters in party _____

Date _____ Time In _____ Total time hunted _____

Date _____ Time Out _____ Man hours total _____

Hunting Time, Game Seen and Killed by Compartments

		Compt. A	Compt. B	Compt. C	Remarks
Road	Time Spent				
	Game Seen				
	Game Killed				
Hunting	Time Spent				
	Game Seen				
	Game Killed				
Other	Time Spent				
	Game Seen				
	Game Killed				

Fig. 7. Broad Run check station data collection form, 1959 through 1964.

been uniform only since 1964.

The 5 x 7 data card was discontinued in 1965, and all hunter pressure-success data were recorded on the first page of a 3-page questionnaire (Fig. 8) designed to gain socio-economic information on the hunters using the Broad Run Management Area.

The hunter pressure-success data collection form was completely redesigned in 1968 by Robert Hooper of the U.S. Forest Service. Hooper's form was designed to facilitate the transfer of data from the field form to IBM data punch cards. The new form, used to the present time, deleted such items as vehicle license number, time of entry and departure, and number in the hunting party. By the use of this form, time needed to tabulate such data as total man-hours hunted, total man-hours of road time, game seen by compartment, and game killed by compartment, was greatly reduced (Curtis 1970). Drawbacks of this form and a suggested new form for gathering data more accurately is discussed (with illustrations) in the recommendations section.

Original field data taken from seasons 1957 through 1967 have been transferred to coded Hunter Use-Observation Survey Forms (Fig. 9), now on file at the Virginia Cooperative Wildlife Research Unit, Blacksburg. Data from these forms eventually are to be used in IBM tabulations.

Curtis (1970) in his work on climatic factors and sightings of deer at Broad Run, tabulated all data related to hunter sightings, from 1964 through 1970, on IBM sheets and the data were key-punched on data cards.

Gun Seasons And Game

It has often been cited that the 3 purposes of hunting laws are to:

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 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.

		Compt. A	Compt. B	Comp. C	Remarks
Road	Time Spent				
	Game Seen				
	Game Killed				
Hunting	Time Spent				
	Game Seen				
	Game Killed				
Other	Time Spent				
	Game Seen				
	Game Killed				

Fig. 8. Broad Run check station data collection form used from 1965-1967.

HUNTER USE-OBSERVATION SURVEY FORM

Department of Forestry and Wildlife
Virginia Polytechnic Institute
Blacksburg, Virginia

Card No. ___ (1) Date ___ ___ ___ ___ ___ ___ (2 3 4 5 6 7) Vehicle License No. _____ No. in party ___ ___ (8 9)

Area ___ ___ ___ _____ (10 11 12) Acreage of area ___ ___ ___ ___ ___ (13 14 15 16 17)

County ___ ___ ___ ___ (18 19 20) State ___ ___ ___ (21 22) Questionnaire No. ___ ___ ___ (23 24 25)

Time in _____ Time out _____ Total time ___ ___ ___ ___ ___ (26 27 28 29 30)

Compartment ___ (31) (A 1, B 2, C 3)

Time ___ ___ ___ ___ ___ ___ . ___ ___ ___ ___ ___ . ___ ___ (32 33 34 35 36 37 38 39 40 41 42 43 44)

Game Seen

Deer	___ ___ (45 46)	___ ___ (47 48)	___ ___ (49 50)
Turkey	___ ___ (51 52)	___ ___ (53 54)	___ ___ (55 56)
Grouse	___ ___ (57 58)	___ ___ (59 60)	___ ___ (61 62)
Squirrel	___ ___ (63 64)	___ ___ (65 66)	___ ___ (67 68)

Game Killed

Deer	___ (69)	___ (70)	___ (71)
Turkey	___ (72)	___ (73)	___ (74)
Grouse	___ (75)	___ (76)	___ (77)
Squirrel	___ (78)	___ (79)	___ (80)

Fig. 9. Hunter-use observation survey form used by the individual hunter in each compartment in the Broad Run Management Area.

(1) Keep man from killing animals to extinction.

(2) Regulate each year's harvest and influence the number of animals for each year's hunting.

(3) Assure each hunter an equal opportunity to harvest his fair share of available game.

It is important that hunting laws be subject to annual review. If need be, they should be changed to accommodate game population fluctuations and new findings in wildlife research.

Several game regulation changes have spanned the 16 years of hunting at Broad Run and Brush Mountain. Two landmark alterations came about: one, in 1961, when turkey became legal game in Craig County for the first time in 2 decades; two, in 1964, when 2-week deer seasons were initiated in Craig County for the first time since the western counties were first opened for hunting after deer had been re-established there by the Virginia Game Commission (Gillam 1964). Table 3 shows hunting seasons for forest game at study and Control areas from 1957-1972.

Deer

From 1957 through 1963 there were only 6-day hunting seasons at the management and Control areas. The number of days any-deer was legal varied. In 1957 and 1958 bucks only were hunted the first 4 days and any-deer was legal game the last 2 days. In 1959 either sex was legal the last 3 days while, in 1960 and 1961, hunting either sex was allowed the first 3 days. In 1962 and 1963 one "any-deer" was legal game on the first day of the season. From 1964, with the advent of the 2-week season, through 1967, either sex was legal only on the first day of

Table 3. Gun season dates for Craig County and Broad Run, 1957-1972*.

Year	Deer	Turkey	Squirrel	Grouse
1957-58	Nov. 18-23	Closed	Nov. 18- Jan. 10	Nov. 18- Jan. 10
1958-59	Nov. 17-22	Closed	Nov. 17- Jan. 10	Nov. 17- Jan. 10
1959-60	Nov. 16-21	Closed	Oct. 1-15; Nov. 16-Jan. 15	Nov. 16- Jan. 15
1960-61	Nov. 21-26	Closed	Oct. 1-15; Nov. 21-Jan. 14	Nov. 21- Jan. 14
1961-62	Nov. 20-25	Nov. 20- Jan. 15	Oct. 2-15; Nov. 20-Jan. 15	Nov. 20- Jan. 31
1962-63	Nov. 19-24	Nov. 12- Jan. 15	Oct. 1-15; Nov. 12-Jan. 31	Nov. 12- Jan. 31
1963-64	Nov. 18-23	Nov. 18- Dec. 14	Oct. 1-14; Nov. 18-Jan. 31	Nov. 18- Jan. 31
1964-65#	Nov. 16-28	Nov. 2- Dec. 15	Oct. 1-14; Nov. 2-Jan. 30	Nov. 2- Jan. 30
1965-66	Nov. 15-27	Nov. 1- Dec. 15	Oct. 1-14; Nov. 1-Jan. 31	Nov. 1- Jan. 31
1966-67	Nov. 21- Dec. 3	Nov. 7- Dec. 17	Nov. 7- Jan. 31	Nov. 7- Jan. 31
1967-68	Nov. 20- Dec. 2	Nov. 6- Dec. 16	Nov. 6- Jan. 31	Nov. 6- Jan. 31
1968-69	Nov. 18-30	Nov. 4- Dec. 17	Nov. 4- Jan. 31	Nov. 4- Feb. 28
1969-70	Nov. 17-29	Nov. 3- Dec. 20	Nov. 3- Jan. 31	Nov. 3- Feb. 28
1970-71	Nov. 16-28	Nov. 2- Dec. 19	Nov. 2- Jan. 30	Nov. 2- Feb. 28

Table 3. Gun season dates for Craig County and Broad Run, 1957-72 (continued).*

Year	Deer	Turkey	Squirrel	Grouse
1971-72	Nov. 15-27	Nov. 1- Dec. 18	Nov. 1- Jan. 31	Nov. 1- February 28
1972-73	Nov. 20- Dec. 2	Nov. 13 Dec. 31	Sept. 15-30; Nov. 13-Jan. 31	Nov. 13- Feb. 15

*Data obtained from issues of Virginia Wildlife Magazine.

2-week season began.

the season. From 1968 through 1972 all deer have been legal game on the final day only.

Why did the 2-week season come about, and why were the number of either-sex hunting days reduced to only one? Gillam (1964) explained the 2-week season hopefully would dilute "the intense hunting pressure" experienced in counties west of the Blue Ridge in recent years.

"The Commission felt additional buck shooting days were justified in this section (of the state) to increase hunting opportunity and distribute pressure since the removal of a generous number of bucks does not affect the productivity of a deer herd," wrote Gillam (1964:14).

One deer/license year has been the bag limit. Bucks must have antlers visible above the hair line to be legal.

Turkey

Turkeys became legal game in Craig County in 1961 and the first 2 seasons were 2 months in duration. However, at Broad Run, the check station has recorded turkey and small game kills and sightings only during deer seasons. In 1963 the turkey hunting season was reduced to about one month because there had been 2 poor nesting seasons in succession the previous years. The turkey situation improved by the next season, however. Opening day was pushed up 2 weeks to run concurrently with an early small game season. Since 1964 fall seasons have run 6 weeks. Bag limit: 2 turkeys (either sex)/license year (one/day).

Small Game

The ruffed grouse bag limit has remained unchanged over the years at

3/day and 15/license year. It was not until 1968 that the season for this game bird was extended to as late as February 28.

Squirrels, on which the hunter has had a bag limit of 6/day and 75/season since hunting began at Broad Run, were hunted on a split-season basis in Craig County from 1959 through 1965. In 1966 the straight season returned and remained until 1972, at which time the split season became operative again, with the earliest opening day ever recorded—September 15.

From 1957 through 1961 the small game season began on the same day the deer season opened in Craig County. In 1964 there was a one-week advance in small game hunting in the western part of the state to give small game nimrods a "crack at the lesser species before the opening of the big game season." This early season did not appeal to many landowners and hunters west of the Blue Ridge and was discontinued in 1965 (Gillam 1963). In 1966, however, a 2-week early small game season was instituted in the west "to compensate for some of the hunting days invariably lost to bad weather late in the winter." (Gillam 1964:14). The 2-week advance season has remained in practice, for the most part, up through 1972.

Bear

Bears have been legal game in Craig County every year hunting has been permitted at Broad Run. It has been unlawful, however, to use dogs for hunting bears during the open deer seasons. One bear a year continues to be the limit. Up until the 1972 season, the bears must have weighed at least 75 lbs to be of legal size. In 1972, the legal size for bears was at

least 100 lbs.

Harvesting and hunting pressure data and evaluation will be discussed later in this report.

Archery Seasons

Hunter pressure and success data were kept for bow and arrow hunters on the Broad Run Management Area during special seasons when these weapons were used exclusively in 1957 through 1962. During these years, the special seasons ran from mid-October until November 1. In 1963, the special season was extended from October 15 through November 15. This season has remained the same each year to the present time. Since 1963 there has been no check maintained on archery season activities at Broad Run and Brush Mountain (McGinnes 1972: pers. comm.), although bow hunters have been free to use these areas during the special and regular hunting seasons.

During the 1957 and 1958 archery seasons, both entrance gates into Broad Run were closed and archers using the area were forced to enter on foot. Data on pressure and success were collected by a mobile run. All hunters observed during this run were consulted as to the number in their party, or other parties they had encountered, the hunting success of these parties, and the number of deer seen. Reports of deer seen were recorded according to proximity to known points, i.e. agricultural clearings and waterholes (Quillen 1959).

Table 4 indicates bow hunting pressure greatly increased from 1957 to 1958. Only 2 hunter-days were recorded for 1957. Hunter-days increased to 44 in 1958, and although no deer were killed, 2 were reported

hit by arrows. The pressure was the greatest in 1958, perhaps because more hunters learned about the Broad Run area. The agricultural clearings were only in their fourteenth month after establishment at this time.

"Vegetation of the clearings seemed to be highly desirable during this period and they provided excellent sites for bow hunters," Seneca (1961:74) stated.

Bachant (1970) reported the 1962 archery season was open to any deer, bear, and squirrel as legal game. Again no game was harvested, but 29 deer and 69 squirrels were sighted at Broad Run by archers.

Table 4. Hunter pressure and success for the 1957-1962 archery seasons at the Broad Run Management Area.*

Year	Length of Season (days)	Hunter Hours	Kill
1957[s]	10	16	0
1958[s]	16	352	0**
1959[s]	16	30	0
1960[s]	16	75	0
1961[b]	15	80	0**
1962[b]	16	143	0

* No hunter pressure, or hunter success data were reported from the Brush Mountain Control Area because of low deer population

** Two deer hit, but not recovered

[s] Data taken from Seneca (1961:75)

[b] Data Taken from Bachant (1963:73)

LITERATURE REVIEW

One of the objectives of this thesis is to present a synopsis of the research done at the Broad Run Management Area by graduate students at Virginia Polytechnic Institute and State University's Division of Forestry and Wildlife Sciences. Up to this time there have been 17 theses written from studies performed at Broad Run. Five works concerned browse and mast studies (Whelan 1962, Thompson 1962, Patton 1963, Guthrie 1964, and Shutts 1968); 4 on wild turkey (Bachant 1963, Raybourne 1968, Shugars 1971, and Martin 1972); 3 on whitetailed deer (Quillen 1959, Seneca 1961, and Perry 1970); 2 on wildlife practices (Larson 1966, and Trumbo 1967); one on the fox (Oleyar 1969); one on climate and the hunter (Curtis 1971); and one on songbirds (Hooper 1967).

From these theses this writer gleaned 193 results from previous research at Broad Run. The results took the form of either succinct factual findings, summary conclusions, distilled discussions on background information, or as evaluations on information unearthed, or research performed.

Browse Studies

Whelan (1962) wanted to find if there was a viable shortcut to determining the quantity of available browse without actually having to clip and weigh it. He sought an answer to this question: Could the amount of available browse be determined by measuring such site quality variables as site index, depth of the A1 soil horizon, position on slope, elevation, and the number of stems/sampling unit?

Whelan conducted his study in 2 forest cover types: Cove Hardwoods (Oak-Hickory-Poplar-White Pine type), and Mixed Oak-Pine type. Each comprised a circular $\frac{1}{4}$-acre plot, from which data on the 8 variables were taken, and a square 1/100-acre plot, located in the center of the larger plot, from which the browse was clipped. Data from both plots were compared and a multiple regression analysis was used to determine the degree of correlation between the quantity of browse clipped and measurements of the 8 independent site quality variables on their respective double-sampled units.

This is what Whelan found:

(1) The number of stems clipped/sampling unit and the depth of the A1 soil horizon were significantly related to browse weights/acre in the Cove Hardwood type. These 2 significant variables, however, explained only 48.63% of the total variation in browse weights found on the sampling units. Whelan concluded the final estimating equation should not be used as a reliable estimate of browse production in this cover type. The equation is: Y (lbs of browse/acre) = -0.14 + 0.06 (number of stems clipped/sampling unit) + 0.61 (depth of the A1 horizon).

(2) In the Mixed Oak-Pine type, the number of stems clipped/sampling unit was the only variable significantly related to browse weights/acre. This significant variable, however, explained only 17.97% of the total variation in browse weights between sampling units. The final estimating equation, using only one significant quality measurement, is: Y (lbs of browse/acre) = 2.24 + 0.07 (number of stems clipped/sampling unit).

(3) Data from the Mixed Oak-Pine type indicated a mean browse

weight of 3.93 ± 2 lbs/acre for the 5 species clipped: azaleas, red maple, black gum, white oak, and red oak.

(4) Data from Cove Hardwood type indicated 2.40 ± 1.90 lbs/acre.

(5) Analysis of varience indicated no real difference in browse production between sampling units in Mixed Oak-Pine type, but there appeared to be a real difference in the Cove Hardwood type.

(6) The sampling unit of 1/100-acre square plots for browse clipping was determined to be the quickest and most efficient size within each forest type. Square plots are recommended because their boundaries are less difficult to determine than those of circular plots.

Yhompson (1962) also worked on browse availability in the Cove Hardwoods type at Broad Run. He estimated browse/acre by random and double sampling techniques. Involved were 217 plots, 1/100-acre each, randomly distributed in 15 coves. Browse twig counts were taken on all plots. Clipping and weighing of browse was restricted to 49 randomized plots. Browse twigs by species were recorded on 150 plots. Thompson found:

(7) From a simple linear regression it was determined, with 95% confidence, that there was an average of 9 ± 1.1 oven-dried lbs of browse available/acre in the Cove Hardwoods forest type at Broad Run.

(8) The mean number of browse twigs/plot in the Cove type was 987.92.

(9) Of all species recorded on twig counts, 16 accounted for 96.41%. More than 70% of twigs counted on 150 plots were of species recognized as good deer browse.

Patton (1963) found different cutting intensities and age of cut

influenced the amount of browse available for deer in Broad Run's Mixed Oak-Pine forest cover type.

Browse produced on 45 cut and 4 uncut sample units, of ½-acre each, was estimated by averaging 4 sample plots (of 1/250 acres each) on each sampling unit.

The data from cut units, using age of cut and percent basal area removed as variables, were subjected to a regression analysis, which was found to be significant. A table was then prepared for predicting browse production from 1 to 4 years after cutting with 30% and 80% of the basal area removed. The table disclosed:

(10) One year after cutting, at 30% basal area removed, 31 ± 6 lbs/acre were produced. At 80% removal, 154 ± 36 lbs/acre were produced.

(11) The range of browse production after 2 years of cutting was 37 ± 5lbs/acre (at 30%), and 180 ± 35 lbs/acre (at 80%).

(12) The range of browse production after 3 years was 43 ± 7 and 210 ± 42 lbs/acre, at the respective 30% and 80% removal.

(13) The range of browse production after 4 years of cutting was 50 ± 11 and 246 ± 63 lbs/acre at the respective 30% and 80% removal.

(14) Uncut units in Mixed Oak-Pine type averaged 10 lbs/acre.

Patton (1963) also compiled a table that indicated the carrying capacity in days for deer at Broad Run as influenced by forest cutting. Based on the premise that deer need 3 lbs of browse (dry weight)/day in winter, the table showed:

(15) A range in per-acre carrying capacity of 8 days (30% removal, one year after cutting) to 103 days (80% removal, 4 years after cutting).

Patton (1963) concluded: that basal area removed and age of cut are

2 correlative variables used to predict available browse production; it was possible to predict available browse in Compartments A and B at Broad Run's Mixed Oak-Pine type at 66% confidence level; at least 50% of basal area must be removed to make timber and pulpwood sales worthwhile for increasing deer carrying capacity; and that comparable prediction of deer carrying capacity could be made for other areas.

Guthrie (1964) sought to determine the most efficient plot size (between .001 and .1 acres) for estimating the weight of winter browse in mixed hardwoods at Broad Run, and to determine the more efficient method between simple random and double-sampling methods. He found, after a twig count was made on each square milacre plot, and current annual terminal growth was clipped from each unit, and oven dried and weighed, that:

(16) In simple random sampling, a one-man crew using a 1 milacre plot was generally superior to all other combinations within the range of the data. All larger plot sizes were less efficient.

(17) In simple random sampling, location time had a pronounced affect on optimum plot size where more than one worker was involved. "For a 2-man crew, the effect of location time is to shift optimum plot size upward as cost increases...if location time is as much as 10-crew minutes,..optimum plot size is 2 milacres; 20 minutes, 4 milacres; 40 minutes, 9 milacres; and 60 minutes, 25 milacres (Guthrie 1964:33)."

(18) In double-sampling on unequal-sized plots, Guthrie found a survey involving 4-milacre plots was about 50% as costly as one in which 1-milacre plots were used; 9-milacre plots were about 52% as costly, and so forth, up to 25-milacre plots, which were 66% as costly.

(19) In double-sampling, if the consideration of location time was omitted, larger plot sizes were more efficient than the 1-milacre plot. The optimum plot size was about 4 milacres.

(20) When both survey methods used equal-sized plots, the efficiency of double sampling decreased from small to large plots (e.g. the cost of simple random sampling using a 2-man crew on a 1 milacre plot was 23% of the cost of double sampling). The cost of simple random sampling exceeded double sampling when plot size increased to 25 milacres.

(21) On equal plot sizes, double sampling did not approach the efficiency of simple random sampling until the plot was 25 milacres or larger.

(22) Simple random sampling was preferred to double sampling in all cases except the largest plots.

Mast Fall and Mast Availability

Thompson (1962) studied mast fall and sought to determine availability of oak mast in the Cove Hardwoods forest type at Broad Run. Six deer exclosures and 6 open plots were selected for these studies. Oak mast fall was sampled by 6 mast traps and 12 paired ground plots at random locations within each study area.

Thompson designed a conical polyethlene mast trap for his study and compared it with 7 other types of mast traps. The plastic trap was the most efficient, retaining more than 99% of 400 acorns dropped into it from heights of 35' and 55'. Its 3.000 mil material was least influenced by wind, had best drainage and was not easily damaged by falling sticks.

The plastic trap was comparatively low in construction cost and appeared durable after a year afield.

(1) Thompson found (using a t-test at the 1% significance level) no significant difference between the number of acorns (in all conditions) collected in mast traps and on ground plots. He concluded:

(2) "That data collected from ground plots could be analyzed with the same degree of confidence as data collected from mast traps; therefore intensive sampling of mast fall would not be limited to the use of expensive mast traps (Thompson 1962:45)."

(3) A t-test disclosed that data collected from ground plots under the crown edge were significantly different (at the 20% level) than data collected from under the center of a tree crown. This "indicated that the position of sample plots under a tree canopy was an added source of variation in estimating the oak-mast fall for extensive acreage," wrote Thompson (1962:45).

Thompson tried to determine the amount of annual, sound, well-developed, and undamaged mast crop on the ground that was available to wildlife at the time of collection. Thompson found on the 12 study areas that:

(4) There was no significant difference in the amount of oak mast available in uncut timber stands as opposed to stands selectively cut.

(5) There was no significant difference between oak mast available in enclosed and the open study areas: thus, the amount available was affected by deer feeding habits.

(Both these conclusions were based on tests where study areas were treated as sample units for analysis of variance tests for a random com-

plete block design).

(6) There was a significant difference in oak mast availability on belt transects in selective cut exclosure and unenclosed study plots.

(7) There was a significant difference in oak mast availability on belt transects in uncut deer exclosures and unenclosed study plots.

(These conclusions were based on t-tests of unpaired and unequal observations.)

Wild Grapes

Shutts (1968) used Broad Run for most of his study on "the autecology and fruit production of summer and silverleaf grape in Virginia Highlands." The subject was relevant because of the importance of the wild grape as food for wild turkey, bobwhite quail, ringneck pheasant, ruffed grouse, mourning dove, red squirrel, cottontail rabbit, and white-tailed deer. The grape plant is also important cover for some wildlife.

Shutts studied the summer grape and silverleaf grape. These grapes are widespread in Virginia. Vines are high in fruit production and are vigorous, producing excellent food and cover while resisting disease.

The objectives of Shutts' study were: one, to determine the relationships of 10 stands of grape with various ecological factors; second, to determine peak period of fruit drop and estimate incidence of disease of a small stand of grapes.

Eight of 10 stands were selected in Craig County. The summer grape vines were located on Brush Mountain.

The 33' square plots were situated a chain apart along 13.2' wide transects bisecting each stand. These plots, which were superimposed on

the transect lines, ranged from 4 to 10 to a stand, depending on stand size. Total number of plots for 10 stands was 61.

For each ecological variable, analysis of variance and Duncan's Multiple Range Test was run to determine if a significant variation occurred within or between stands. Simple correlation coefficients involving soil variables and 2 grape variables were calculated.

Circular scaffolds held the grape vines. All vines had aerial attachments. Polyethylene sheeting between scaffold supports were used as fruit traps.

Shutts' findings and evaluations were as follows:

(1) The number of grape vines and basal area of grape vines decreased from stand center to periphery, as did site variables—soil pH, calcium, magnesium, percent organic matter, depth of humus, and site index—on corresponding plots and stands.

(2) Site variables differed significantly between stands (at the 95% level), but the number of vines and total basal area of vines were not significantly different.

Conclusion. Grape abundance was fairly constant for each stand despite variations in fertility. Therefore, this indicated grapes grow over a wide range of soil and site conditions on a given site. Shutts suggested greenhouse studies that would show the influence of the growth of grape plants on soil conditions (sic).

(3) Fruit traps would seem to be 100% efficient and original grape count 98.5% efficient. A total of 449 grape bunches was counted on 6 grape vines and 456 bunches collected in traps. No evidence was found of grapes falling outside traps.

(4) Data for 6 vines showed an increase in number of grape bunches with increase in vine diameter.

(5) Almost half the grapes collected were affected by black rot fungus. The mycelium destroyed the berry flesh, or the food value component. The Virginia Polytechnic Institute and State University Plant Pathology Department recommended Folpet or Captan spray to combat this disease.

(6) According to fruit collection data, considerable quantities of grape were available to ground feeding wildlife between October 1 and December 31 with peak abundance about the first 2 weeks in November. The period of peak grape abundance on the ground coincides with the fall turkey season. Grape stands, therefore, may be effective in concentrating turkeys for harvest.

(7) A large number of individual berries--9,834--were produced by 6 vines, with stem diameters ranging from 0.8" to 2.1". Because grapes are important as food for wildlife, Shutts suggested an investigation be made into the effects of silvicultural practices on grape establishment, growth, and production.

Wild Turkey

Bachant's Work

Bachant's (1963) thesis was the first emanating from work soley concerning the wild turkey at Broad Run. Recognizing the increasing usage of National Forest land for turkey hunting and "the paucity of information on wild turkey distribution and abundance," Bachant chose

as the main objective of his study "to determine population densities, reproductive success, mortality, distribution patterns, and movements of wild turkeys in each of the 4 management compartments" at Broad Run.

Techniques used in the field went to the heart of Bachant's data gathering and his conclusions on the wild turkey's abundance and distribution at the Broad Run Wildlife Research Area. Bachant (1963:42) wrote:

> "Because marked individuals yield the best data for abundance and distribution estimates, the field work for this study emphasized trapping and banding activity. It was believed that baited areas would also enhance the possibility of obtaining more sight observations."

Bachant used a cannon net and 2 types of grain baits—whole corn and a mixture of wheat, oats, and cracked corn. Three types of bands were used—colored plastic leg bands (used to improve sight observation); lap seal tags with embossed printing; and modified aluminum butt-ends used in the self-operated camera operations.

The self-operated camera was tested by Bachant as a possible means of collecting data. These were inexpensive fixed-focus, fixed time cameras of 2 types: the Kodak Fiesta and Kodak box-type. The cameras were loaded with Verichrome Pan film and were protected by sheet plastic and camouflaged by burlap bags and leaves. The box-type camera employed a mouse trap to operate the shutter release lever. The Fiesta camera was a more complicated mechanism. The shutters on both cameras were activated by a trip wire. Photo identification of birds was employed by the use of a system of bands with different symbols which represented digits from 0 to 9. The cameras were set up along bait lines near clearings.

Other techniques were used to obtain abundance and distribution

data; sight observation data from reliable personnel, soliciting information of turkey flock location and size from local residents, aerial surveys, gobbling counts, and snow track counts, hunter interviews, and sex and age data from turkeys observed and killed.

Results from Bachant's work encompassed an evaluation of the techniques used, and the conclusions of turkey abundance and distribution based on data gleaned from the above techniques.

Concerning live trapping and banding:

(1) No mortalities resulted from using the cannon net on wild turkeys. All turkeys caught suffered slight feather loss.

(2) Failure to capture turkeys with the net was largely because of the malfunction of propellant charges; namely, the plastic cartridges were found to be incompletely sealed. This can be remedied by sealing the cartridges with paraffin wax prior to installation.

(3) The cotton net developed flaws. Its weight and shape enabled turkeys to outrun the nets on the sides. The stresses of projection also weakened the nets causing holes. Bachant recommended use of a nylon net, not less than 30' x 60'.

(4) Too many bait lines in close proximity thwarted a regular pattern of turkey visitation to any one line. Few bait lines, set apart at about one air-mile or more, were found to be sufficiently spaced to attrack family flocks in the vicinity regularly during the summer.

(5) Of the 90 times turkeys used bait lines during the 11-month baiting periods, 50% of these visits occurred only on a single day with flocks failing to return on the second day. A pattern of 2 successive days of bait line attendance occurred only 17 times (38%) during 11

months. Flocks visited bait lines 3 and 4 days straight only 3% or 4% of the time, respectively. The greatest number of consecutive visits were in July and August.

Concerning self-operated cameras:

(6) The box camera was the more reliable of the 2 cameras. The Fiesta camera frequently had shutter malfunction resulting in overexposed film. Bachant recommended self-operated cameras for precise measurement of flock distribution and abundance and accurate brood counts.

(7) Because of periods of low light intensity a faster film than Verichrome Pan was recommended; or a flash attachment be used during early morning or late evening.

(8) An airtight case for a camera was suggested by Bachant rather than just sheet plastic.

(9) The use of a trip wire for activating the shutter was found unsatisfactory because the sord was often struck by falling limbs or by deer at night.

Concerning census techniques:

(10) According to sight observations made by project personnel, Bachant estimated a 1962 fall production of 60 wild turkeys (50 definitely known in the management area; 10 estimated for the Control Area).

(11) During one aerial census when there were favorable flying conditions and good snow cover, 2 turkeys and 4 deer were seen. Appraisal of this technique, therefore, was inconclusive. Bachant believed aerial census, using a helicopter, merited further testing. Light aircraft was recommended for censusing during the winter.

(12) Sight observations by non-project personnel was of value only for distribution data because some of the reports on numbers were thought to be inaccurate. Only population estimates considered were those which were accurately described and within reason. It is important, Bachant noted, that signs identify compartment boundaries, water holes, and that clearings should be maintained to help identify wildlife spots.

(13) Snow track counts (28 counts on the management area and 3 counts on the Control Area from 1958 to the spring of 1963) indicate a general reduction in the population density of wild turkeys during the winter.

(14) Turkey tracks on the management area were located in Compartment C and in the northern half of Compartment B (up through 1962).

(15) During winter months of 1958-1959 and 1961-1962, turkeys were attracted to agricultural clearings which had been freshly planted to winter wheat, clover, and grasses. The pattern of usage quickly ceased after the first year subsequent to seeding.

(16) No tracks of wild turkey were ever found in the Control Area (through 1962).

(17) Spring gobbling counts from 1958 to 1961 indicated a gradual increase of mating males over three years.

Based on information gathered by the above techniques and by harvest information, which is confined to the results section of this thesis, Bachant devoted a section of his thesis to plotting and interpretation of data. He discussed the turkey's seasonal distribution patterns, movements, population density, reproductive success and mortality.

Concerning distribution patterns:

(18) Spring (1962): The intensity of gobbling increased through May and ended in June. Boundaries of ranges of 7 males was roughly estimated and ranged from 64 acres to 102 acres (95-acre average). Hens, generally in close association with males, remained near agricultural clearings. Black fluid caecal droppings were found in several clearings.

(19) Summer (1962): Once the mating season ended, adult males became increasingly nomadic, displaying little or no territorialism. The average cumulative range of family flocks was about 500 acres for the summer season. Family flocks showed a definite tendency to frequent agricultural clearings and open spaces on the management area and the farming pasture lands on the lower elevations. Bachant said this may explain the extended range for the flock in Compartment C. Abundant insects and dusting sites are probably shief attractants of these clearings. Dusting forms were found on the perimeter of several clearings and in the deer imprint plots.

(20) Autumn (1962): From early fall to late November, distribution patterns gradually narrowed and became elliptical. As the season progressed and weather became more severe, the flocks in Compartments C and E were seen on the study area much later in the season than those in Compartments A and B. The flocks finally left the study area for the other side of North Mountain by early December 1962.

(21) Winter (1962): According to snow track counts and sight observation records since 1957, the size of the turkey population was reduced during the winter. Those few turkeys present during the winter favored the productive lower elevations of Compartment C and the northern half of B. Snow tracks in the winter of 1962-1963 indicated birds roost-

ing in Virginia pine stands and feeding in the Broad Run Valley bottom and the lower slopes of the eastern face of North Mountain. In the winter of 1961-1962 preference was shown for clearing No. 10, which had been seeded the previous fall. The total area covered by these turkeys was less than one square mile, or 640 acres. Areas covered in a single day during severe weather and snow were not more than ½-mile in diameter.

It is believed the east face of North Mountain is the wintering range of the flocks on Broad Run's Management Area. It is generally warmer, has less snow cover than the west side and has abundant food. The exact distribution of birds on North Mountain's east side was unknown.

(22) Annual distribution: 3 or 4 flocks on the management area existed entirely within the boundaries of the management area. The ranges of these flocks were not precise because of the difficulty in describing the boundaries (especially for Compartment A). However, Bachant had estimates for 1962 flocks to be 1400 acres in A; 1530 acres in B and 2180 acres in C.

Concerning periodicity and flock movements:

(23) Daily bait line inspection indicated 2 main periods of feeding for turkey: dawn to mid-morning and mid-afternoon to dusk. Most bait-line feeding occurred in the mornings.

(24) Bait lines set up in March 1962 were not regularly visited by turkey until late May and only by adult males. The time interval between visits to bait lines was reduced from late May to early June. Bachant felt this may have reflected the end of breeding and an increased intrest in feeding to replenish fatty reserves lost during the breeding

season. After mid-June, gobblers abandoned their gobbling territories and became completely nomadic.

(25) Family flocks began visiting bait lines in late June. There was a gradual increase in time interval. Bachant said this showed increasing mobility of poults with age. There was gradual decrease in bait-line attendance after mid-September's oak mast fall. From mid-September until late fall, flock movements increased. By November, hunter observation indicated flocks were roosting in valley bottoms and moving to the head of coves and ridge tops to feed.

Bachant (1963) interpreted increased fall movements by turkeys to be influenced by ripening oak mast and grapes. The ripening of mast occurred first from trees of the lower elevations, then progressed to trees of the higher elevations during successive weeks. During the winter, flocks at Broad Run roamed extensively over flats and coves of the lower elevations during fair weather and during inclement weather their movements were restricted to small areas in the vicinity of coves and slopes with southeastern aspects.

Concerning population densities:

(26) Compartment C, the only compartment considered to have accurate population figures because of better data, had the highest population density in the fall of 1962. Bachant (1963:103) said this was so because "wildlife practices, several undisturbed pastures on private lands in Broad Run Valley, and the lack of human disturbance." Bachant indicated Compartment C had a good turkey population since 1958 (to 1962) because of these factors. Compartment C had one bird/102 acres, density. Bachant indicated the 1962 fall population of one turkey/170

acres (67 turkeys) for the entire research area was a favorable density. In his opinion, a density of one bird/91 acres to one bird/114 acres is the maximum carrying capacity of the Broad Run Wildlife Research Area.

Concerning reproductive success:

(27) Although no nests were found on the management area during the spring of 1962, Bachant inferred 100% nesting success in 1962 because 7 hens were found on the study area in the spring and the same number of hens were later found with young.

Concerning brood counts:

(28) Bachant believed brood sizes remained constant from 1957 through 1962 and disagreed with Seneca (1961) that the increase in the turkey population on Broad Run was because of increased brood size. Bachant argued that observations made in June and July were not accurate because of the poults' ability, at that time, to freeze and hide when alarmed. Also, observations taken in September may have been faulty because of the difficulty in distinguishing the hen from her poults. Therefore, Bachant discounted the accuracy of Seneca's 1957 and 1958 ratios because they were determined from June-July counts. Seneca's 1960 count (1:8.8) was taken in August-September and was more in keeping with August-September Virginia average of 1:8.5, taken by McDowell in 1954 (Bachant 1963:106). Bachant authenticated his argument by his August hen:poult ratio in 1962 of 1:6.1 which was not too different from what he reported McDowell's count to be for southwestern Virginia in 1954, i.e. 1:6.0.

(29) Bachant found the reproductive success of hens differed little between compartments, especially for 1962 (the range being 1:5.5 to 1:60

in Compartments A, B, and C).

(30) Bachant considered ratios based on hunter observation not to be reliable because of the difficulty in discerning hens from poults in November. Hunter observations of 1962 indicated a hen:poult ratio of 1:5 while the ratio based on harvesting of 2 adult males and 7 poults indicated an adult:immature ratio of 1:3.5.

Raybourne's Work

Through the means of radio telemetry, Raybourne (1968) sought to determine the autumnal size, shape, and location of the wild turkey's range in the Broad Run Management Area.

Raybourne's secondary objectives were to evaluate the effect of forestry practices (clear-cutting and wildlife clearings); to determine the effect of hunting pressure, and weather on turkey movements; and to determine the turkey's habitat preference during the fall.

As Raybourne (1968:2) expressed it:

> "Once information is obtained on the extent of the range under various conditions, during different periods of the year, and types of habitat most frequently utilized, then a management program can be proposed."

Concerning the use of trapping and banding equipment:

(31) No malfunctions resulted from the use of the cannon-projected net trap (of treated cotton twine). The plastic UMC 1024 cartridges used were waterproof and detonated properly. No birds escaped and there were no mortalities from use of the cannon net trap.

(32) Six baiting areas were originally selected within the study area, but were apparently too close together, but reduced to one area

before a regular pattern of attendance could be determined. A minimum of one mile between baiting sites seemed adequate to allow for a regular pattern of attendance by each flock at each bait site.

(33) Based on records of daily bait line attendance, during a 3-month baiting period, turkeys used bait line 82 times. A pattern of 2 successive days of bait line attendance occurred 34 times (41%). Flocks visited bait lines 3 days in succession only 8 times (9.7%). The greatest number of consecutive visits were in August and September.

(34) Radio transmitters and receivers designed to operate continuously on a separate frequency between 26.550 mc and 26.650 mc, operated their intended duration without mechanical failure. Battery life ranged from 78 to 84 days. Transmitters held true when the unit was subjected to a rapid change from 85° F to 0° F, and when held at 0° F for 2 hours. Precipitation did not seem to affect performance adversely.

Maximum range through moderately dense timber and under line-of-sight conditions was about 1¼ miles. Maximum range through dense timber in mountainous terrain was about one mile. Optimum range with a portable receiving unit was ½ to 3/4 miles. Battery life ranged from 78 to 84 days for the 4 transmitters.

(35) Custom-built portable receivers with directional loop antennae proved adequate for this study. In tests for accuracy, using a stationary transmitter and readily visible land marks, the location error was ± 25' at ¼ mile. Raybourne suggested use of the yagi antenna for locating birds at the beginning of the tracking period, but its antenna size for 26 mc to 27 mc reception would restrict its use in timbered terrain, except as a permanent or semi-permanent structure.

(36) Only one of the marked birds has been recovered to date. Mosby (pers. comm. 1973) reported one of Raybourne's turkeys was recovered in February 1973 across Route 311 from Broad Run about 4 miles from where it was captured, marked, and released at clearing No. 14. Mosby stated:

> "The harness and radio were still attached, but the man who 'captured' the turkey said it was in poor condition, weighing no more than 7-8 pounds and that the feathers below the radio were worn off and the flesh was black. The harness was in excellent shape and had to be cut off. No leg bands were turned in, but the bird could be definitely identified from the number on the radio transmitter."

(37) Monitoring techniques: The time lapse involved (from 3 to 5 minutes) when the investigator moved from one station to another was a potential source of location error; however, this time lapse did not appear to cause any significant error in the movement data since the marked birds did not move long distances or at a rapid rate. This error factor could be reduced by using receivers and a communication system between 2 observers so bearings could be obtained simultaneously.

Raybourne captured 4 immature wild turkeys---3 hens and a gobbler. The birds were trapped and banded when about 133 days old. The day before the hunting season began the birds were 163 days old. Bands, indicating a number, sex, age, weight, and length of the number 10 primary feather, length of spur or beard and transmitter number were attached to the leg of each bird. Also, each turkey carried a radio transmitter containing batteries, which was attached to the bird by a harness (all weighing $\frac{1}{2}$ lb). Raybourne used 2 tracking periods---80 days before the fall hunting season and 83 locations during the hunting season. The 4 birds remained together throughout the study.

Concerning the home ranges of these immature wild turkeys:

(38) The marked birds consistently used an estimated 350 to 500-acre area.

(39) The minimum home range prior to the hunting season was 425 acres compared to 552 acres during the hunting season.

(40) Prior to the hunting season, 80 radio locations were recorded. Home range major axis was 1.50 miles and minor axis was 0.68 miles. Distance between extreme diel locations (DBE) ranged from 0.23 to 1.48 miles and averaged 0.84 miles. The minimum total distance moved in a diel period (MTD) ranged from 0.24 to 2.60 miles and averaged 1.47.

(41) During the hunting season, 83 radio locations were recorded. The major axis was 1.60 miles and the minor axis was 0.95 miles. DBE ranged from 0.50 to 1.40 miles, averaging 0.98 miles. MTD for the period ranged from 0.75 to 2.68 miles and averaged 1.69 miles.

The location of the range did not shift drastically from pre-hunting to hunting period. In fact, the shift was so small that it could not be definitely determined that hunting pressure was responsible. Vehicular disturbance by hunters could have caused the shift.

(42) Prior to the hunting season 29 radio locations (36%) occurred north of the access road while only 9 (11%) occurred north of the road during the hunting season.

Concerning activity periods of the immature turkeys:

(43) There were 2 distinct periods of daily activity—late morning and late afternoon. Periods of lesser movement were early morning, mid-day, and early afternoon.

(44) The average distance traveled/day was 1.47 miles during the

tracking period prior to hunting, and 1.69 miles during hunting.

Concerning rate of travel:

(45) The average daily rate of travel varied little between 2 tracking periods. The birds averaged 0.169 miles/hr during the hunting season.

Concerning habitat preference:

(46) During the study period, turkeys were not observed in the interior of a 60-acre clear-cut area even though the periphery was used. This was especially apparent during the hunting season.

Concerning the effect of weather on movements:

(47) A temperature range of 36° F to 72° F during the study produced no discernable effect on the birds' activities. Precipitation did not seem to affect movement adversely.

Martin's Work

Because of scarcity of information on food of young turkeys and lack of quantitative and qualitative information on attractiveness of forest wildlife clearings on wild turkey, Martin (1972) sought to determine the following:

(a) The effect of insect availability on wild turkey use on forest wildlife clearings

(b) The percent protein and caloric content of food eaten by turkey poults

(c) An examination of techniques for the removal of crop content

(d) Any differences between using turkey poults and standard entomological techniques to sample insect availability

In carrying out his objectives, Martin sampled with 120 domestic poults which were about equally divided into 2, 4½, and 7½ week-old groups. These groups were sampled separately in paired pens. Four clearings were selected for both poult and insect population sampling sites. Four plots in each of these clearings were matched with plots in adjoining woods. Insect samplings were collected by the D-Vac machine.

In analysis of food eaten by the poults, Martin gathered crops and gizzard contents. The contents were sorted, dried, and weighed under 3 categories: insects, vegetation, and unidentifiable matter.

Concerning turkey poults and wildlife clearings:

(48) There was no significant difference in the amount of insects eaten by domestic turkey poults in clearings and in wood plots.

(49) Seven and one-half week old poults consumed significantly more vegetation in clearings than in woods.

These 2 findings were based on a 2-day analysis of variance with replicates of the dry weight figures of crop and gizzard contents.

(50) The percentage of vegetation to total food material was significantly higher in 7½-week poults that fed in clearings than those that fed under the forest canopy, in both crop and gizzard (according to analysis of variance and use of arcsin percent transformation).

(51) When insects were sampled by the D-Vac technique, there was a highly significant difference (at the 99% level of confidence) in the amounts of insects in clearings, and the amount of insects under the forest canopy (using the t-test of insect dry weight). There were 25 times as many insects in the clearings when all samples were totaled (using the D-Vac machine).

Martin (1972:65) stated:

> "This contradiction to the findings obtained by using turkey poults as the sampling medium suggest that appetite may be a factor in insect consumption rather than availability of insects."

(52) Insects contained more crude protein than vegetation or unidentifiable parts of the ingested food material (according to proximate analysis of crop and gizzrd contents).

(53) There was significantly more calories in the insects taken with the D-Vac machine than the insects removed from the poults. This indicated partial insect ingestion within the bird. Caloric content of the insects was about 20% to 25% greater than the caloric content of the vegetation and unidentifiable matter. The tests indicated more calories in the softer body parts of insects.

Shugar's Work

Shugars (1971) had 3 objectives in his study and conducted his work on 2 areas. One objective was to determine the extent of movements of wild live-trapped turkeys released in unoccupied, suitable habitat. He obtained these turkeys by live trapping on the Gathright Wildlife Management Area near Hot Springs, Virginia, and released them for study in southwest Virginia. This part of his study does not concern this thesis.

Shugars' other 2 objectives involved the Broad Run Management Area. These objectives were: one, to determine the home range of a resident population of wild turkeys on this area, and two, to determine the reproductive attainment of a sample of juvenile hens from breeding season through the early brood-rearing season.

Attempts to capture a resident population of turkeys for instrumentation were unsuccessful because of delay in the delivery of transmitters from the manufacturers, and because inclement weather made access to the management area difficult. Trapping attempts began late, October 10. By this time visits to trap sites by turkeys had become irregular.

From this sequence of misfortune Shugars found good reasons why one should not try turkey live trapping in Virginia as late as October.

(54) Abundance of food in the form of fall mast will result in irregular visits to baiting sites by turkeys.

(55) Deer may also remove bait at night.

Shugars changed bait from whole corn to a mixture of whole corn and wheat. However, deer removed corn and wheat was not attractive enough to hold the birds.

The deterioration of the Broad Run access road because of precipitation made entry into the management area prohibitive for bird study.

Deer

Works by Quillen and Seneca

Quillen (1959) and Seneca (1961), the first 2 researchers to undertake studies in the Broad Run project, sought to determine distribution and abundance of deer, and their use of the habitat in the study area. These data were acquired through observation, and pellet group, snow track, and imprint plot counts. Many of their conclusions were obtained by analysis of variance (at the 95% level), t-test, and chi-square meth-

ods.

The researchers' conclusions were applicable only to the Broad Run Management Area. However, their findings might be similar to those found in studies elsewhere.

Concerning agricultural clearings:

(1) Deer used agricultural type forage to the greatest extent in the fall, according to seasonal track counts (Quillen 1959).

(2) A definite deer distribution pattern existed around clearings, based on transect lines, clearings, and pellet group count data. Using a fall pellet group count, a population estimate of 130 deer was derived (Quillen thought the estimate too high, and felt there should have been about one deer/100 acres, or 75 deer on the study area.)

(3) There was a significant difference in clearing usage at different times within the year, based on analysis of variance of imprint plot count data (Seneca 1961).

(4) There was no significant difference in clearing usage between years, according to the same test and indices used in (3) (Seneca 1961).

(5) There was no significant difference in clearing usage between seasons, between years, nor any significant interaction between seasons and years, using the same test and indices found in (3) and (4) (Seneca 1961).

(6) Seneca (1961) found a decrease in usage by deer of clearings as the clearings matured, according to snow track and pellet group counts.

Concerning water holes:

(7) Track counts showed usage of water holes varied directly with

available natural supply (Quillen 1959).

(8) There was a significant difference in usage of individual water holes, a significance "seemingly governed by the scarcity of natural water during intermittent periods of drought," according to analysis of variance of imprint plot data (Seneca 1961:90).

Concerning general distribution of deer:

(9) Compartment C appeared to be preferred over A and B, according to pellet and track counts, and sight observations on clearings (Quillen 1959). But Compartment B and C supported more deer than A, according to seasonal pellet counts over 1957-1961 (Seneca 1961).

(10) Seneca (1961) found, however, through snow track counts, that Compartments B and C received much more use than A (where there are no water holes or clearings) during 1959-1960, and 1960-1961. From June 1960 through March 1961 250% more deer were observed in Compartment B than in either A or C, but winter-month sightings indicated 300% more deer in C than in either A or B (because deer congregated in the lower elevations along Broad Run Creek).

(11) Forest cover types 1 and 2 (Pine-Bear Oak and Virginia Pine, respectively) and 3 (Mixed Oak-Pine) were used more by deer than types 4, 5, and 6 (Mixed Oak-White Oak; Oak-Hickory-Poplar-White Pine; and Chestnut Oak-Mixed Oak, respectively), according to analysis of variance of pellet group counts. The cover types were placed in 3 groups because of biological similarities. Observations from June 1960 through March 1961 resulted in 65% of the deer being seen in Type 3.

(12) There was no significant difference in the number of pellet groups found on northeast as opposed to southwest exposures, according

to Student's t-test (Seneca 1961).

(13) There was no significant difference of deer use between 3 strata of percent slope; 0-31, 31-60, and 61-100, according to analysis of variance (Seneca 1961).

(14) There was no significant difference in deer use in the 4 topographic features--ridge, slope, flat, and ravine, according to analysis of variance (Seneca 1961).

Concerning winter distribution of deer:

(15) Some 66% of deer track counts during the winter of 1958-1959 were recorded in 3 adjacent clearings in lower elevations of the study area in Broad Run Creek Valley where there are patches of honeysuckle (and a definite browse line) and conifer cover (Quillen 1959). This was borne out by sightings as discussed in (10).

(16) On a 7% strip pellet group sample in a one-acre honeysuckle patch, 136 pellet groups were recorded during the winter of 1958-1959. This became 1943 groups, or 140 deer-days of use on a per-acre basis. During the same winter, a pellet count was conducted in a clearing and the 19 groups recorded were expanded to a per-acre basis and produced only 1.5 deer-days of use (Quillen 1959). This implies deer will not frequent exposed places during cold weather.

Concerning Brush Mountain Control Area:

(17) Snow track counts in the winter of 1958-1959 showed 2 deer and 16 dogs--the latter being, therefore, a limiting factor on the deer population (Quillen 1959, and Seneca 1961).

Concerning techniques for deer study:

(18) Snow track counts were a reliable index for indicating deer

herd density (Quillen 1959).

(19) The 1/100-acre circular plot was the optimum plot size for use in pellet group counts (Quillen 1959).

(20) Optimum time interval for ennumeration of imprint plot counts at agricultural clearings and around waterholes was one week (Seneca 1961).

(21) The t-test revealed a significant difference between winter and summer pellet counts because of dung beetle activity. Adult dung beetles and their larval stages are known to destroy pellet groups during spring and summer. The winter count is considered the best seasonal count (Seneca 1961).

Miscellaneous findings by Quillen (1959):

(22) Deer observations indicated a buck-doe sex ratio of 1:0.9; doe-fawn ratio of 1:0.9.

(23) There was no tree species preferred for "buck rubs."

(24) Favorite natural deer foods were smilax, red maple and sourwood.

(25) Preferred agricultural forage for deer was clover.

(26) Apples were best deer bait for deer trapping.

Perry's Work

Broad Run was one of 3 areas used by Perry (1970) in his study of free-running dogs. The other 2 areas were Big Levels Wildlife Management Area, and Poverty Hollow. The areas were selected because of their previous dog problems. Five techniques were used for learning more about the movements and activities of dogs and their possible influence on

deer. These were rural inhabitant surveys, radio telemetry, sand plot track counts, questionnaires, and trapping.

From these techniques Perry (1970) concluded the following:

(27) Because of the great time required for observation, and because of the unpredictability and infrequency of dog movements, telemetry was found to be inefficient in measuring these movements. During the study at Broad Run, 11 dogs were tracked for 264.5 hours, but no significant movements were recorded for any of these dogs. The costs/unit of information gained by this method were very high.

(28) There was a probable inverse relationship between the number of residents for which a dog warden is responsible and the percentage of licensed dogs in the area. Through a rural inhabitant survey, with the aid of county dog wardens, it was discovered that the greatest percentage of licensed dogs among the 3 areas was at Broad Run. This was probably because of the fewer number of residents in the county.

(29) The most successful technique used to measure dog activity in this study was the activity index from sand plot track counts.

(30) There was no significant difference in dog activity between the 3 areas and 3 seasons (summer, fall, and winter), according to analysis of variance of dog track data taken from 10 sand-plot tracks in each area. The Virginia Department of Health rabies control trapping data indicated dog activity to be greatest during winter and spring, and the lowest during summer and fall. As observed by wardens and biologists questioned, dog activity was greatest in spring and during dawn and dusk.

(31) Activity of dogs seemed greatest between 7 A.M. and 10 A.M.

(32) About 50% of deer killed by dogs were healthy deer, according to responses to questionnaires sent to Virginia game wardens and game biologists. Those questioned, however, said they investigated only a small number of deer killed by dogs.

(33) Hounds and mongrels were blamed for causing the most damage to deer, according to wardens and biologists questioned.

(34) One hundred percent of the 14 biologists questioned and 80.4% of the 109 responding wardens felt dogs affected the natality of deer, mainly by them pursuing pregnant does.

(35) The deficiency in useful data on dog-deer relationships was most likely due to the subjective (bias) approach to the problem and the controversial nature and complexity of negative influences of dogs on deer. Wardens were asked to state whether a dog could kill a healthy adult deer. A chi-square analysis indicated the responses were independent of whether the wardens owned a dog or not, but a relationship did exist between this question and whether or not dogs were legally used to hunt deer in the questioned-warden's county. Where dogs were legal for hunting deer (eastern part of the state), significantly fewer wardens of such areas believed a dog could kill a healthy adult deer. Such wardens may also undervalue a dog's capacity to destroy an adult deer because, in the east, there are more water areas (swamps) where deer could seek refuge. In the western mountainous section of Virginia, there may be a greater energy drain on chased deer, and this may be why wardens from this area rated highly a dog's deer-killing ability.

(36) Relatively little is known about the age or condition of the type of deer most often killed by dogs. Data on age and condition of

deer killed by dogs is usually not recorded.

(37) Dogs are probably serious predators when an area is newly restocked with deer, or at times when deer populations are low. The magnitude of the dog problem would appear to dissipate with the increase in the deer population because dogs would be crossing more tracks and be sidetracked more often. Chased deer would find more rest times.

(38) Enforcing dog laws seemed to be the most effective way to control free-running dogs. Trapping, poisoning, and shooting should only be employed as control measures when enforcement methods are ineffective.

(39) Little evidence in Perry's study indicated dogs to be a problem of great magnitude statewide. The influence of dogs on deer populations is purely speculative and lacks substantial proof.

Wildlife Agricultural Clearings

Two studies at the Broad Run Wildlife Research Area concerned agricultural clearings in forests. Trumbo (1963) concerned himself with herbicides as a clearing tool, and Larson (1966), in the only doctoral dissertation to come out of the area, gave a critical appraisal and pinpointed the needs of such clearings.

Trumbo's Work

Trumbo (1963) studied the techniques in using chemicals for establishing wildlife clearings. He sought to determine the possibility and feasibility of creating clearings by using herbicides rather than such conventional methods as bulldozing and hand clearing.

Four herbicides were tested: Monuron, Fenuron, 2,4,5-T, and ammonium sulfamate. Ten herbicide test sites were picked and stratified for treatment on Broad Run's Compartment E. Each test site was a square plot, ranging from 0.27 to 1.60 acres, and was divided into 4 equal sections, one of the 4 herbicides being applied to each.

The effectiveness of each herbicide on major woody species--expressed as percent kill--was determined by total stem counts in each clearing, both immediately after application and after one complete growing season.

Herbacious sample plots, 1/100 acres in size, were established in 4 areas representing 4 topographical features. Two stem counts were made on each of these 4 areas.

Monuron and Fenuron, applied at rates of 5 and 10 g/stem, or clumps of stems produced the following results:

(1) They killed more than 80% of 10 out of 14 species treated.

(2) These dry chemicals were effective agents for killing most major tree species and are easily transported into inaccessible areas.

(3) Fenuron proved to be practical because of its quick results.

Ammonium sulfamate and 2,4,5-T were applied to frills at respective rates of 7 lbs of crystals/2 gals of water and 12 lbs (active ingredient)/100 gals of No. 2 diesel fuel. Ammonium sulfamate was applied on overlapping axe cuts, while the 2,4,5-T treatment was made to axe cuts spaced about 4" apart. Concerning the results of the above 2 herbicides:

(4) An 89% crown kill was obtained on all woody species in ammonium sulfamate-treated areas, but 66% of all treated stems resprouted. Trumbo (1963:61) felt "frills should be made near the root collar for more com-

plete kill."

(5) A 15% kill on all woody species treated with 2,4,5-T was had.

(6) The 2,4,5-T applied to axe cuts spaced 4" apart was not a satisfactory way of killing woody species; rather a complete frill.

Larson's Work

Larson's (1966) expansive dissertation on wildlife forage clearings on forest lands included a critical review and appraisal of the subject, plus a presentation of research needs in the area. His objectives were both "to determine the nature and extent of forage clearing practices in forests of the eastern United States for game-animal management," and "to critically evaluate the present body of knowledge concerning the contribution of this practice as a basis for programing effective research," and for "providing guides for interim management policies and procedures pending expanded knowledge (Larson 1966:8)."

Larson's critical review comprised 4 parts. It traced the history of the creation and maintenance of forest clearings from 1935-1965, inventoried the extent of the practice, critically reviewed the basis for the practice, and made scientific research and management recommendations based on the review. The study concerns only one type of clearing practice--clearings in forest habitat planted in agricultural forage crop species (herbacious agricultural, or native plants), or left as simply grassy openings.

In an 18-page literature review, Larson (1966:10-28) presented the evolution of thought on forage clearings as a game management technique, from 1911-1964. The sweep of such a review runs as follows:

(7) In the "beginning" the question of wildlife food needs under mature forests was recommended for research. In 1928, it was recognized that "critical factors of the environment" had something to do with presence or absence of certain animals; in 1930, Leopold asked for research to discover the means of manipulating forests for game preduction ("edge effect" reference); in 1931, Stoddard advocated opening up woodlands and maintaining open cultivated acres at frequent intervals (his quail habitat manipulation inspired game managers to apply his recommendations for such species as deer and turkey); in 1933, Leopold defined "edge effect" and introduced the concept of diverse types of vegetation in juxaposition, a concept which recognized certain species to be associated with certain vegetative types (this came to be known as "law of dispersion"—frequent juxaposition of diverse types determines population density); by 1936, foresters and game managers were accepting possibility of coordinated effort in using openings in the forest for the benefit of game; in 1937, the plantings of agricultural food species in clearings was being introduced; by 1938, clearings were becoming popular as a tool of game management and, in that year, plantings of buckwheat for turkey was undertaken on Virginia's Big Levels Wildlife Management Area; studies on clearings as a tool for management of such species as quail and ruffed grouse proliferated and through the 1940s estimates were being introduced on what percentage of the forests should be opened for species; by 1945 extensive incorporation of clearings in wildlife habitat was begun on eastern National Forests with federal and state funds; by this time, clearings were being regarded not only as an essential element in varied native vegetative habitat, but as a source

of supplemental food. Wheeler's 1948 work was a major influence on clearing installation, as he declared well-distributed forest clearings to be the key to a turkey management program in Alabama. Wheeler's publication became an important manual on agricultural treatment, crop rotation and listed advantages and disadvantages of various crop species used in clearings. By this time "clearings were finally entrenched as a provider of supplemental food in most states using them." From 1950 various investigators worked to answer many questions still left unanswered by research. Sweet found deer populations to be in direct proportion to intensity of management, but found it difficult to correlate the number of clearings with deer populations. Bailey , in 1951, suggested higher fertility in clearings as a possible explanation for the attractiveness of clearings and felt planted food held such disadvantages as furnishing species food at "non-critical" times, of being insufficient for turkey because of deer competition, and expensiveness. Larson went on to quote sources who worked on clearings, making comments and recommendations on planting of winter species, clearing shapes and sizes, bulldozing tactics, effectiveness of grassy openings, nutrient requirements and game species, expense and economics, and research problems.

Larson also documented the extent to which 22 eastern states have been involved in the use of clearings. Larson gleaned his information from unpublished administrative reports, through interviews, mailed questionnaires, and correspondence with federal and state wildlife representatives and officials and researchers, and through personal field inspections in states that seemed most heavily involved with the techniques. Status of clearings in the eastern states by 1966 was thus:

(8) In 1935 Ohio and Pennsylvania were the first states to install organized use of clearings. Mississippi started somewhere between 1935 and 1939, Maryland and Virginia in 1936. Larson credited work by Stoddard and Leopold as influencing these early programs. During the period immediately after World War II increased funds and personnel revived game management programs, and from 1945-1947 Texas, West Virginia, Alabama, Georgia, New Jersey, Kentucky, and Florida initiated clearing projects. Work by Mosby and Handley in 1943 added support to the creation of clearings. Wheeler's 1948 turkey bulletin helped initiate clearing installation programs in other states—South Carolina in 1948, North Carolina in 1949, Tennessee and Oklahoma in 1950, New Hampshire in 1951, Indiana in 1953, Louisiana in 1954, Illinois between 1950 and 1954, Missouri in 1959, and Massachusetts in 1964. Up to the time of Larson's work, New York had no organized program for creation of agricultural clearings.

Larson's latest findings on clearing installations among the states were as follows:

(9) Clearings were located on state-owned land administered by game and forestry agencies (like that at Broad Run), on privately owned lands, and on federal land administered by the U.S. Forest Service and other federal agencies, or on National Forest land—on which 1/3 to ½ of the total acreage in forage clearings occur.

(10) Most states have clearings and are continuing to maintain those already established.

(11) There seems to be some trend toward new agricultural clearings, but at a reduced rate of installation.

(12) With a few minor exceptions, all agricultural clearings are now created in a similar manner (trees removed by bulldozing or through timber sales; brush and slash piled around borders; seed bed preparation through some form of plowing, disking or harrowing).

(13) Nearly every state has attempted to grow a great variety of crops on forage clearings.

(14) Both local experience and experimentation have been used in each state. Experience comes from farmers near management areas and experimentation usually means a conscious effort to find a species that will meet a specific need.

(15) As a group, states have progressed through several stages with regard to crop species. Annual plantings of high-energy species were initially tried and replaced by perennials. Among perennials the trend is away from species requiring mowing to more self-maintaining species.

(16) Nearly every state has used standard soil tests on clearings, to some extent, as the basis for soil fertilization. Usually soil tests are used sparingly. One test may be made at the creation of a clearing and all future periodic applications are based on it; or one clearing is deemed representative of a local group after it is tested.

(17) One to 3 tons of lime/acre is the common initial treatment. Most states tend toward a "standard application as time passes and the clearings program grows."

(18) Maintenance amendments usually consist of top dressings applied on an annual schedule, or as often as not, are left up to the "observation of needs" as determined by the local manager.

(19) Actual sizes of clearings installed in the various states

range from a low of 1/10-acre to a high of 30 to 60 acres, most commonly one to 3 acres. Size of clearings are usually determined by the amount of money and site size available.

(20) In practice, in almost all states, shape of the clearing is determined by shape of the available site. Most often they are rectangular for ease of cultivation.

(21) Location of the land itself is the first consideration in the selection of a clearing site, and because National Forest and state-owned land is usually involved, this means the site is located on land of rugged topography and of low agricultural value. Permanent clearings are often located on land least desirable to the forester.

(22) Old field sites were used in preference to making a new opening, if the choice was open to the states.

(23) In practice, the U.S. Forest Service's recommendation to have 5% of the forest in permanent opening has rarely been reached.

(24) Some states have developed plans for spacing clearings--all governed by access road patterns to some degree. In most states where a percent goal is set, tentative locations are determined by some kind of grid plan.

(25) Larson failed to find any objective evidence, or investigations, to support percent area goals or specific patterns for clearing distribution among the states.

(26) Biologists throughout the states think providing supplemental food is the major role of clearings in forest-game management programs. Second most cited role is the addition of "edge effect." A few states listed either the influencing of game harvest, public relations, influ-

encing of animal distribution, or creating jobs for refuge managers to be the prime role of clearings.

(27) There is almost a complete lack of studies to measure wildlife utilization of vegetation planted on clearings, or to measure the effects of clearings on animal numbers or distribution. There is a similar lack of information on the effect clearings have on hunter success, distribution, and use of management areas.

(28) No studies have been conducted on the "input and output" economics of clearings. However, installation costs as estimated by the states ran from $15 to $1,000/acre. Costs in the coastal plain and Piedmont ranged from $15 to $100/acre; in the mountains, $200 to $400/acre; where mowing and top dressing alone is involved, $50 to $90/acre.

The third part of Larson's work was to evaluate the basis for clearings. Larson took the host of conclusions about clearings as given by game managers and, in the light of existing knowledge, appraised these conclusions as either 1. Valid 2. Invalid 3. Tentative or meaningless, pending more information.

Larson discussed all conclusions given by the managers as directly influencing the use of agricultural clearings in forest-game management. Then Larson, in summary, listed the conclusions as follows (Larson 1966: 96-98):

(29) Valid conclusions:

> "1. Diversity of vegetative cover is correlated with forest game abundance.
>
> "2. Openings are a necessary component of forest-wildlife habitat.
>
> "3. Where openings do not exist, they should be

created.

"4. Based on the current state of knowledge, agricultural clearings supplement to food base of forest game only through introduction of additional plant species.

"5. Planting or encouraging growth which will tend to maintain the open character of a clearing is a valid effort as long as least expense guides the selection of the technique.

"6. Soil condition on prospective clearing sites is an important consideration frequently given only lip service in practice.

"7. 'Edge' as a basic component of diversity, is a needed factor contributed by clearings.

"8. Agricultural clearings have value as a public relations tool, but with decided reservations.

"9. Human use of an area is directly influenced by the access pattern afforded by an existing system of clearings, but except for special requirements such as bowhunting, the clearings themselves contribute little to the actual use."

(30) Invalid conclusions:

"1. Supplemental food plantings are essential for forest-game species.

"2. Economic studies of game management are not necessary.

(31) Conclusions not meaningful because of lack of information:

"1. The qualitative and quantitative means by which agricultural clearings may supplement the food base

"2. The role agricultural clearings play in game production

"3. The value of planting clearings to crops which involve expensive maintenance

"4. The applicability of standard agronomic recommendations as guidelines in clearing management

"5. Optimum size and shape of clearings

"6. Optimum percent of a management unit to devote to clearings and pattern of distribution of clearings

"7. Determination of how much, where and what kind of 'edge' should be contributed by clearings

"8. The degree to which animal use of agricultural clearings is an expression of need or preference

"9. The extent to which agricultural clearings increase man-animal contacts"

Meaningful conclusions which cannot be drawn because of lack of information demonstrates areas where there is a need for research. The research needs constituted Larson's recommendations.

(32) He found information inadequate in 4 basic problem areas (Larson 1966:99-100):

"1. The need for base line information on existing range food resources (quantitative and qualitative) is pertinent to understanding: the possible supplemental food role clearings may play; the need for maintenance of expensive crops; the value of agronomic recommendations; the optimum size, shape, density and distribution of clearings, and the need for added 'edge.'

"2. The need for reliable estimates of animal numbers is pertinent to all but the last of the areas listed in '1' and is also needed to better understand: the role agricultural clearings play in game production, and the degree to which signs of animal use are indicators of preference or need.

"3. The need for better animal behavior information is essential to understanding optimum size, shape, percent of area devoted to clearings and distribution of clearings; what needs there may be for added 'edge'; the degree to which animal use of clearings expresses need or preference, and to what extent agricultural clearings increase man-animal contacts.

"4. Studies of hunter behavior are also needed to asses the role clearings play in man-animal contacts."

Larson concluded by discussing these needs in more detail, suggesting various avenues of approach, pinpointing various aspects of these

problem areas in more detail, and presenting some of the guidelines that have been used in the past.

Foxes

Oleyar (1969) aimed his thesis at the population-control problem of the fox, which, as a rabies vector, is a threat to man's interest and welfare. Oleyar said the present program for vector population control, using state trappers, is inadequate, expensive and time consuming. He also saw fox population manipulation as necessary because of the fox's role as a predator. Predator control may be needed more in the future as stresses on other wildlife populations increase with the shrinkage of habitat.

Oleyar observed foxes to be rather resistant to conventional control methods (increased mortality) and he proposed the use of chemosterilants (antifertility agents) as the better method for suppressing fox production. To prevent fox reproduction by the latter method, 2 considerations are uppermost: first, the antifertility agent applied must be suitable, and second, the target species must be treated at an appropriate period in the breeding cycle.

The objectives of Oleyar's study were: (1) to determine the feasibility of using the chemosterilant disthylstilbestrol (DES) as an agent for reducing reproduction in a wild fox population and (2) to field-test techniques of administering chemosterilants to foxes.

In addition to Broad Run, which was used as a principal reference area, 2 other study areas were involved in this study--the Havens Wild-

life Management Area, a 6,000-acre tract on Fort Lewis Mountain, Roanoke County; and the city dump of Salem, Virginia, a second reference area.

The field activities comprised pre-baiting followed by application of baits (of ground beef suet) treated with DES as the hormone used for disrupting pregnancy. Application of an oral marker, demethylchlortetracycline (DMCT), was used to identify treated foxes. This work was done from late January to late March, the optimum breeding period for gray fox, the primary target species. The 2 main phases of Oleyar's study were treatment of population and collection and processing of specimens. For the latter phase, 614 treated baits were distributed from April 21 to June 3, 1968.

All pre-baiting and baiting of sets took place on the Havens area, while Broad Run was involved as one of the 3 trapping areas. For reasons of continuity Broad Run's involvement will not be separated from work done on the other 2 areas during the trapping phase of Oleyar's study.

Concerning sex and gray and red fox trapping ratios:

(1) Both Broad Run and the Havens areas showed the expected 50:50 sex ratio among red foxes (no red foxes were trapped at the Salem area).

(2) The sex ratio for gray foxes showed 55:45 for Broad Run, 33:66 for Salem, while the Havens area was significantly in favor of males at 68:32.

(3) Gray to red fox ratio was 5:1 on Broad Run, 5.2:1 on Havens.

(4) Based on total land area, Broad Run's study area (17.8 square miles) produced 0.6 gray foxes/square mile, o.1 red foxes/square mile, and 0.7 total foxes/square mile; while Havens respectively produced/ square mile—1.0, 0.2, and 1.2.

Concerning the incidence of marking (Oleyar 1969:42):

(5) "Apparently DMCT was a satisfactory marker. A clear-cut demarcation was observed between marked and unmarked animals; specimens showed either obvious evidence or no evidence of flourescence (of bone specimens examined under long-wave ultra-violet light)."

Evidence of the marker was observed for animals collected from the Havens area only. No evidence of marked animals occurred at Broad Run, none at Salem. Five of 6 gray females trapped on the 2 reference areas had successfully reproduced.

Concerning reproductive success:

(6) The DES treatment had no obvious effect on red fox reproductive success, all 3 red females captured having successfully reproduced (although none was marked).

(7) Among gray foxes, from the Havens treatment area, 6 of 6 failed to reproduce. Five had been marked. "Perhaps most significant was that none of the 6 animals ovulated as evidenced by the absence of corpora lutea (Oleyar 1969:44)." A chi-square test indicated unsuccessful reproduction on the Havens area to be associated with the treatment.

Concerning age and physical characteristics:

(8) Single eye lens weight (or the mean of both when available) ranged from 224 mg (yearlins) to 277 mg (older animals) for red foxes; for gray foxes from 163 mg (yearlings) to 216 mg (older animals).

(9) Correlation of tooth wear with lens weight was very good for red foxes, but for gray foxes, there was little consistency or predicability.

(10) The 2 criteria above permitted assignment of some animals

to discrete age classes.

Concerning parturition and breeding dates:

(11) Parturition dates, based on relative enlargement of post-partum tracts, were estimated between early March and mid-April for the 3 red female foxes. Taking into account the 53-day gestation period, breeding dates were estimated between mid-January and the third week in February.

(12) The 5 successful gray foxes apparently gave birth between late March and early May, corresponding breeding dates (53-day gestation) being from late January to late March.

The Hunter And The Weather

Curtis (1971:1) undertook an ambitious thesis "designed to supply new information about the interactions of hunters, white-tailed deer, and climatic conditions," and he examined "the overall influence of climatic conditions on the magnitude of deer-to-hunter contacts" at the Broad Run Wildlife Research Area. The reasoning behind Curtis' objective was as follows:

> Deer harvesting is an important means of controlling deer population size. Weather is an important factor in determining hunter population size, and, therefore, frequency of hunter-deer contact. Weather, therefore, can make the difference between an adequate or an inadequate deer harvest. An adequate harvest is one in which all, or nearly all, surplus deer are removed.

Curtis sought to identify the climatic variables significantly affecting hunter-deer contacts. Also, through mailed questionnaires, Cur-

tis sought to determine what influences, if any, certain weather factors had on deer hunters. Knowing what weather factors are significant for deer-hunter contact, one could help explain why a harvest was or was not adequate. Also, weather forecasts could lend more predictability as to what kind of success one might expect from an upcoming deer season.

Curtis compiled, tabulated, and analyzed data associated with daily sightings of deer by hunters at the Broad Run Wildlife Research Area. As Curtis (1971:31) stated:

> "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 season."

Curtis used 2 tools of statistics in evaluating weather variables and their possible effects on hunter-deer contact--multiple linear regression analysis and the linear correlation coefficient.

At this juncture, it may be well to interject discussion of the meanings of these 2 terms. Sokal and Rohlf (1969:404-405, 496) stated that regression estimates the relationship of one variable with another by expressing the one in terms of a linear function of the other; a function being a mathematical relationship enabling one to predict what values of a dependant variable "Y" correspond to given values of an independent variable "X". "In correlation, by contrast," they explained, "we are concerned largely whether two variables are interdependent of covary--that is, vary together...A more typical assumption is that the two variables are both effects of a common cause. What we wish to estimate is the degree to which these variables vary together." The correlation coefficient is designated by "r". As Curtis (1971:59 pointed

out, a correlation coefficient of -1.0 represents perfect negative linear association, while +1.0 represents perfect positive linear association. "R^2" is the coefficient of determination, defined as the percentage of the corrected sum of the squares that is "explained by" the fitting of the multiple linear regression. R^2 is referred to by saying that a certain percentage of the variation of the dependent variable is associated with the multiple regression.

Curtis was concerned with 3 dependent variables--number of deer seen/day; number of deer seen/hunter/day; and number of hunters/day. Weather variables were average daily temperature; amount of precipitation on day of the hunt; amount of precipitation 24 hours before 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).

Curtis' findings were as follows:

(1) Concerning the number of deer seen/day, there was one significantly correlated (at 90% confidence level) variable (tested singly)--number of hunters/day ($r = 0.736$). This implies that the number of deer seen/day increased with the number of hunters/day.

(2) Together, number of hunters/day and average daily temperature were significant in the multiple linear regression equation (at 90% confidence level). The R^2 was 0.5706, meaning these 2 independent variables accounted for 57.06% of the variation in the number of deer seen/day. Number of hunters/day alone accounted for 54.16% of the variation.

(3) Average daily temperatures and total precipitation on the day of the hunt were 2 weather variables significantly correlated (at the

90% confidence level) to deer seen/hunter/day. Total precipitation was positively correlated ($r=0.394$); average daily temperature was negatively correlated (-0.282).

(4) Total precipitation and average daily temperature on the day of the hunt, significant in the multiple linear regression equation at the 90% confidence level, accounted for only 27.3% ($R=0.2726$) of the variation in the number of deer seen/hunter/day.

(5) There were no weather variables that were significantly correlated (at the 90% level) to the number of hunters/day on low hunting-pressure days.

(6) An independent variable—year—was significantly correlated (at the 90% level) to the number of hunters/day ($r=0.543$), but accounted for only 28.4% ($R=0.2836$) of the variation in the number of hunters/day on low hunting-pressure days.

(7) On heavy hunting-pressure days, year was found to be positively correlated to the number of hunters/day ($r=0.709$), while total precipitation on the day of the hunt was negatively correlated ($r=-0.335$).

(8) In multiple stepwise regression analysis, 3 variables were found to be significant to number of hunters/day on heavy pressure days—year, total precipitation on the day of the hunt, and average wind speed on the day of the hunt. These 3 variables accounted for 63% ($R^2=0.630$) of the variation in the number of hunters on opening day, Saturdays, and holidays.

Curtis (1971:84) wrote:

> "There is no reason to believe that the weather conditions recorded during the seven hunting seasons (1964-70) were not typical for the Broad Run area...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."

Curtis indicated the failure of weather strongly to influence these variables was because of the comparatively mild weather at Broad Run and the short deer season west of the Blue Ridge (a fact encouraging hunters to take every opportunity to hunt).

The second part of Curtis' thesis dealt with mailed questionnaires sent to hunters. The questionnaires asked hunters about the influence weather had on their hunting habits. There were 114 usable returns. Their results were as follows:

(9) When asked how many other men these hunters usually hunted deer with, 14% replied they usually hunted alone, 33% with a buddy, 29% in groups of 2 or 3, and 24% with a group of 4 or more.

(10) Most frequent method of hunting: 8% on organized drives; 23% walking-stalking; 69% still hunting-sitting.

(11) Would bad weather prevent them from going on a planned week-end deer hunt? Fifty-four percent answered "yes". The 2 weather conditions most likely to prevent their going hunting were: heavy rain, 74%; deep snow, 63%; severe cold, 32%.

(12) Would bad weather prevent them from going deer hunting on the first day and last day of the deer hunting season? Fifty-four percent answered "yes". The 3 weather conditions listed most frequently were (in descending order): heavy rain, deep snow, and severe cold.

(13) Were their chances of seeing a deer affected by weather conditions? Some 81% of the respondents felt it would. What were the worst weather conditions for seeing deer? Of the respondents, 79% felt

high winds were the worst weather conditions, while 57% felt heavy rain, and 44% felt a dry forest floor.

(14) What weather conditions would constitute the ideal deer hunting weather? No wind, 80%; damp forest floor, 73%; cool temperatures, 70%, and overcast skies (no rain), 40%. Very few felt either cold or warm temperatures, in themselves, made ideal deer hunting weather.

(15) Would weather conditions greatly affect the number of other hunters who would go hunting? Ninety-nine percent answered "yes".

(16) Would weather conditions greatly affect the total number of deer killed during the season? Seventy-one percent answered "yes", while 23% felt they did not know.

Curtis concluded from his returns of the questionnaires that most hunters placed greatest importance on personal comfort and the technical aspects of the hunt.

Songbirds

An ever-expanding population is putting an increasing demand on our National Forests. More than ever before this fact places greater significance on none-consumptive wildlife. Hooper (1967b) pointed out the need for more information on what effect forest management has had on such non-consumptive wildlife as songbirds. More specifically, Hooper sought to determine the influence of timber removal, wildlife clearings, and forest cover types on bird populations in southwestern Virginia. His "proving ground" was the Broad Run Wildlife Research Area.

The Broad Run area was characterized by Hooper as a "typical forested area" of southwestern Virginia, i.e. where timber was in the pole

stage (at least 6 years after cutting) and where the soils were "inherently infertile."

Hooper used transects 1,000' x 200' (4.6 acres) as sampling sites for bird observation. Four transects (16 total) were used each on middle slope cut, middle slope uncut, bottom slope cut, and bottom slope uncut areas. Crossing wildlife clearings, 3 transects were located on middle slope cut areas and 3 on uncut stands. Twenty transects were located along the Deer Trail and Turkey Trail.

Cover maps were prepared for each transect. On these maps forest type boundaries and other important features were recorded. Quantitative measurements of vegetation (tree d.b.h., percent crown closure, shrub-layer density) were also recorded after 10 wedge prism plot centers were located throughout each transect.

In estimating breeding bird populations, Hooper used the spot-map method in conjunction with the transects. His indices were the singing of the males and visual observations of both sexes. The sex, location, and relative age were recorded on a tally sheet each time the transect was sampled. A minimum of 3 trips was made to each transect, for a half-hour each trip. Relative abundance of birds during non-breeding seasons was calculated by finding the average number of times a species was observed on a certain transect. On Deer and Turkey Trails a composite number of breeding pairs and average number of birds observed in each cover type were obtained on a per-acre basis.

Hooper's study compares the bird density of given species and the bird species' diversity under different circumstances—at cut and uncut sites; at middle and lower slopes; along trails and through clearings;

under different forest types and during different seasons. Hooper presented his results by seasons.

During the breeding season (May 16-July 6), Hooper found that slope position and cutting practice had a significant effect, in most cases, on breeding bird densities and the number of breeding species found on the transects. He found:

(1) There was significantly more breeding pairs on cut and uncut bottom slopes than on cut and uncut middle slope transects, respectively.

(2) Significantly more pairs of birds were discerned on uncut bottom slopes than uncut middle slope transects.

(3) The difference in pair densities between cut bottom and cut middle slope transects was not significant.

(4) The number of breeding species were higher on cut and uncut bottom slopes compared to respective cut and uncut middle slopes.

(5) Cut middle slope transects produced significantly more pairs than uncut middle slopes.

(6) More different species pairs were found on cut middle and lower slopes than in uncut middle and lower slope transects, respectively.

(7) No significant difference was found between breeding bird densities on transects with wildlife clearings than those without clearings.

(8) On middle slope transects with clearings, cut slopes averaged significantly more breeding pairs and numbers of species than uncut slopes.

The middle slope sites were designated well-drained areas supporting mixed oak-pine stands. Bottom slope sites supported oak, hickory,

poplar, and white pine stands that were more productive because of a better soil and proximity to water.

Hooper also followed the method for comparing different ecological bird communities. These communities differed because of different numbers of species and density variation among various species. The comparison was based on the sum of differences in bird densities divided by the sum of all bird densities. Hooper found:

(9) The greatest percent difference between breeding bird populations was between uncut and cut middle slope transects (61%) and between uncut and cut middle slope transects with wildlife clearings (59%).

(10) A direct correlation ($r = 0.86$) existed between breeding bird density and the number of species inhabiting a given area. The more breeding pairs/acre the greater number of species existed. (This stands to reason because of the territorial behavior of breeding birds. Because, in a given species, density is regulated by territory, if there is an increase in overall bird density, it must result from the influx of more different species. Such an influx must mean more niches are available.)

(11) That the greater the percent crown closure in an uncut area, the lower the number of breeding pairs/acre ($r = -0.72$).

(12) The greater the percent shrub cover in uncut areas, the greater the breeding pairs/acre ($r = 0.68$). (Obviously, this means the greater the percent crown cover, the lower the percent shrub cover, with $r = -0.77$. Hooper recommended removal of certain canopy trees to increase breeding bird density by stimulating the understory.)

(13) The greater basal area at a site, the less the breeding bird

density ($r = -0.68$).

Concerning forest cover types sampled on Deer and Turkey Trails, Hooper found:

(14) Burned Oak-Hickory had the highest density of breeding birds and the second highest number of species. (Areas subjected to disturbance, such as fire and cutting, are where the higher densities of breeding birds result.)

(15) Cove Hardwood had the highest densities of the undisturbed forest cover types, but species diversity was relatively low.

(16) Pine-Bear Oak had the lowest density, but the highest acreage (decrease in edge).

During the post-breeding season, or late summer (July 7-September 15), Hooper found:

(17) Unlike during the breeding season, the overall effect of slope position on bird density was found to be non-significant during the summer. There was little difference in the total relative abundance of birds on uncut bottom and middle slope transects.

(18) The overall effect of cutting was significant on increasing bird density or average number of species.

(19) During late summer, cove hardwoods had the highest density of birds, but the greatest number of species would be found in the Mixed-Oak forest cover type on the 2 trails.

(20) Disturbed forest stands, such as burned Oak-Hickory stands, or cut Mixed Oak stands, had higher densities than birds of undisturbed stands along forest trails. (Hooper recommended any practice that creates brushy areas in which birds can feed and seek shelter for molting

in late summer. He suggested day-lighting roads.)

During the Fall Migratory Period (September 16 to October 31) Hooper found:

(21) Cutting and slope position were non-significant in relation to bird density. This is explained by the migration of open habitat species and the influx of migrant species from other areas.

(22) Wildlife clearings had a non-significant effect on bird density, i.e. clearings had little value in attracting migrating birds.

(23) Cove Hardwood and Mixed Oak had the highest bird densities of cover types sampled on the 2 trails and the Mixed Oak had the greatest number of species (as was the case during late summer).

During the winter period (November 1 to February 15) Hooper found:

(24) The overall effect of slope position on bird density was found to be non-significant.

(25) The effect of cutting on bird density was found to be significant, with more birds on uncut sites than cut sites.

(26) The effect of wildlife clearings on bird density was found to be non-significant. Significantly more birds were found to be on uncut than on cut transects with clearings.

(27) The Cove Hardwood forest cover type transects sampled on Deer and Turkey Trails had the highest density in late summer and fall, but had no birds during the winter. Density in other forest cover types also dropped, except for the Pine-Bear Oak forest cover type, which stayed unchanged from the fall.

Concerning the evaluation of the habitat over the seasons, Hooper

concluded:

(28) The relative value of cut forest stands was high during the breeding and late summer periods, but during the fall and winter more birds were observed in uncut stands.

(29) Slope position had significant effect on birds during breeding periods only, with uncut bottom slope transects having significantly higher breeding bird density than uncut middle slope transects.

(30) The value of wildlife clearings in increasing occurrence of birds was found non-significant for all periods. During late summer and fall migratory birds were attracted to food patches (which accounts for higher densities observed in middle slope transects with clearings).

(31) Of forest cover types sampled on the 2 trails, the disturbed cover types (cut or burned) had the highest bird densities during breeding and late summer periods. There was a large decrease in bird usage during the winter. Cove hardwoods of the ravines had highest bird densities among undisturbed cover types for all periods except winter.

RESULTS AND DISCUSSION

> "No wildlife study techniques are of more interest or importance than are those that deal with the determination of animal numbers or population trends," remarked Ramussen and Doman (1943:369)."

Much of what game management is all about concerns the population of game species. The reason is rooted to the game manager's immediate objective: to insure harvested animals are those that are expendible; that they be culled from a population, the survivors of which are—despite the ravages of predation and winter—sufficient in number to reproduce to a level that could again be safely presented for harvesting the following season. It follows this conforms with the game manager's ultimate objective: to provide more recreational hours for hunters by continually offering them open seasons.

It is essential, therefore, that some measure of population abundance (or lack of it) be determined. Eberhardt (1969:458) pointed out that essential measures of abundance can be divided into 3 classes: (1) estimates of actual numbers (total legal harvest of an area, for example); (2) indices, or measurements of relative abundance (number of animals seen/hour of observation); and (3) rates and proportions (births/female, sex ratio).

The second class—measures of relative abundance—is the population criteria used in this thesis. Specifically, hunter-hours/game seen reflects how game management and forestry practices have influenced indigenous game populations at the Broad Run Management Area.

As an index, hunter-hours/game seen is an indirect method of determining game abundance. It is not designed to estimate actual game num-

bers. However, it is designed, in this study, both to reflect population trends, year by year, across the study area, and to indicate relative abundance of species in each of the treated compartments--A, B, and C.

> "It is believed by the authors," stated Rasmussen and Doman (1943:369), "that overemphasis has been placed on attempts at determining total numbers of big game. Determination of trends is usually much more feasible and of nearly equal value in management programs."

Curtis (1971) found numbers of hunters/day at Broad Run to be significantly linearly correlated (at the 99% confidence level) to number of deer seen/day, with a correlation coefficient (r) of 0.736. In short, the more hunters there are, the more game is apt to be seen. This does not mean the cause of more deer seen is necessarily more hunters afield.

The major premise with which the index of hunter-hours/game seen is used, is just as apparent; that is, the less time it takes a hunter to see a representative of a game species, the more abundant the species must be. In other words, the less hunter-hours/game seen, tabulated for a season in a compartment, the more game is assumed to exist.

There are other assumptions, a couple to be discussed in more detail later. First, animals seen in various compartments are animals of those compartments. The compartments are large enough so that the same animals, for the most part, will not be seen in more than one compartment. A second assumption: hunter visability is on a par for all compartments. Third assumption: all hunters possess enough experience so their abilities to sight an animal are not significantly different.

A fourth assumption is that animals seen are a random sample. If, for instance, more deer are seen during a specific year, it is because

more deer exist to be seen. Essentially the hunter assumes one of the roles of game manager. The hunter visually "traps" an animal in his mind at random and "releases" it untagged. Appendix Tables V - VIII show hunter-hours and the number of deer, turkey, grouse, and squirrels seen in the 3 compartments during the seasons from 1964 through 1972.

Deer

Compartment Study

Appendix Table V shows hunter-hours and deer seen in each of the 3 compartments from 1964-1972. Compartment A is where silvicultural practices alone were the treatment. Compartment B is where silvicultural and wildlife practices were the treatments. Compartment C is where wildlife practices alone were the treatment. Wildlife practices are the presence of agricultural clearings and waterholes. Silvicultural practices are clearcuts and intermediate cuts.

Are hunter-hour/deer seen averages significantly different between the compartments, or did they occur merely by chance alone? The hunter-hours/deer seen were averaged for each year (Table 5) and, through analysis of variance, found to be significantly different (Table 6) at the 90% confidence level, with 2 and 24 degrees of freedom. Duncan's new multiple range test (Table 7) determined that Compartment B's average was significantly different than Compartment A's average. However, Compartment C's average was not significantly different than A's average. The result would seem to imply that silvicultural practices alone (as in A) do not provide a forest with the habitat that would produce,

Table 5. Hunter-hours/deer seen by compartments, at the Broad Run Management Area, 1964-1972.

	COMPARTMENTS		
Year	A	B	C
1964	57	21	16
1965	14	20	57
1966	19	13	26
1967	157	16	28
1968	40	19	22
1969	58	25	17
1970	38	11	16
1971	46	18	22
1972	10	13	14
Total	439	156	218
Average	49	17	24

Table 6. Analysis of variance of hunter-hours/deer seen, at Broad Run Management Area, 1964-1972.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Test
Treatment (among)	2	4,918	2,459	3.42*
Error (within)	24	17,221	718	
Total	26	22,139		

*Significant at the 90% confidence level, with 2 and 24 degrees of freedom.

Table 7. Duncan's new multiple range test on hunter-hours/deer seen, at Broad Run Management Area, 1964-1972.*

Standard error = 8.94

P	2	3
Significant Studentized Ranges	2.92	3.07
Least Significant Ranges	26.11	27.45

Compartment	B	C	A
Rank of Means	17.33	24.19	48.79

*Significant at the 95% confidence level

attract, or carry the most deer.

What the other 2 compartments (B and C) have in common are agricultural clearings and water holes. However, Compartment C's average is not significantly different than either A's or B's. This would imply a "canceling out" of C's significance and would intimate (but not prove statistically) that both wildlife practices and silvicultural treatments—as carried out in Compartment B—are necessary to provide a habitat that would promote and support the most deer at Broad Run.

These findings corroborate sight observations by project personnel during the first 4 years of the study, the 4 years before hunter sight observations by compartments was initiated. Seneca (1961) showed that from 1957 through 1960 there had been a total of 64, 167, and 136 deer sighted in Compartments A, B, and C, respectively. Seneca (1961:73-74) made sight observations from June 1960 through March 1961:

> "These observations...indicated that about 250 percent more deer were seen in Compartment B than in either Compartments A or C, both in clearings and elsewhere...This observational period also included the winter months during which time the observations in Compartment C were 300 percent greater than in either Compartment A or B, due to the Compartment C concentration of deer along the Broad Run Creek."

Assumptions

Are the compartments large enough so most deer will stay in one compartment throughout late November to be counted as inhabitants of that compartment? This would imply the immediate offspring of these deer would also become denizens of certain compartments as a reflection of the compartment's capacity to support a certain abundance of deer.

If the answer to the question is "no", this means a hunter's sight-

ing of a deer as belonging to one compartment is not valid. The same deer may very well be sighted as "belonging" to another compartment at another time. If the compartments are large enough, then hunter sightings of deer as inhabitants of a specific compartment can be considered as a valid index of the compartment's relative population.

When one asks whether the compartments are large enough, one is asking whether these areas are big enough to accommodate a white-tailed deer's annual "home range". Seton (1909:26) pointed out that: "No wild animal roams at random over the country; each has a home-region, even if it has not an actual home." Burt (1940:25) defined home range as "that area about its established home which is traversed by the animal in its normal activities of food gathering, mating, and caring for young." Smith (1966:375) called the home range "the area over which an animal habitually travels while engaged in its usual activities."

Why an animal has a home range is enmeshed in what motivates all animal behavior—survival. Smith (1966:377) wrote:

> "...the home range provides the animal with the necessities of life—food, cover, water, a place to rest and to rear the young. By remaining within a restricted area the animal becomes extremely familiar with the environment where the food is located and knows where the best shelter is located and where to escape from its enemies. Such familiarity places the animal at a great advantage over its enemies and any newcomers in the area. The ability of an animal even as large as a...deer to outwit a hunter in a restricted area attests to the animal's extraordinary knowledge of its immediate surroundings."

How large is the whitetail's home range and could it fit into any of the compartments with little or no overlapping? The 3 compartments range between 2,000 and 3,000 acres. Compartment A is 2,550 acres (4 square miles), B is 2,858 acres (4.5 square miles), and C is 2,037 acres (3.1

square miles).

Smith (1966:376) tells us that white-tailed deer have a relatively restricted home range, under normal conditions remaining within a ½-square mile area. Marchinton (1966) found in an Alabama forest that 23 deer outfitted with small radio transmitters and monitered for 4 months, had definite movement patterns resulting in restricted home ranges averaging well below 300 acres. Michael (1965:44) studied the movements of marked whitetails at Texas' Welder Wildlife Refuge and found the area covered by 7 bucks to range from 240 to 880 acres and by 9 does, from 60 to 340 acres. In his literature review he noted deer in warmer climates are less inclined to move great distances. Thomas et al. (1964:463) worked 9 years in trapping, tagging, and recovering whitetails at Edwards Plateau in Texas. Only 3 of the 186 recovered deer were found at distances greater than 1½ miles from the point of original marking on this grass-forb-timber type range. Severinghaus and Cheatum (1956:152), in their literature review of the whitetail's home range, pointed out Seton's observation that this deer's home range was probably smaller than that of any other member of the deer family in America and that, as Audubon and Bachman pointed out, "the whitetail usually is found in the same range and often not 50 yards from the place where it was started before." They also noted Townsend and Smith's report that the whitetails "may stay in a given locality for several weeks, moving thereafter to more favorable feeding grounds nearby, but never wandering far from the section in which they were born, except perhaps, in exceptional instances."

Progulske and Baskett (1958:185), in a Missouri study, found marked

deer to have "small, distinct home ranges during the spring, summer, and early fall--these ranges to be about ½ square mile for the 2 deer most frequently observed. Winter tracking showed an area as large as 2¼ square miles used by a group. Average maximum distances moved by 17 marked bucks were 1.9 miles; for 11 does and 3 fawns, 1.4 miles. The average maximum distance moved for all deer was 1.7 miles; average area encompassed, 695 acres.

It must be acknowledged that whitetail at Broad Run could move from one compartment to another, if their behavior so dictated. Downing et al. (1969:19) stated as much:

> "...almost every state has instances of deer having spread from small nucleus herds to occupy adjacent and sometimes distant ranges. We should keep in mind that we are dealing with a potentially mobile species that has shown the ability to seek solitude, cover, and better food in rather distant places, and to escape from floods, fire, deep snow accumulations, predators, and hunters as necessary."

However, information on home range above indicates whitetails are not highly mobile, at least in the southern range. "It seems that the majority of the deer in the South do not move far during their lifetimes," stated Downing et al. (ibid.).

In discussing deer movements at Broad Run, one must try to establish, within reason, that deer sighted by hunters are, for the most part, deer of the compartments in which they are seen. The deer-of-the-compartment concept is intimately linked with the reason deer would be seen in, let us say, Compartment B. One could say deer seen in B are deer of that compartment, simply because they are seen in B. One would not suggest these deer are in B merely by chance. Deer are not highly mobile and the

reason deer are seen in B is because, in most cases, their home range is in B and, if their daily requirements for food and cover were not available in B, they would not make B their home range. For deer whose home ranges overlap the boundaries of B, the reason the deer may be seen in B rather than the other compartments could be because of chance alone (if the forest is homogenous). However, if significantly more deer are seen in B than in A and C, then one might suggest the reason to be that, either more deer have their ranges in B, or the larger portions of the overlapping home ranges are in B. Even if, for some deer, the smaller portions of the home ranges are in B, the reason they are spotted in B could be because they spend more time in B. All these possibilities would imply that B offers a greater attraction for deer than the other compartments.

What makes a portion of a forest attractive? Diversity of habitat. Openings that offer "edge effect" offer succulent and accessible browse and, in the case of agricultural clearings, palatable plants. Since all 3 compartments have been subjected to habitat manipulation, each has a measure of attraction. The question comes down to which compartment has the strongest "holding power" throughout the years, power not only to attract deer, but to support the largest number of young and old alike with its carrying capacity. That compartment with the greatest carrying capacity will be that compartment producing the largest number of young and will contain those does with the greatest degree of fertility as a reflection of the added nourishment available from the habitat. Herein lie the salient reasons why one compartment's herd may eventually outpopulate another's.

Deer, then, do move to where food is attractive. Severinghaus and Cheatum (1956:150-151) agree:

> "The movement of deer populations because of an abundance of especially favored foods may occur at any season...(attractive food) will draw deer for a distance of 3 to 5 miles and in some instances as far as 8 miles. In some cases deer come to these areas of bountiful food during the day, but more often at night and after feeding return to their normal range."

This statement might be interpreted to mean that most deer feeding in attractive areas out of their home range might not be those counted by hunters afield during the day.

Downing et al. (1969:20), in their study of deer movements at Radford, Virginia, noted a 22-acre clearcut seemed attractive to deer during the early fall and winter, 27 having been spotted there at one time. Some 133 deer were also counted feeding at a 20-acre planting of alfalfa in early fall. However, no marked deer were observed to move a great distance to reach this planting.

Even the attraction of food may not be enough to "pull" a deer out of its home range. Thomas et al. (1964:471), in their Edwards Plateau (Texas) paper indicated this:

> "...deer have a strong social affinity to a known area, which is unaltered by any inadequacy in the life requirements that may arise. Knowledge and familiarity with an area are thought to be the binding force that restricts deer movements. No impediments in movement are generally present. Food supply, water, and sometimes even cover may fail, and yet the deer remain and often die as a result."

Lay (1969:9) gave this account:

> "Deer move to seasonal supplies of acorns and other fruits. Yet they will not move out of their established territory. Deer die offs have occurred in pastures located within a mile of understocked range with surplus food."

There is one time of the year when deer at Broad Run might very well move out of their respective compartments—especially deer inhabiting Compartment A. This would be during the winter, several weeks after the hunting season. Not to be compared with the northern climates, mountainous Broad Run does have its periods of severe cold. Its mean annual temperature is 54.5° F., but during January and February the mean drops to 37° F,, while the annual snowfall averages 18.3", most of it occurring during the same 2 months (Curtis 1971). Snow track and pellet group counts and sight observations have shown deer, during these times, to concentrate along the Broad Run Creek Road, which forms the lower boundary of Compartment C and 1/3 of B. Seneca (1961:79) interpreted these movements as follows:

> "There is no apparent indication that deer move to the lower elevations along this creek until severe weather... occurs. The exact time (when) deer move...and the duration ...they stay varies from year to year and is governed by the severity of the winter snows. During intermittent periods of relatively good weather in the winter, deer leave these lower elevations and range over the study area. This concentration of deer...is neither an actual yarding, as is seen in the more northern states, nor do deer exhibit any seasonal preference of range as is seen in some of the western states."

Do these overwintering movements "shuffle up" the herd so that deer, returning to the higher elevations, are apt to choose new compartments in which to live? Trippenssee (1948:188), and Severinghaus and Cheatum (1956:153) remind us of the whitetail's homing instinct. The former states the whitetail "to be found in the same winter and summer habitata year after year." The latter noted whitetails "tend to use the same general summer range and return to the same winter range regularly."

But during the fall cannot the normality of the deer home ranges

be upset by hunting pressure, thus making sightings biased? A review of the literature indicates that the only times deer are forced from their home territories to travel inordinate distances (several miles or more) would be when they are being chased by dogs during hunts or during census drives. Neither case is applicable to Broad Run.

During the seasons of 1967-1972, hunters have averaged hunting 5,000 hours at Broad Run each November. This is an average 416 hunter-hours at Broad Run each hunting day. Spread out over the 7,500-acre, 3-compartment area, this means that even without allowing for walking time, hunters could spend only 3 minutes/acre if each acre at Broad Run were to be hunted each day. Also, many hunters don't stalk. It is obvious the great majority of acreage cannot be visited by hunters. This means that, at Broad Run, any time a deer is spotted or approached, it has an immense territory into which it can escape and still remain within—if not its home range—its home compartment.

Carhart (1946:60) pointed this out:

> "Undisturbed, a deer will remain at any season, within the confines of a few square miles, following the same routine day after day. Because he knows this place so well, a buck will remain there under heavy hunting pressure. He knows every trail, ridge, stream, thicket, and grassy park in his domain many times better than you ever can know it within the limited time of a hunting season. And he willuse that knowledge to outwit you."

Deer, because of their keen senses and wariness, may not have far to go to elude hunters. Downing et al. (1969:20) related how 80 archers/day had influenced deer movements at the Radford enclosure.

> "Deer soon learned to stay in the large openings, and even here they sometimes were stalked by impatient archers. Harassment of the deer was probably as intense as with any other type of hunting except dog hunting, and a great deal

> of movement was noted for all sex and age classes. Even so, most deer were seen near their centers of activity on hunt days and no change in home range resulted."

Madson (1961:72-73) stressing the fact of how intimately whitetails know their own habitat, reported this experience:

> "Thirty-nine Michigan deer--including 9 bucks--were once stocked in a mile-square enclosure from which they could not escape. It was an area of hardwoods, pine swamp and open pine barrens. Six experienced hunters went into that square mile in clear weather with ideal tracking snow. Yet, it was almost 4 days before one of them even saw a buck."

Madson also noted the deer's talent for skulking before and behind hunters and for effacing itself from the landscape.

Severinghaus and Cheatum (1956:153) noted Schoonmaker's observation that when persistently hunted a whitetail is apt to go beyond the limits of the home range, but usually returns. Downing et al. (1969:19, 22) found in their Radford, Virginia study that 2/3 of 36 tagged deer moved outside their normal ranges during hunts, many of them going as far as the enclosure fence would allow. "We have not proved that permanent changes in the range occur as a result of hunting," he said, "but we do know that hunter returns of tagged deer do not necessarily indicate the normal range of the animals." The enclosure encompassed 2,322 acres, about the size of a Broad Run compartment.

Finally, we might ask whether the Broad Run compartments could contain the breeding movements of deer. The general breeding season for deer in Virginia, similar to that found in other states, have adult bucks in condition to breed from early September into January and does beginning estrus as early as late September, extending into January (Davey 1957:19).

It is generally agreed males move over a greater range than females (Michael 1965; Progulski and Baskett 1958; Thomas et al. 1964; Downing et al. 1969; Sanderson 1966). Trippensee (1958:187) wrote:

> "Adult males are particularly active during the rutting season. At that time their efforts to locate susceptible females often involve travel considerably in excess of that normally indulged in at other seasons. Does tend to move about less freely than bucks at all seasons..."

Palmer (1951) indicated buck fall range to be in excess of ½ mile and Michael (1965) stated that during the breeding season does continued feeding in the same areas they had used during previous months and when pursued by bucks, they usually moved in wide circles, seeming reluctant to leave their regular feeding area. He also reported that Texas bucks ranged the farthest afield from January through April. Downing et al. (1969) reported 8 does moving more than ½ mile from the center of their activity during November, and stated many bucks were seen outside their home range during the rut (one 3½ year-old observed 3 times to be a mile from its normal range). However, they reported no permanent change in home range. Severinghaus and Cheatum (1956:123) presented this account:

> "In Michigan, game technicans assisted by crews of 60 to 80 men have made deer census counts in late summer and early fall. Some of these drives covered a square mile...as many as 30 to 80 deer were found on one occasion, and repetition of the drive several days later resulted in virtually an identical count. Such information indicates that deer prefer their home territory and that their home range in the fall probably does not cover more than 2 or 4 square miles."

Another assumption that might be subject to argument is that visibility, on the whole, is equal for all compartments. This is saying a hunter is able to see a deer just as well in one compartment as another. On first thought, one might assume places in a wooded area opened by

clearcutting and for agricultural planting to be places where hunters would be able to see more game. Quillen (1959:103, 105) confirmed this assumption, based on deer sightings made by project personnel during the first 2 years of the Broad Run project study. "The majority of the deer sight observations," he said, "were made in the agricultural clearings due to the presence of preferred deer food and ease of observation."

Quillen went on to explain that 79% of all deer observations were made in the agricultural clearings. He also reported that because 10 of the 11 clearings in Compartment C are located adjacent to the access road and offer clear observation, more deer were observed in this compartment from the fall of 1957 to the spring of 1959.

Two important things must be remembered when reading Quillen's report: one, that the reported observations were made prior to the beginning of silvicultural practices in Compartments A and B. Also, the sight observations were made by a few "benign" project personnel, not by large numbers of hunters.

Although there are no data to suggest where hunter observations were made, one may assume a goodly share did not remain on the access road awaiting deer. If most hunters hunted around the agricultural clearings, they would have had just as clear a view of a deer in C as in B, since each of these 2 compartments are about equally open in this respect. There are 13 clearings, or 5.8% of the land area, in B, and 10 clearings, or 5.1% of the land area, in C. Even with all the clearings, they total only 31.7 acres—a very tiny portion of the range.

Better opportunity for sighting deer because of open space provided by clearcuts would not have been much of a factor until 1964, when most

of this kind of treatment took place. Table 1 reveals that prior to 1964, only 112 acres had been clearcut—all in Compartment A.

In 1964, 172 acres of A were clearcut while 350 acres of B were clearcut. Although 503 acres of B and 470 acres of A were treated from 1959-1964, since 1960, 284 acres of A and 350 acres in B were clearcut. The remainder of the total 973 treated acres were subjected only to intermediate cuttings—light thinnings that amounted to only about 5% of the basal area removed (Todd 1972, pers. comm.).

Table 5, depicting hunter-hours/deer seen, by compartments, (1964-1972) gives no indication, the first year, of any greater ease at seeing deer in the clearcut compartments. The next 4 years, 1965-1968, show it took longer to see a deer in Compartment C than in either one or the other cutover compartments. In 1965 and 1966, it took the hunter longer to see a deer in Compartment C than in either one or both of the cutover sections and this could be interpreted to mean the visibility was better because of the clearcutting. However, in 1967 it took a hunter significantly longer to spot a deer in Compartment A than in B or C. From 1969 through 1971 the effect of clearcutting on visibility disappeared as most of the regeneration reached at least head height. During this span it took the hunter longer to see a deer in A. However, in 1972 it took slightly less time to see a deer in A—during a year when the advantage of visibility via clearcutting had long passed.

There is no clear indication that the reason it takes less time to see a deer in one compartment is because there is better visibility in that compartment. Clearly A has had more open space than C has ever had, yet less time (though not significantly less) to see deer is recorded for

C than for A.

Those who hold open spaces to be significant in spotting more deer base their argument on the assumption that most of the deer will be, and were, seen in those open spaces. Presumably, deer would be there feeding. True, it is the tenet of this thesis that these openings attract and support more deer. However, this means more deer will be in the compartment that supports more deer, not that more deer necessarily would open themselves to view so easily during a hunting season. It is a fact that hunters must be highly selective in picking those times of day when they would be apt to see deer in the peripheries of open spaces.

Severinghaus and Cheatum (1956:150) acknowledged "most deer feed during early morning and late afternoon with a preference for the evening hours." They stated that feeding from 7 P.M. to 5 A.M. is the average condition, but some deer can be seen feeding during all daylight hours. However, they pointed out that feeding at night is especially the case "where deer are harried by man and during hunting seasons." Lay (1969:9-10) corroborated this noctural inclination of deer, stating:

> "When undisturbed deer generally have 2 feeding periods—early and late daytime. With disturbance, they feed at night or when they can. Corn, for instance, when placed in front of a hunting blind, is generally taken when the blind is empty."

Trippensee (1948:187) revealed more about the deer's feeding routine:

> "Feeding and drinking are confined mainly to the early morning hours near dawn and the twilight period of evening... The hours between feedings are periods of desultory activity during which deer alternately rest and cruise about, usually on upland terrain and almost always in wooded cover, though sometimes in relatively open cover."

Madson (1961:74-75) gave this advice to hunters:

> "Since deer are usually on the feed in very early morning and early evening, and spend much of the midday bedded down in their coverts, the wise deer hunter is out early and watching a runaway in an attempt to intercept the deer between footpatch and bed."

Madson found from a report of about 2,000 hunters that the 2 peak shooting times were in the first hour after "shooting light" and in late afternoon. "Another good place (to hunt)," Madson continued, "is near...extremely heavy cover where deer hide during the day in heavily-hunted country. Be there early, when the deer are returning from predawn visits to feeding areas."

He stated that where hunting is heavy and deer are stirred up, runway sitting may be the best method of hunting. Where hunting is light, it's best for the hunter to walk slowly through the coverts on the off chance of jumping a deer.

Hunter and Harvest Data

The thrust of this thesis is to indicate whether silvicultural and wildlife habitat manipulation attracts and is able to support more deer (and turkey) than would otherwise be the case. Another consideration, also based on information obtained from hunters, concerns the condition of the overall herd at Broad Run. In managing a deer herd several questions seek to be answered. How many deer are there? Is the given range able to support the herd? If the range is ample, then for how many more years? How is harvesting affecting the deer population? Are too many deer being killed, or not enough? Answers to these questions would tell game managers whether hunting regulations should be altered, and/or

whether further habitat manipulation is necessary. To what extent can our available hunter-harvest data answer these questions?

Population estimates--Kill records have been used as an index of population trends and as an indirect measure of population estimates since the earliest days of game management. Leopold (1933:139) defined an index to a game population as "any condition which can be measured, and which may be expected to vary in proportion to the population which cannot be measured." He stated the first step in management to be the census, or measuring the stock at first hand.

How many deer live in the 3 compartments at Broad Run? During the first 5 years of the study, Quillen (1959) and Seneca (1961) estimated the Broad Run population to range anywhere from 70 to 165 deer. The mean is about 120. In 1967, Hooper indicated increases to have remained small, primarily because of dog predation and poaching. Seneca (1961) found 40% of the known kills from 1957-1960 to have been illegal, but no records since this time have been kept on such kills. During the past 10 years this has remained an unknown quantity. Obviously, illegal and natural deaths continue to have at least some effect on the deer population level on the Broad Run Wildlife Research Area.

An indication the overall population level has not greatly changed at Broad Run throughout the years might been seen by the overall hunter-hours/deer seen. Appendix Table II shows that since 1958, a steady average of about 20 hunter-hour are required to see one deer on the management area. Fig. 10 shows this relative constancy. Although the validity of hunter observations has been discussed at length, it would be appropriate, at this point, to refer to one of the few studies indicat-

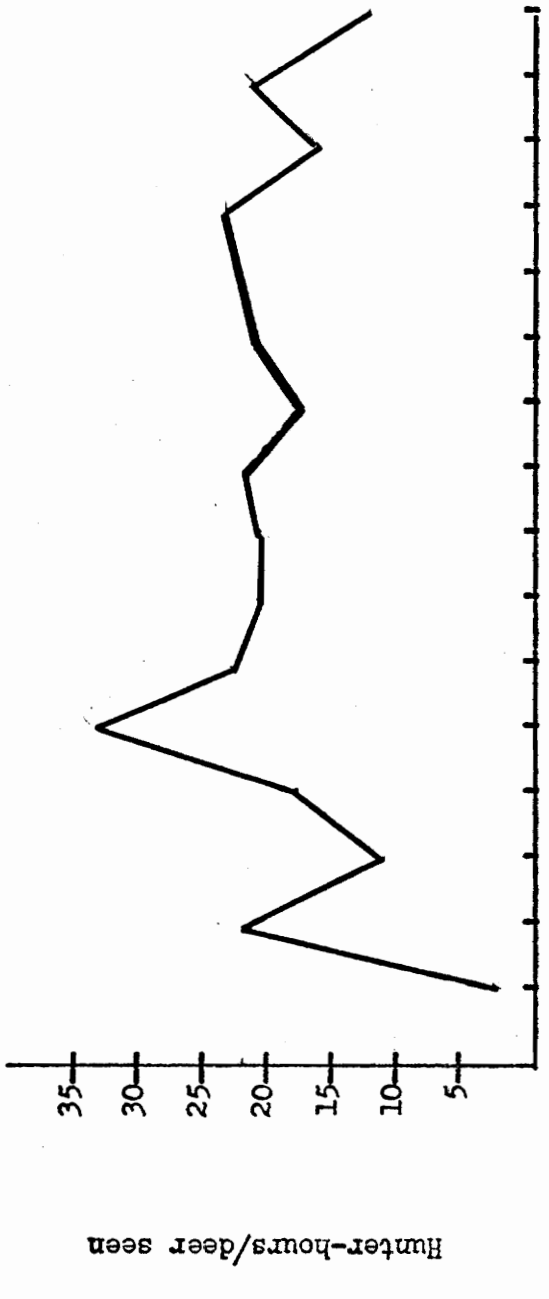

Fig. 10. Hunter-hours/deer seen/year, at Broad Run Management Area, 1957-1972.

ing hunter observations as a workable index. Downing et al. (1965) compared deer population indices with known populations in a 176-acre enclosure in Albany, Georgia. They found gun hunters walked while hunting 64% of the time and saw twice as many deer while walking as by sitting. They stated that the method of hunting--rather than population size, number of hunters, day of the hunt, and weather conditions--appreciably affected the percentage of the population seen/hour. They said:

> "Users of this technique (hunter observations) should be cautioned against using the 'overall' deer-per-hour figure unless there is reason to believe that the ratio of sitting to walking is unchanged from sample to sample."

Downing et al. (1965) stated the technique is limited in its accuracy, but no more limited than many other conventional techniques, and concluded hunter observations appeared "to be an excellent index, but only if the same area is compared year to year." This is the case at Broad Run. An assumption, therefore, is that the ratio of still and stalking hunters has not changed at Broad Run throughout the years.

If the deer population has remained fairly stable since 1958, then the early estimated population range of between 70 and 165 deer would still be valid. Davey (1957) included Craig County in a formula devised to estimate minimum population/square mile of range, based on the best adult buck harvest during the 3-year period, 1954-1956. The steps from which this minimum is derived are as follows for Craig County. The land area for Craig is 336 square miles, and the deer range is 275 square miles. The best adult buck kill during these 3 years was 282, or 1.02 bucks killed/square mile of range. Using a constant factor of 12, the minimum population of 12.2 deer/square mile was derived. Since

the 3 compartments at Broad Run comprise 11.6 square miles, this formula could mean a population of 142 animals. But a part of a range does not necessarily apply to the whole range. What would the application of recent kill figures at Broad Run indicate for this range?

First, Davey (1956) stated only adult bucks are to be used in this computation. Since, in later discussion, he breaks down the deer herd into 4 segments--antlered adult bucks, antlerless buck fawns, adult does, and fawn does--one assumes he is including 1½-year-old antlered bucks in the adult class. Davey figured the antlered-antlerless ratios in herds west of the Blue Ridge to vary from 15:85 to 25:75, and the legal take to be 30% to 40% (or less) of the adult bucks. The adult buck kill would represent between 5% and 10% of the whole herd. The constant factor of 12, or bucks killed being 8% of the herd (100/8 = 12).

Davey's calculation for Craig County was based on a one week hunting season. During the first week of the 1971 season, 15 bucks were harvested at Broad Run. This amounted to a kill/square mile of range of 1.29, or a minimum square-mile population (using the constant factor 12) of slightly more than 15 animals. Since there are 11.6 square miles in the 3 compartments, one might hypothesize the minimum population of the area to be about 180 deer. Davey cautions his figure to be conservative because the total range is not hunted. If one were to estimate the population to be 180 animals, one would exceed by only 15 the upper limit of Seneca's 1961 estimated population level (117 $\pm$ 48). Since Seneca's upper limit is a liberal estimate and the 1971 estimate perhaps a conservative estimate, one can assume population growth during the intervening 10 years. However, since the hunter-hours/deer seen has varied

only slightly during these years (Appendix Table II)—indicating a stable population—2 conclusions might be offered: one, that there has been some inaccuracy in the tabulation, or gathering, of hunter-hours and deer seen; and 2, that some of the increased numbers of deer spread out over the range into areas less frequented, or less accessible to hunters and, therefore, not seen by them. In 2 cases the correlation between hunter-hours/deer seen and more deer existing may be seen in Appendix Table II. In 1970 and 1972 the least number of hunter-hours/deer seen was realized for the first time since the very earliest seasons on the Broad Run Management Area (1957 and 1959). It is also noteworthy that the greatest harvest of deer occurred in 1970 and 1972, for single seasons. Perhaps this was because there was the greatest number of hunter-visits during those seasons. However, in 1971, there were only 843 hunter-visits, yet the harvest was the third highest in the management area's history. It might be logical to conclude that the high harvest of the 1970, 1971, and 1972 seasons was due to the area's largest population abundance, also reflected in the low number of hunter-hours/deer seen in 1970 and 1972. The very low number of hunter-hours/deer seen in 1957 may be rooted to the fact that only 60 hunter-trips occurred. This may not have been a large enough sampling for a true sight estimate of the herd's relative size.

That the population has been growing—especially in recent years—is reflected by the age structure of the herd, which is based on the ages of harvested deer during 13 seasons at the management area (Table 8). Of the 143 killed deer on which age information could be obtained, 87, or 61%, are classified "young"; 52, or 36%, "adult"; and 4, or 3%, "old".

Table 8. Deer kill by age classes for 13 seasons at Broad Run Management Area (1957-1962; 1964-1965; 1968-1972).*

Age	Buck	Doe	Number Killed/ Age Class
½	15	6	21
1½	61	5	66
2½	26	5	31
3½	17	4	21
4½	1	1	2
5½	0	0	0
6½	1	0	1
7½	0	0	0
8½	1	0	1
Total	122	21	143

*Kill card data on deer for 1963, 1966, and 1967 are missing.

Seneca (1961), from the first 4 seasons of harvesting (1957-1960), found 48% of deer harvested to be young, 40% adult, and 12% old. In contrast, the most recent 4 years (1969-1972) revealed from 82 deer harvested, 63.4% to be young, 35.3% to be adult, and 1.2% to be old (Appendix Tables XVIII-XXI).

Are these percentages representative of the population as a whole? If they are, this would mean hunters killed, or shot at, the first deer they came upon—they selected their harvest at random. Otherwise—that is, if hunters shot to kill only a certain segment of the population (such as antlered bucks instead of does, or bucks with only large antlers)—the age structure would reflect a biase. Since 62% of the killed bucks that were aged were fawns or 1½ year-olds, it appeared hunters shot what they saw at random. During the 21 days available for any-deer kills, in the 13 seasons (through 1972) data were preserved, 23 does (2 females were not aged) were killed—about 1.1 does killed/day. During the 111 days bucks were legal, 122 bucks (11 were not aged) were killed—again, about 1.1 bucks killed/day. Preferred-sex selectivity does not seem the case here. There could be biase where deer in concerned, however, because deer may vary in intelligence and wariness.

Allowing for these possible shortcomings in random sampling, the age structure indicates a young population now existing at Broad Run. "A normally increasing population should have an increasing number of young; a decreasing population a decreasing number of young," stated Smith (1966:352-353). In his theoretical age pyramids, Smith labeled a population with 48% young—what Broad Run theoretically had during 1957-1960—to be in poor production. Fig. 10 shows that from 1959-1961 the

hunter-hours required to see a deer showed its greatest increase in the history of the study, indicating, at least indirectly, a steep dip in population. Smith labeled a population with 64% young--near the 13-year average at Broad Run--to be in normal production. The 63.4% young tallied for Broad Run from 1969-1972 reflected a population with a "normal" production. Odum (1971:175-176) commented:

> "...the ratio of the various age groups in a population determines the current reproductive status of the population and indicates what may be expected in the future. Usually a rapidly expanding population will contain a large proportion of young individuals, a stationary population, a more even distribution of age classes and a declining population a large proportion of old individuals."

Smith (1966) stated, however, that a population may be decreasing, yet show an increase in the percentage of young, while Odum (1971:126) stated a population may pass through changes in age structure without changing in size. "There is evidence," he said, "that populations have a 'normal' or stable age distribution toward which actual age distribution are tending. He added that "if this stable situation is disrupted by temporary changes in the environment, the age distribution will tend to return to the previous situation upon restoration of normal conditions."

Possibly the 1971 estimate of 180 deer at Broad Run is based on a population when it was at its peak, but a peak not significant enough to be detected by increased hunter sightings. If this is so, then one might conclude that the population may return to its lower "stable" level in the seasons to follow. If the age distribution <u>did</u> reflect a true increase in young animals, then the promise of larger populations in the future may be expected, an increase which would be reflected in lower and lower numbers of hours necessary for hunters to see deer.

Since only one day a season is set aside for legal doe hunting, and since only 9 does have been killed during the past 3 seasons (1970-1972) at Broad Run, one might assume a "bucks only" system to be in force there. If 180 pre-hutning deer did exist at Broad Run in 1971, and since 22 bucks were harvested in 1971, then the rule that the legal harvest of males is nearly always less than 10% of the population (Allen 1962) might indicate a greater herd-size than 180 individuals. Even if one stayed with the 180-animal herd size, Allen's (1962:136) statement that "nearly any deer herd can furnish an annual harvest of at least 25% of its fall numbers" means 45 animals (including fawns and does) could have been harvested at Broad Run during its 2-week season in 1971 without significantly affecting the herd's reproductive capacity.

Food and carrying capacity--With 180 deer on Broad Run's 7,445 compartmentized acres, there would be nearly 16 deer/square mile, or section, or about 41 acres/deer. Setting aside habitat for the moment, how do these ratios compare with figures recorded for other deer herds? Trippensee (1948:207) acknowledged heavier concentrations of deer are found in the northern states, from Minnesota to Maine, while southern states have sparser populations.

> "Although local concentrations of more than 200 deer per section...have been reported, it is not likely that the average density, over broad tracts such as a county or National Forest ever exceeds 50 animals per section. In Michigan the estimated deer population in 1938 was 16 per section for the Upper Peninsula and 42 for the Lower Peninsula...Comparable values for 4 sub-divisions of Wisconsin's range were 18, 20, 34, and 42 deer per square mile...(in) 1939. In Minnesota, the estimated average for 1939 was 14 per square mile."

But density is more than numbers. Deer populations are inextricably

tied up with quality and quantity of food available to the population. The more sustenance available to the herd, the greater density a habitat can support. The "carrying capacity" concept is incorporated.

Hosley (1956:224) defined carrying capacity as "the maximum number of deer per unit area that can be supported through the year without deterioration of the range." Hosley and Trippensee indicated the criteria determining carrying capacity to be dependent on the amount of winter food available on the range. Winter is a critical time of a deer's year, a time when high densities could reduce herds by starvation as food becomes limited. Although carrying capacity varies in different parts of the whitetail's range, Hosley (1956) quoted several sources indicating carrying capacity to range from a high of 64 deer/section to a low of 8 deer/section. Hosley (1956:224-225) stated:

> "Considering the wide range of conditions represented, there is a surprisingly close agreement in the carrying capacities reported. Twenty deer per section or a deer to 32 acres can be taken as an appropriate average carrying capacity..."

To determine whether a habitat meets the nutritional needs of a deer herd, obvious factors must be known. These are the size and age composition of the herd and the composition of the range. Here, we are assuming there are 180 deer at Broad Run. Using the age percentages of the last 4 years (1969-1972), this means the herd is comprised of 114 fawns and yearlings and 66 older deer. What are the average live weights of the different age groups? These are determined by samples of harvested deer over the 4-year period. During this interim, 7 fawns sampled averaged 63 lbs; 19 yearlings, 104 lbs; while 17 adult deer averaged 138 lbs. These weights were taken from Appendix Tables XVIII-XXI. Since

these tables show the herd composed of 37% adult and older deer during these 4 years, this means there is a total of 9,246 lbs of deer in this age category (138 x 67). About 11% of the herd from the 4-year sample harvest comprised fawns. This means there was about 1,260 lbs of fawn (63 x 20); and 9,672 lbs of yearling (104 x 93). In short, the estimate is about 20,000 lbs of live weight of deer at Broad Run in 1971.

To be maintained, a deer's weight must be replaced by energy provided from food. Whitetails are ruminants and woody browse makes up one of the components of their diet. Patton (1963:17) described browse as "the current annual growth of all woody plants, including the leaves of evergreens, from ground level to a height of 5 feet." Trippensee (1948:194) said browse meant "leaves, buds, twigs, and bark of woody plants."

Assuming for the moment that browse is the sole source of sustenance, 2 questions need to be answered: first, how much browse is required to maintain the vigor and health of a deer? second, what amount of browse does the research area provide? To the first question, Halls and Ripley (1961:1) related:

> "An adult 100 pound deer requires 4 or 5 pounds (air-dry weight) of food daily. The range should contain a variety of plants that will provide a year-around supply within the herd's home territory of slightly more than a square mile."

Four lbs falls in line with Engles' (1969) estimate of daily browse requirement for deer, while estimates for Michigan and Wisconsin have ranged from 5 to 7 lbs (Severinghaus and Cheatum 1956).

If whitetails require, let us say, 4 lbs of browse/hundred weight/

day to remain vigorous, and there are 200 "hundred-weights" present, this would mean the herd at Broad Run requires 800 lbs (dry weight) of browse/day.

The amount of browse produced on uncut areas at Broad Run is 10 lbs of dry weight browse/acre (Patton and McGinnes 1964). Since the 3 compartments at Broad run comprise 7,445 acres, this means there are (assuming all acres uncut) 74,450 lbs of browse available each year. This is enough browse to maintain the Broad Run herd for 90 days, or 3 months, if the whole range were used, and browse were the sole means of support.

Obviously, if deer at Broad Run had to rely on the annual growth of woody stems and leaves 5' above the ground, their numbers would soon be decimated by starvation. The 180 deer would greatly exceed the range carrying capacity.

However, there are 5 other sources of food at Broad Run that greatly enhance the range's carrying capacity. These are:

(1) Additional browse produced by cutting

(2) Leaves above the 5-foot limit of browsability

(3) Herbaceous plants

(4) Mast

(5) Food in agricultural clearings

Items 1 and 5 have been directly involved in studies at Broad Run. Patton (1963) gathered data for predicting available browse from cutover areas in Compartments A and B (Mixed Oak-Pine type). He listed the lbs of browse that would be yielded on plots where from 30% to 80% of the basal area (measuring at stump height) was removed. Patton (1963) said browse availability begins to decline about the fifth year after cutting

and "a marked decline in available browse should occur after 6 years." Just how marked a decline, he did not specify.

According to Table 1, there were 522 acres clearcut at Broad Run in 1964, which means that by 1970, a "marked decline" should have evolved. Does this mean that by 1971, the area would have reverted to its original 10 lbs of browse/acre? Two points indicate that browse of this 522 acres may still have exceeded the minimum poundage/acre. One, McGinnes (1972, pers. comm.) indicated that years after Patton's study, there appeared to be greater abundance of browse produced than originally forecasted. Two, Todd (1972, pers. comm.) said that 90% of the basal area (d.b.h.) had been removed in the clearcuts, rather than Patton's 80%. According to Patton's figures, at maximum removal in 1964, there would have been 243 lbs ($\pm$63)/acre available by 1968. This would have provided 126,846 lbs of browse for this 522-acre area alone, enough browse to feed 180 deer for 6 months.

But deer are not totally dependent on tender woody shoots and leaves up to 5' above ground. Work in Pennsylvania by Watts (1964) and Healey (1967) show where dead leaves are an important winter staple and herbaceous material and important early-spring staple for deer.

Healey (1967) discovered twig browsing to be confined largely to late autumn and winter. In time studies, Healey found about 91% of browsing time on green leaves took place in late spring and early fall. Herbaceous material, such as grasses, sedges, and forbs, accounted for about 54% of early-spring feeding time. Healey (1967) found deer spent 9.4% of their time eating dead leaves in the winter.

Watts (1964), however, found dead leaves to be a very significant

food in winter, an indication a range's browse is given relief during this time of year. Watts (1964) discovered that while 52% of the deer's diet during the winter was twigs, 36% consisted of dry leaves.

In the early fall, Watts found 40% of the feeding time was spent eating acorns, and 50% eating green leaves. Watts (1964:18) stated:

> "The plant parts utilized are chiefly those most available, with the exceptions of dry leaves in the winter, which were taken more readily than availability would suggest. Twigs, during most seasons, were taken less readily than availability would suggest...Green leaves, available in the autumn, were taken less readily than would be expected...The herbaceous species...are used 37 percent less frequently than woody species, even during their season of greatest usage."

A significant study was made by Harlow and Hooper (1971), who analysed 956 rumen samples of white-tailed deer in the Southeast. They discovered—counter to the idea that woody browse forms the bulk of the deer's diet—that, for all seasons, hardened woody twigs had the lowest volume of all food categories tested. For instance, the Southern Appalachians, where Harlow and Hooper sampled 155 samples in the fall, oak mast was the most abundant food item eaten. Also abundant were non-mast fruits. Other important items were green leaves of rhododendron and honeysuckle, evergreen forbs (such as galax and wintergreen), sedges, grasses, and fungi. In the winter, categories found most abundant included dried (dead) deciduous leaves of woody plants, green herbaceous stems and leaves, hardened woody steams (which occurred frequently, but in small amounts), and mushrooms.

Harlow and Hooper (1971) found, for all seasons and all areas (mountains, Piedmont, and coast) that green leaves of woody plants were highest by volume (35.7%) and frequency (92%), followed by fruit (21% volume

and 64% frequency). Ranking at the bottom of the list--below forbs, sedges, grasses, fungi, and dry leaves (all of which contributed 35.9% by volume of the deer's diet)--were hardened twigs and buds (2.3% by volume and 22% frequency). Harlow and Hooper (1971:42) stated:

> "This study demonstrates the comparatively small contribution made by hardened woody twigs to the diet of white-tailed deer in the Southeast. Woody twigs are readily available throughout deer ranges, yet they failed to show up in the stomach samples at a frequency approaching their availability."

No work has been done at Broad Run quantifying the amount of herbaceous growth on the forest floor has been studied to discern deer utilization. This study has not been completed. Herbaceous species available for deer food at Broad Run include blueberry, grape, greenbrier, liverleaf, galax, teaberry, plantain, and pipsissewa (Weekes 1971). The writer has also noticed blackberry, dewberry, sumac, deerberry, and various weeds, sedges, and flowers. Whelan (1962) also listed such herbaceous species present in the understory as huckleberry, hawthorne, mountain laurel, and maple-leafed viburnum. Quillen (1959) noted there are also patches of Japanese honeysuckle. The above herbaceous species are verified as deer food by Halls and Ripley (1961) and Hosley (1956).

To what extent do the 23 agricultural clearings on the study area affect the carrying capacity of the range? These 31.7 acres have been alternatively planted in Kentucky Bluegrass, Dutch white clover, Kenland clover, wheat, rye, and such mast and fruit-bearing trees as sawtooth oak, English dogwood, apple, and honey locust.

In the Southeast, where winter moisture and temperatures are favorable, the above agricultural crops are listed by Davison and Graetz

(1957) as "choice"--food that is nutritious and readily eaten during the season when they are available and is palatable. Moore and Johnson (1963:2) wrote:

> "Not only are forage clearings known to provide enormous quantities of succulent forage when compared with surrounding hardwood understories, but the opportunities to introduce deficient nutrients by fertilization are virtually unlimited."

How does such choice food affect the carrying capacity of the range? First, one should get a picture of what the carrying capacity would be without agricultural clearings. If all of Broad Run were uncut forest, there would be about 10 lbs/acre of browse (dry weight) on 7,445 acres, or 74,440 lbs of browse. If 100-lbs whitetails require 4 lbs of browse/day, then for a year's time, Broad Run could support, theoretically, only 55 100-lbs deer on browse alone.

But this, as indicated, does not take into account food available from mast (distributed throughout the study area), natural herbaceous material and the agricultural crops. Larson (1966b:35) noted:

> "Game managers have generally concluded that agricultural forage clearings supplement the food base of forest game. However, to reasonably evaluate the supplemental role of clearings in terms of a food base, it is necessary to obtain information on 'natural' foods available on the management areas where clearings are to be installed. While it is fairly easy to accurately estimate the quantity and quality of agricultural foods grown on forage clearings, this is of no value unless accompanied by baseline information on what is already available to game before clearings are created."

Larson (1966b) stated wildlife managers have not applied the knowledge of forage production and wildlife utilization to forage clearings. He sampled 3 clearings of pure ladino clover at the Jefferson National Forest, Virginia. Larson discovered clover was heavily eaten by deer,

never being allowed to exceed more than 1" in height during the spring growing season (a critical time for food). Variation in clover produced and used on these clearings was estimated to range from 35 lbs/acre to 725 lbs/acre--or an average range from 115.5 lbs/acre to 359 lbs/acre.

Moore and Johnson (1963) also noted there has been little evaluation of preference in degree of utilization of agricultural forage as supplemental deer food in the Southeast. Their study, however, confirmed that deer ate red and ladino clover more heavily than grasses when available. The consumption of the latter was restricted mostly to the winter and spring. Consumption of available clover was less in late summer and early fall when native foods--mast and fruit--were abundant. Kentucky bluegrass was least used (on a lbs/acre basis) among the grasses, clovers, and other legumes planted at Pisgah National Forest, where the study took place.

Sauer et al. (1969) found deer, in a 56.8-acre enclosure in New York, averaged eating 2.3% of all the herbaceous species recorded, an amount considered minimal. One percent of the available bluegrass was consumed and 0.3% of available clover was eaten in late spring. These percentages went up in August to 1.4% and 1.3%, respectively.

Davison and Graetz (1957) opined that most studies underrated herbaceous plants in deer diets. They listed 6 sources who concluded that grasses, clovers, and other agricultural plants offer much improvement of deer habitat. They also noted the benefit of high protein, calcium, and phosphorous these species provide.

However, these studies do not help us determine quantitatively how the carrying capacity of a range---such as at Broad Run---is affected by natural herbaceous material and agricultural forage. There is an indication that deer will use these sources for food, especially in spring and summer, and that agricultural crops at Broad Run will furnish at least 3 times the dry matter/acre of food than would an un-clearcut forest (according to Larson's estimate of ladino clover production).

But Larson (1966a) stressed that more research is needed to determine the role of supplemental food clearings in game management and game production, and to determine the degree to which animal use of clearings expressed need or preference.

Physical characteristics---Previous discussions about the Broad Run range have been confined to analysing the quantity and quality of the habitat by direct observation and measurement, drawing conclusions as to whether or not it provides a sufficient amount of food for the herd. Another method of evaluating a range is by investigating the condition of the herd and inferring from these data the adequacy of the range. The physical condition of deer may infer 2 things: the quality and quantity of food, and the relative size of the deer population. If there are too many deer for the range, or the range is a poor one, physical deterioration of the herd will be evident.

Appendix Tables XXII-XXVIII indicate various measurements of harvested male deer. These are dressed weight, antler diameter, antler points, total body length, shoulder height, heart girth, and tarsus length.

In most, if not all cases, there was not enough deer harvested in each age group, each year, to give a true evolutionary picture of the

herd condition. Simply stated, there have not been enough deer taken each year.

However, totals for all years for which information was available may give a hint of the herd's physical shape. Physical characteristics have been divided into 4 general categories:

(1) Dressed weight: Prefacing sources giving "typical" weight of a whitetail, it should be noted that citations usually categorize weights either as live or dressed, male or female, immature or adult. Making any comparison between data compiled in Appendix Table XXIV and those obtained from other herds in the country is difficult because age compositions may be dissimilar. The Broad Run herd apparently is composed of many young individuals. Weight averages, therefore, are likely to be less than those of many other herds. Most deer keep growing until they reach age 5 to 5½ years (Severinghaus and Cheatum, 1956:76).

Weight evaluations, in most studies, are usually segregated according to sex, Because there were too few females listed in Appendix Tables IX-XXI, does were not categorized by weight for evaluation in any subsequent appendix tables. Also, the concept of "adult" is defined here as 1½ years and older.

In the matter of weight, the writer found data listed for dressed and live weight. To be consistent, the writer listed only male dressed weight in Appendix Table XXII, subtracting 20% from the live weight where this weight was listed. Total dressed weight for all adult male deer, numbering 102, is 10,010 lbs, or an average of 98 lbs. Average live weight would figure at 117 lbs. Average dressed and live weight for all male deer samples, 2½ years or older (43 weighing 4,935 lbs) is 115 and

and 138 lbs, respectively.

Severinghaus and Cheatum (1956) used a source who stated live and dressed weight of bucks (from 544 samples) from Pisgah National Forest to be 173 and 112 lbs, respectively. Trippensee (1948:181-182) stated the average live weight of males to be between 100 and 200 lbs. The average live weight among 89 bucks shot in Michigan ranged between 147 to 193 lbs, but Southern deer are smaller on the average. Park (1938) found the average live weight of bucks harvested on the Alleghany National Forest in Pennsylvania to be 112 lbs in 1935, 117 lbs in 1936, and 116 lbs in 1937. Harvested male fawns in 1935 averaged 58 lbs (those at Broad Run averaged about 50 lbs). Severinghaus (1955) compiled male dressed deer weights, according to age, from 2 wilderness areas in the central Adirondacks of New York and in areas outside these areas in 1954. Average weights in the areas were 53.6 lbs (fawns), 83.6 lbs (yearlings), and 130.4 lbs (older adults). Outside these areas averages were 95.5 lbs (yearlings), and 142.4 lbs (older adults). Except for the older adults, the Broad Run averages are comparable to the Adirondack figures. In the older adults category, the New York study had samples totaling 440 and 126 deer with about 40% of the total comprising deer older than $3\frac{1}{2}$ years.

Taking into account the small samples at Broad Run, weights on deer there do not appear to be out of line with averages depicted in many other ranges.

(2) Antler beam: Appendix Table XXIV shows the average number of points for bucks harvested at Broad Run. Again the samples are so small that no conclusions about the condition of the range can be drawn from the tine numbers. The largest sample--42--was taken from the $1\frac{1}{2}$-year-old

class. The average number of points was 3. Severinghaus and Cheatum (1956) found that from more than 3,000 specimens of deer in the central Adirondacks, the average number of points for yearling deer was 2.96, while in peripheral areas of that region, the average was 3.4.

(4) Miscellaneous characteristics: Other characteristics used less frequently to determine the condition of a deer herd include total body length, shoulder height, heart girth, and tarsus length (Appendix Tables XXV-XXVIII. The first 2 indices have been introduced only recently, so comparisons cannot be made over a span of years. In the $1\frac{1}{2}$-year-old class, which has the most numerous samples, there appears to be a steady reading the last 3 years. Since the sampling is so meagre, no conclusions can be presented from these data. The average length of the 15 male deer at Broad Run, $2\frac{1}{2}$ years and older is 4.9', or 58", which is rather smaller than the 70"-77", 72", or 65.7" Severinghaus and Cheatum (1956) quoted sources as being "typical". These sources also recorded the tarsus bone on male Virginia whitetail to average 20", $19\frac{1}{2}$", and 17", while male hindlegs from Broad Run samples ($2\frac{1}{2}$ years and older) averaged 17.1". Shoulder height and heart girth categories are also very sketchy, but are included "for the record" for those future researchers who might want to investigate these indices of Broad Run deer.

Wild Turkey

Compartment Study

Appendix Table VI shows the hunter-hours and turkey seen in each of the 3 compartments.

As with the deer, one asks whether the 3 compartment averages for hunter-hours/turkey seen differ significantly, or did the differences occur merely by chance alone? The hunter-hours/turkey seen were averaged for each year (Table 9) and, through analysis of variance, were found to be significantly different (Table 10) at the 99% level of confidence with 2 and 21 degrees of freedom. Duncan's new multiple range test (Table 11) determined Compartment C's averages to be significantly different from B's and A's averages, and B's average to be significantly different from A's. These tests imply that wildlife practices alone (agricultural clearings and water holes as practiced in Compartment C) are the best methods for providing the most useful supplemental habitat for the production and maintenance of wild turkey populations, and that silvicultural treatments alone (as practiced in Compartment A) were the least satisfactory in this respect.

The attractiveness of Broad Run's agricultural clearings for turkey has been noted from the beginning of the 15-year study period. Quillen (1959:99-100) observed 2 large flocks and smaller groups "in September and October when the rye and wheat growing in 5 of the agricultural clearings were maturing and attracting the turkeys to these points. Of the 13 sight observations involving more than 137 birds, 7 (54 percent) were made in the grain clearings. Most of the other observations were made very near grain plantings...the grain plantings in the agricultural clearings are a great attractant to the turkeys."

Sight observations by Quillen (1959:160) during fall, 1957 to spring, 1959 showed the great preponderance of sightings to be in Compartment C. While turkeys were observed 7 times in Compartment A; they were observed

Table 9. Hunter-hours/turkey seen by compartments, at the Broad Run Management Area, 1964-1972.

	COMPARTMENTS		
Year	A	B	C
1964	396	133	21
1965	122	448	82
1966	73	64	9
1967	392	35	22
1968	174	115	20
1969	83	174	13
1970	237	85	51
1971	296	149	87
1972	602	300	440
Total	2375	1503	745
Average	264	167	83

Table 10. Analysis of variance of hunter-hours/turkey seen, at Broad Run Management Area, 1964-1972.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Test
Treatment (among)	2	581,184	290,592	69.73**
Error (within)	24	100,013	4,167	
Total	26	681,197		

**Significant at 95% confidence level, with 2 and 24 degrees of freedom.

Table 11. Duncan's new multiple range test on hunter-hours/deer seen, at Broad Run Management Area, 1964-1972.*

Standard error = 21.52

P	2	3
Significant Studentized Ranges	3.96	4.14
Least Significant Ranges	85.22	89.09

Compartment	C	B	A
Rank of Means	82.77	167.00	264.33

*Significant at the 99% confidence level

87 times in B and 134 times in Compartment C.

Seneca (1961:38, 84) also used direct observation in concluding that turkeys preferred the grain-producing clearings in the summer and fall, notably those planted in wheat and rye. Also, in the summer, turkeys, he found, were especially fond of using the soft soil in imprint plots for dusting while young turkeys fed on a high protein diet of grasshoppers and other insects found in the clearings.

Bachant (1963:68) stated turkey track on the management area "have always been located in Compartment C and the northern half of Compartment B." He also stated C had the highest population density (1 bird/ 102 acres) "because of wildlife management practices, lack of human disturbance (fewer hunters travel all the way to Compartment C to hunt), and presence of private pasture."

Bachant (1963) noted that sight observations and field signs indicated hens remained in the vicinity of agricultural clearings during the spring of 1962 and he mentioned findings by Mosby and Handley showing the turkey hen's decided preference for locating nests 5' to 10' from openings. In the summer of 1963 Bachant (1963:83) found this:

> "Family flocks showed a definite tendency to frequent agricultural clearings and open areas on the Broad Run Management Area (and)...abundant insects and dusting sites were probably the chief attractions to these clearings."

Seneca (1961) noted turkeys were attracted to water holes during the dry summer months as well. Martin (1972:61-62) also pointed out the attractiveness of clearings because of insects. He said:

> "Although there was essentially no significant difference between the amounts of insects eaten by the (domestic) turkey poults allowed to feed in the clearings and those permitted to feed in the wood plots, a

> number of explanations are possible...It is quite possible turkey poults could obtain their required protein from insects in the woods, but went to clearings because of the far greater abundance of these insects."

Martin (1972) suggested perhaps insects were not the major attractant of poults to these clearings, but that vegetation may be more important than investigators originally believed.

All this leads one to understand why more turkeys prefer a home range in a compartment where there are agricultural clearings. Both Compartments C and B, however, have about the same acreage of agricultural clearings, which have been renewed on a rotational basis throughout the 15-year study period. Why then would more turkeys apparently exist in Compartment C than B?

Both Compartments C and B have clearings and water holes, but Compartment B also has clearcut and intermediate cut areas. Compartment A, where the most number of hunter-hours were required to see a turkey, has silvicultural treatments only. Logically, one would conclude that, in some way, silvicultural treatments may somehow deter the carrying capacity of a turkey range if not accompanied by agricultural clearings.

One might summarize the situation as follows:

Compartment A--Would offer succulent young sprouts found on clearcut spots, but this would be less preferred than the cultivated crops found in agricultural clearings.

Compartment B--Would offer preferred agricultural food in the clearings, but this possibly could, in part, be offset by too much open space provided by the addition of clearcut areas.

Compartment C--Would offer preferred agricultural crops, plus the

security of closed forest canopy elsewhere.

Obviously, there is a point of diminishing returns in the amount of open space in a forest that would be beneficial to a turkey population. One end of the spectrum would have a whole forest clearcut. This would not only take away the preferred mast, but deny the turkey its cover and roosting sites. At what point does clearcutting act as a deterrent to the turkey's well-being? Raybourne (1968:48) suggested shape and size of clearcuts could determine their use by turkeys:

> "...during the study period the turkeys were not observed in the interior of a 60-acre clearcut area even though the periphery of the area was utilized. This was especially apparent during the fall hunting season."

Raybourne (1968:52) radio-tracked 4 immature turkeys. In his discussion he wrote:

> "It is the investigator's opinion that the lack of use of the clearcut area by the birds...was due to less available food (mast) than in the adjoining uncut area."

Also:

> "It appeared that the width of the clearcut area may also be another factor responsible for the lack of utilization."

Through tracking and observation of turkey flocks, Raybourne (1968: 52-53), in commenting on turkey use of clearcuts, found turkeys would use a 150-yd wide clearcut, but would stay within 100 yds of the uncut portion of a 300-yd wide clearcut:

> "This led the investigator to suspect that a usage-width ratio may exist for turkey movements in relation to clearcut timber management areas. It appears...that clearcut areas in excess of 150 to 200 yards in width may restrict turkey movements to fringe utilization of those areas. Length of clearcut areas did not seem to affect turkey movements adversely."

Raybourne (1968) indicated the need for research into the effect on turkeys of the shapes of clearcuttings. In this writer's opinion, this would also suggest research into the effect of clearcutting on turkey in areas already opened up by agricultural clearings.

However, more turkeys may have been seen in Compartment C because of topography rather than the quantity of clearcuts or agricultural clearings.

Bachant (1963:85) indicated why more turkeys might be seen during the hunting season in Compartment C:

> "As the season progressed and the weather became more severe, the flocks in Compartment C and E were seen on the study area much later in the season than those in Compartments A and B, but finally left the study area for the other side of North Mountain by early December 1962. It is thought flocks remained on the study area longer in Compartment C and E because the Broad Run Valley is narrow and affords more protection than did the slopes in these compartments."

One of Bachant's maps of the research area showed an estimated wild turkey distribution as it was in the fall of 1962. Distribution covered more than half of Compartment C while flock ranges only barely touched the peripheries of A and B. Although the range in C was much larger than in A and B, Bachant said he could discern no real difference existing in the abundance of flocks found in each of the compartments.

Bachant (1963:13) acknowledged Compartment C to have, in his opinion, "the largest inhabited turkey range because of additional acreage of pasture located on the north boundary of that compartment."

This confirmed the concept of cultural vegetation providing optimum turkey habitat, but it also suggested that if, indeed, more turkeys inhabited Compartment C, it was because of a bias provided by supplemental

pasture land. Also, if more turkeys were seen in Compartment C during late fall it may be because Compartment C provided terrain more sheltered (from severe weather) than did either A or B.

Therefore, the hunter-hours/turkey seen by hunters in this study may either confirm the greater attractiveness of agricultural clearings surrounded by a closed canopy forest (as in Compartment C), or it may merely reflect the biases aforementioned.

Assumptions

At the risk of being repetitious, the assumptions discussed about deer may also apply in the case of the wild turkey.

First, one again asks: Are turkeys spotted in a compartment, turkeys of that compartment? Within reasonable limits, would certain turkeys stay pretty well within one compartment? Again, one considers the compartments range from about 2,000 acres (3 square miles) to nearly 3,000 acres (nearly 5 square miles).

As one discusses this question, one recognizes that, generally speaking, turkeys appear to be more mobile and more gregarious than deer. Because seasonal ranges of the turkey have been studied at Broad Run, there is a distinct advantage in having this aspect of the turkey's life evaluated for this study.

How far and where turkeys roam depends principally on available food supply (Dalke et al. 1946; Mosby and Handley 1943). A cruising radius of 2 miles (12 square miles) has been reported for flocks in Virginia by Mosby and Handley (1943). Band returns on studies in Alabama, West Virginia, and Florida indicated the majority of annual movements to be of

2 to 4 miles (Raybourne 1968).

However, Davis (1968) reported minimum ranges, based on banding data, to vary from 200 to 500 acres. Ellis and Lewis (1967) found the minimum annual range of 4 adult gobblers to average 750 acres. Lewis (1967) found the minimum home range of 35 birds with wing streamers and 6 with transmitters to average 840 acres. However, 3 adult males with transmitters had home range averages of almost 1200 acres.

Raybourne (1968) pointed out an Alabama study by Wheeler which, in this writer's opinion, is very appropriate for this study. Raybourne (1968:5) stated:

> "...the locality chosen as range by wild turkey varies considerably throughout the year. Turkeys that used a certain range for a protracted period suddenly would move to another locality...such shifts usually involved movement from one ecological type to another and virtually all of the turkeys would act in concert when a shift was made. Such shifts usually involved only short distances, however, because of the variety of cover types and their interspersion in small areas."

The variety of cover types, the homogeneity of mast-producing trees, and the interspersion of agricultural clearings may well have held turkey flocks at Broad Run within the compartment boundaries throughout most of the year until approaching winter caused them to move into the lower elevations of Compartment C and the east face of North Mountain. Also, the greater movement of flocks in the fall from lower to higher elevations, with the maturity of mast, would tend to run within compartments because their boundaries are at right angles to the contours of the land.

Using various wildlife techniques, Bachant (1963) found several gobbling territories at Broad Run—territories ranging from 64 to 102 acres (average 95 acres) with hens seen "in generally close association with

gobbling males." In the summer, family flocks had an average cumulative range of about 500 acres. In his maps depicting spring and summer ranges, Bachant depicted the territories and ranges to be within the compartments, except that the summer range overlapped from C into 2 directions--slightly into the lower elevations of Compartments B and E.

In the fall, when hunters were afield, turkey distribution patterns become narrow and elliptical. In Broad Run, Bachant (1963) found half of Compartment C was used by turkeys while the east side of North Mountain, south of A and B, was used by turkeys because it afforded more protection than the slopes of these compartments. This undoubtedly may have been another reason less turkeys were spotted by hunters in A and B.

In the winter, the east face of North Mountain is the wintering range of the majority of flocks on the management area. Thus hunters should see less turkeys as the hunting season progresses.

Based on data for 1958-1961 (via sight observations only), Bachant (1963) pointed out that inhabited turkey range at the management area "has remained fairly constant throughout the years."

Another indication Broad Run turkeys could stay well within compartment boundaries (during non-winter months) was reflected in Raybourne's telemetry of turkey movements. He found 4 immature wild turkeys (3 hens and a gobbler) had a minimum home range of about 425 acres prior to the hunting season and 552 acres during the hunting season. There was little change in range size affected by the hunting season and Raybourne felt vehicular disturbance rather than hunting pressure was more responsible for change in range size.

Hunter and Harvest Data

Bachant (1963) reported turkey harvest information was secured from hunter-operated check stations and personal contact at the road-block station. The data which Bachant (1963) recorded, however, is at variance with the data Hooper (1967a) recorded on turkey and small game hunter pressure and success. According to McGinnes (1972, pers. comm.) forms left for hunters to fill out were filled out incompletely and haphazardly, so that Hooper's data, taken solely from road-block stations, are being used as the more reliable source.

Appendix Table III shows the hunter pressure and hunter success and game seen for turkey, grouse, and squirrel since the management area was opened to the public in 1957. Appendix Table IV shows total hunter-hours /turkey and small game seen, for all compartments. It is uncertain if, in the case of the turkey, hunter-hours/turkey seen could be used as an indication of turkey abundance, year to year. Fig. 11 illustrates graphically the annual shift of turkey population at Broad Run based on hunter-hours/turkey seen. The chart reflects an inverse relationship between hunter-hours/turkey seen and total population abundance.

Only one flock, comprising 7 to 22 birds, was Quillen's (1959) estimate for turkey on the management area for the winter of 1957-1958. By 1960, according to Seneca (1961), the population had increased to 100-125 birds, but dropped to 50 by 1962 (Bachant 1963). Hooper (1967) estimated a relatively stable population from 1963 to 1967. Fig. 11 shows an increase in the population in 1959, then a deep dip in 1965 (by way of the increased hunter-hours/turkey seen), and then a rise in 1966 and a

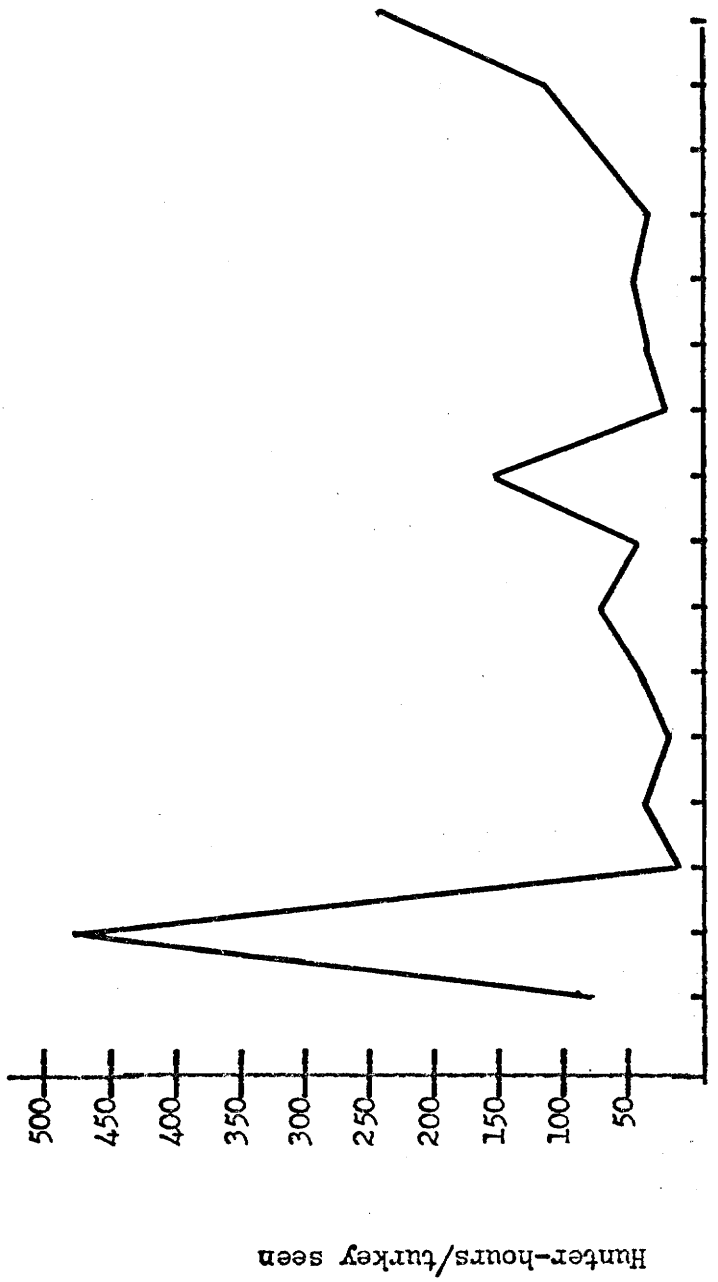

Fig. 11. Hunter-hours/turkey seen/year, at Broad Run Management Area, 1957-1972.

leveling off, so that there has been no drastic overall change in population between 1963 and 1967, as reflected in the hunter-hours criteria. There have been no population estimates since Bachant's work, however, so little can be concluded about hunter-hours/turkey seen as an index of relative abundance. There is, also, the fact that many turkeys leave the management area before the hunting season ends. Predation and illegal harvesting and the normal culling of turkeys pursuant to the trials of winter also act upon a population differently each year so that there may well be a sharp fluctuation in turkeys seen from hunting season to hunting season, thus influencing what a population might be in mid-November, the focal point for each yearly comparison. A turkey population may change drastically from November to January. Bachant (1963), for instance, was told by Seneca that one whole flock may have been eliminated at Broad Run in the fall of 1960 by poaching. By contrast, change in a deer population would be less drastic during the 2 weeks they are hunted and spotted on the management area.

Eastern Gray Squirrel

Compartment Study

Appendix Tables VII indicates the hunter-hours and squirrel seen for all 3 compartments at Broad Run from 1964 through 1972. For each of these years the hunter-hours/squirrel seen was averaged for the 3 compartments (Table 12), and, through analysis of variance (Table 13), it was found that the hunter-hours/squirrel seen over the years was non-significant between compartments, with 2 and 24 degrees of freedom. This

Table 12. Hunter-hours/squirrel seen by compartments, at the Broad Run Management Area, 1964-1972.

	COMPARTMENTS		
Year	A	B	C
1964	79	15	10
1965	26	24	48
1966	5	9	4
1967	11	5	4
1968	27	10	14
1969	17	25	17
1970	14	19	7
1971	19	8	13
1972	80	59	51
Total	278	174	168
Average	31	19	19

Table 13. Analysis of variance of hunter-hours/squirrel seen, at the Broad Run Management Area, 1964-1972.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Test
Treatment (among)	2	850	425	0.90 n.s.
Error (within)	24	11,229	468	
Total	26	12,079		

n.s. non-significant

means the different treatments apparently did not significantly affect the relative abundance of Eastern Gray squirrels between compartments at the Broad Run Management Area.

Quillen (1959) has been the only researcher to study the squirrel population on the management area. Using leaf-nest counts as an index, Quillen sampled each compartment along the transect lines (one chain on each side of the transect center line) and found an average of one leaf nest/26.6 chains along the 2-chain wide belt transects of Compartments A, B, and C.

Quillen found an average of one leaf nest/6 acres in Compartment A; one leaf nest/9 acres in Compartment B, and one lef nest/3 acres in Compartment C. On the face of it, Quillen's result might indicate more squirrels inhabiting Compartment C. Based on hunter-hours/squirrel seen, Table 12 shows there to be the largest number of squirrels in Compartment C, but not significantly the most. Because Quillen sampled only about 30 acres of each compartment, he admitted his conclusion could not be considered valid. In the only published evaluation on Broad Run's squirrel situation, Quillen (1959:93) stated:

> "Broad Run Area cannot be considered good squirrel range due to the age and composition of the timber. The majority of the timber is in the pole stage and growing on poor sites; therefore, the oaks and hickories are not in the optimum mast-producing stage. The mast producers are scattered throughout most of the area with the largest concentrations in the hollows and upper coves; the greater squirrel numbers are found in this same scattered pattern."

Homogeneity of mast-producing trees, the mast being the squirrel's preferred food, intimates homogeneity of squirrel numbers across the study area. There have been no squirrel studies since Quillen's to shed light

on the squirrel population at Broad Run.

Quillen stated neither sex nor age ratio conclusions could be determined from harvesting data at Broad Run because squirrel hunters were too sparse and kills, therefore, too infrequent. Although more kills have been recorded in recent years (Appendix Table III), there has been no attempt to gather sex and age data.

The existence of widely-spaced mast trees—15 years older than in Quillen's day—and hardwood browse would make one assume there is enough food for gray squirrels at Broad Run. Trippensee (1948:138) stated:

> "Whether or not...mixed stands are superior to woodland composed largely of oaks and hickories is perhaps more of academic than practical significance. The theory is that at times when acorns and nuts are scarce, the mixed forest provides substitute materials in greater quantity than the less diversified mixture of oaks and hickories. This is doubtless true; but if a given unit of forest is considered as a whole, the interspersion of natural cover types is usually such that even though oak and hickory predominate much of the area, other species are sufficiently numerous locally to supply all necessary...foods."

Appendix Table IV provides data upon which Fig. 12 illustrates the annual variation of hunter-hours/squirrel seen, from 1957-1972. If hunter-hours/squirrel seen is a valid index for relative population abundance, then Fig. 12 shows the squirrel population at Broad Run remaining relatively stable, although containing rather mild fluctuations normal for a population over a period of years.

Ruffed Grouse

Compartment Study

Appendix Table VIII shows the number of ruffed grouse seen and kill-

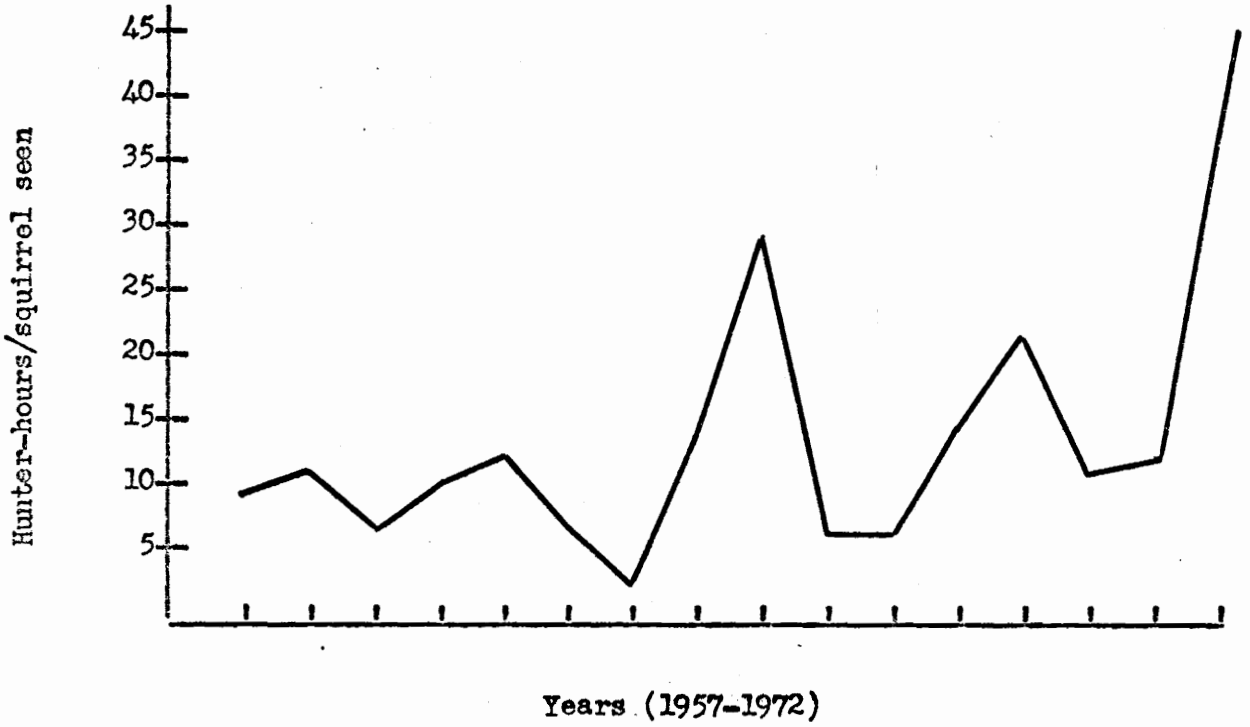

Fig. 12 Hunter-hours/squirrel seen/year, at Broad Run Management Area, 1957-1972

ed by hunters, in each of the 3 compartments at Broad Run from 1964 through 1972. In Table 14, the hunter-hours/grouse seen were averaged for each year, and, through analysis of variance (Table 15) found to be non-significant across the compartments, with 2 and 24 degrees of freedom. In other words, the different treatments apparently did not significantly affect the relative population abundance of ruffed grouse at the Broad Run Wildlife Research Area.

Quillen (1959) was the only researcher to take a grouse inventory at Broad Run. It was conducted by drumming counts, flushing counts, and hunter bag check. His flushing counts, made in December 1957-January 1958, indicated one bird flushed in Compartment A, 2 in B, and none in C. Drumming counts in the spring of 1958 were not categorized by compartment and so are of no use here. Quillen kept a record of all grouse he saw during the course of his study (1957-1958) and reported 11 birds spotted in A, 73 in B, and 22 in C. His harvest data for those years were very small (12 birds harvested) and incomplete.

Although Compartment B, on the face of it, has had more sightings of grouse, we have shown above that number of sightings by hunters were not significantly different between compartments.

Quillen (1959) opined the grouse population had increased from 1957 to 1958, apparently because of the 2:1 ratio of juveniles killed for every breeding female. This is at variance with the data pictured in Fig. 13, which shows more hunter-hours required to see a grouse, and, therefore, theoretically, a lower grouse population in 1958 than in 1957. If hunter-hours/grouse seen is a valid index for relative population abundance, Fig. 14 indicates that the grouse population at Broad Run has been er-

Table 14. Hunter-hours/grouse seen by compartments, at the Broad Run Management Area, 1964-1972.

	COMPARTMENTS		
Year	A	B	C
1964	21	35	17
1965	25	149	36
1966	50	28	37
1967	392	11	0
1968	25	20	38
1969	28	17	28
1970	68	36	55
1971	42	63	189
1972	67	75	54
Total	718	434	454
Average	80	48	50

Table 15. Analysis of variance of hunter-hours/grouse seen, at the Broad Run Management Area, 1964-1972.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Test
Treatment (among)	2	5,585	2,793	0.44 n.s.
Error (within)	24	151,158	6,298	
Total	26	157,376		

n.s. non-significant

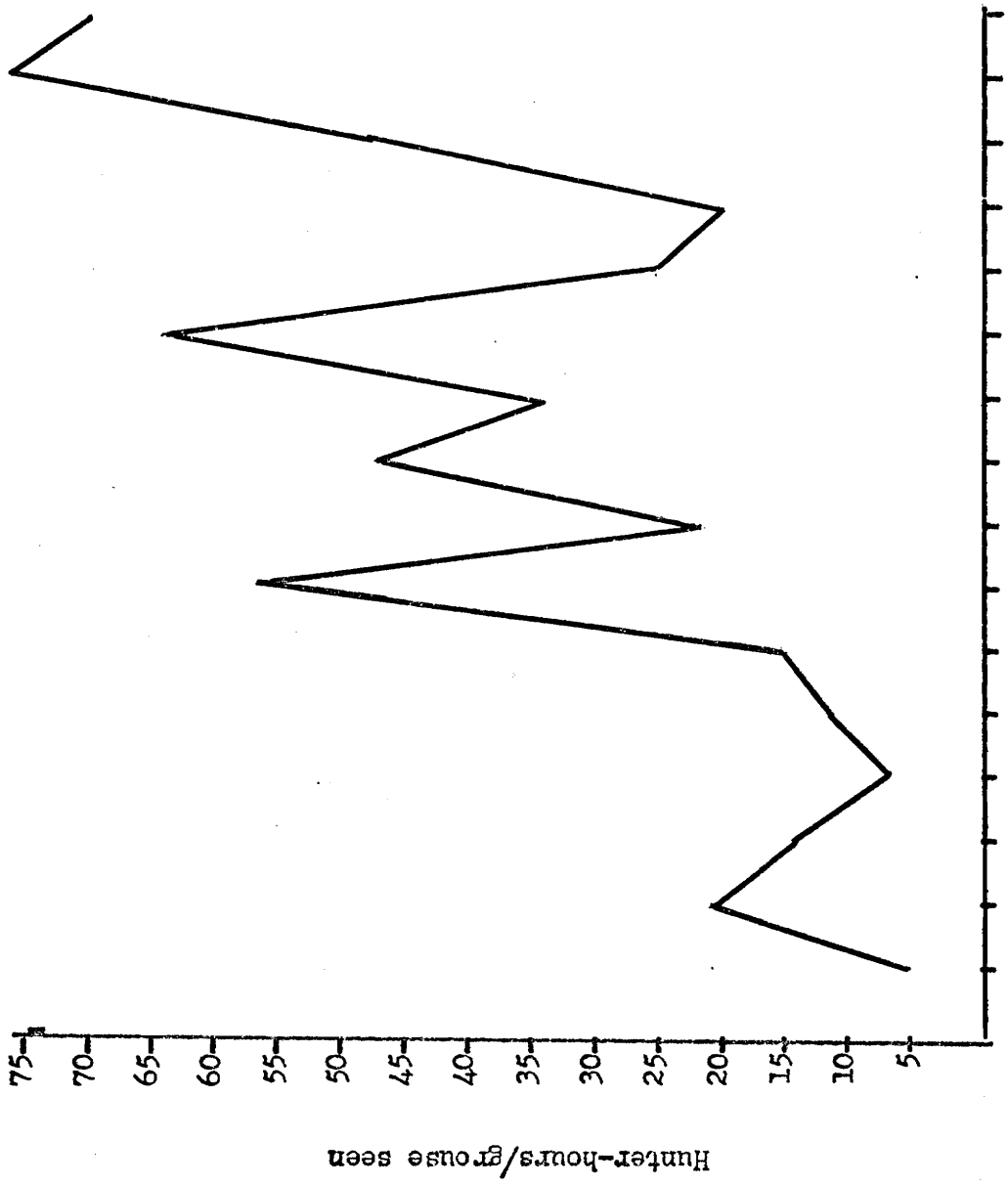

Fig. 13. Hunter-hours/grouse seen/year, at Broad Run Management Area, 1957-1972.

ratic, with sharp peaks and troughs. This possibly reflects this bird's characteristic fluctuations in population density.

Although this study is primarily concerned with the affect of wildlife and/or silvicultural practices on turkey and deer populations, these practices have also encouraged diversity of habitat that might even benefit the ruffed grouse. There are elements in the habitat, however that would seem to make management of this bird per se unneccesary. According to Trippensee (1948) and Allison (1966), a mixed forest of conifers and hardwoods is best. "Group selection, clearcutting in small units, and intermediate cuttings that encourage mixed composition are excellent means (of encouraging grouse populations)," said Trippensee (1948:285). Most clearcutting on Broad Run has involved acreages less than 50 acres and several less than 20 acres. Broad Run forest cover is also well mixed, the conifers providing winter roosts. This writer has also observed hemlock on the study area. Presence of such preferred browsing trees as birch, beech, cherry, oaks, and sugar maple, in addition to such preferred shrubs as viburnums, dogwoods, witch hazel, sumac, and various berries has been verified (Weekes 1971). Clearings and agricultural plots at Broad Run provide insects and low browse and cover growth for the young birds. The interspersion of uneven-aged timber and agricultural clearings would have one conclude the management area provides desirable habitat for grouse--even though the main objectives have been to provide food for turkey and deer and saleable timber for the Forest Service.

RECOMMENDATIONS

New Data Form

In making judgments on how Broad Run game populations have been responding to silvicultural and/or game management practices in designated compartments, Virginia Wildlife Cooperative Unit personnel have heavily depended upon hunter sight observations as an index. Since 1968, hunter pressure and success data have been recorded on, and compiled from, mimeographed sheets (Fig. 14) at the Broad Run check station.

The tally sheet properly allots space to mark compartments visited by each hunter (column 7). Road time for each hunter in each compartment has been fixed at ½ hours (.50 hours)—15 minutes to enter and 15 minutes to leave each compartment. For example, if 3 hunters in the same automobile went to Compartment 3 (C) and hunted, then each of them spent time in 3 compartments and there would be 9 lines properly filled out for this car-load of hunters, as illustrated in Fig. 14. If game were seen or killed on the road or in the field, the number would be so written in the spaces allotted on the tally sheet. If these hunters camped 3 hours in Compartment 3, this time would be filled in, but not included as hunting time (columns 40-44). Road time has been counted as hunting time and included in the hunter-hour total. Seemingly this is a simple, straightforward tally sheet for registering hunter-hours, game seen, and game killed data. Using this tally sheet, one should easily be able to compile hunter-hours/game seen for each compartment. This index hopefully reflects the relative amount of game in each compartment. From this index one should be able to deduce whether the treatment effect, if any,

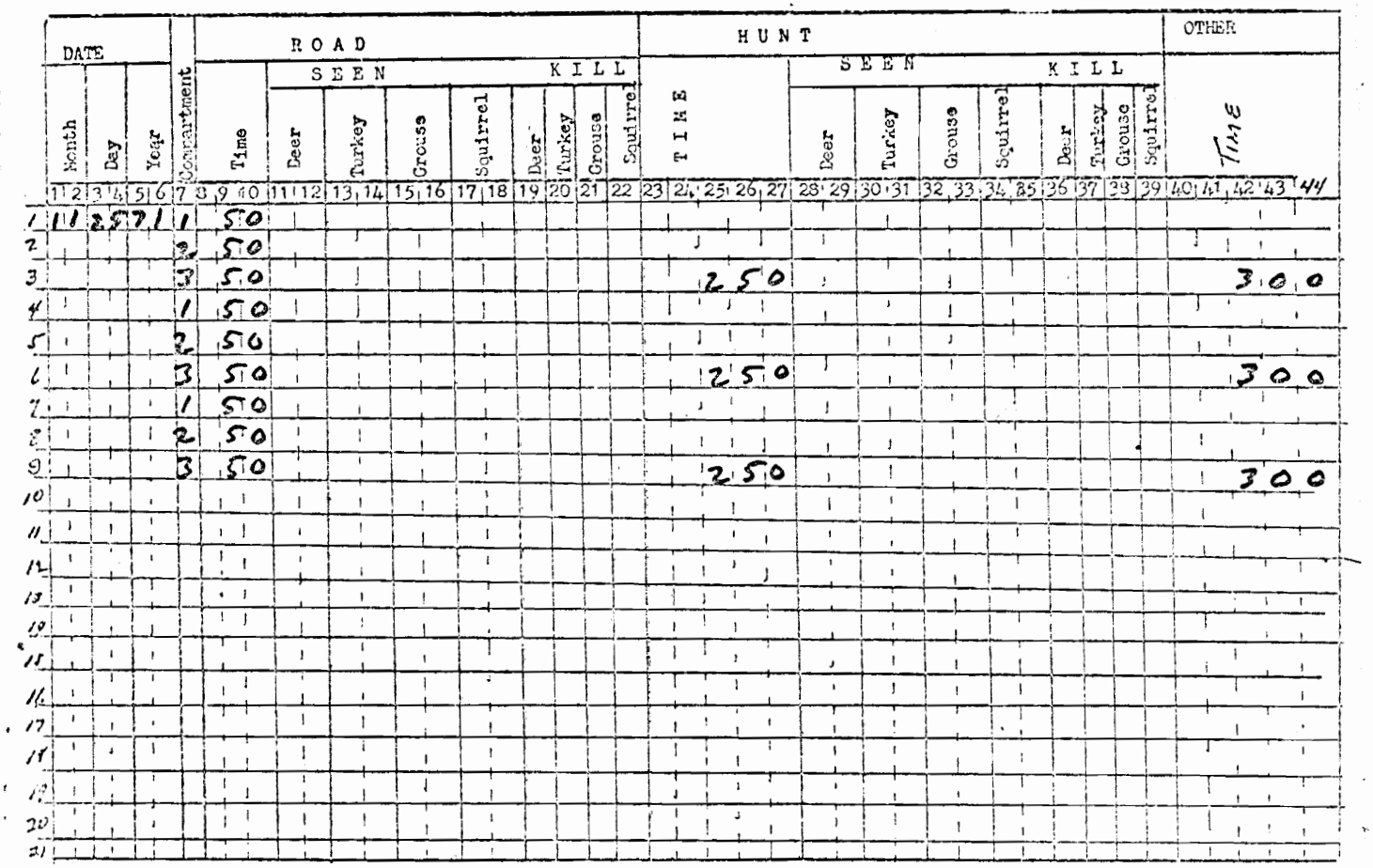

Fig. 14. Form for collecting data on hunter pressure and success, at the Broad Run Management Area, 1968 to present.

has been significant in influencing game populations.

However, the use of this tally sheet has resulted, in many cases, in incorrect recording of information. Some data checkers were evidently confused in lining up the correct columns and rows. The tally sheet requires precise care in placing numbers in small boxes. Check station operators may well have been frustrated in their attempts to be meticulous, sometimes being forced to write hurriedly, in uncomfortable positions, and during times when visability was poor because of approaching darkness, or because of inclement weather.

Hours spent hunting were often assigned to the wrong compartment. A common error was to assign hunting time to Compartment A, but also road time to B and C. The Broad Run Creek gate leading to Compartment C remains closed throughout the year, even during the hunting season. Hunters must enter Broad Run through Compartment A. To reach Compartment C, then, hunters must pass through B. Therefore, hunters are not likely (though it is possible) to hunt in A or B and <u>then</u> go to B or C, respectively. In other cases, hunting-hours were assigned for one compartment, while game seen or killed were recorded for the same hunter to have occurred in another compartment (a physical impossibility).

There was another inaccuracy in listing game seen and killed. At times a single animal was recorded killed (columns 36-39), but the game was not credited with having been seen (columns 28-35).

Error also stemmed from the fact that some hunters hunt alone, while others hunt with companions. After searching the data, this investigator suspects instances where hunting parties have been given credit for seeing more game than they actually saw <u>as a group</u>. To illustrate: Suppose

a single individual hunts 3 hours and sees one deer. Result: 3 hunter-hours/deer seen. Suppose 3 persons hunting together for 3 hours see one deer. Result: 9 hunter-hours/deer seen. Suppose, at the check station, each of these 3 hunters stated he saw a deer. If the checker were not precise in his questioning, he may assume <u>each</u> hunter saw a deer. He would record 3 deer seen by the group, which, in reality, saw only one deer. Result: 3 hunter-hours/deer seen. This compilation would be incorrect because the hunting party was given credit for having seen 2 more deer than it actually saw.

This investigator, in compiling data from 1957 through 1972, caught most of these errors and corrected the data wherever it seemed likely an error had existed. The above errors can be eliminated if the following guidelines for data gathering be stressed in the future:

1. Each hunter be given ½ hour road time for each compartment visited.
2. Game seen by a party of hunters is game comprising the total number of animals seen by the party <u>as a whole</u>.
3. A game animal killed is automatically a game animal seen.
4. Check station operators should obtain information which clearly distinguishes compartments visited from compartments hunted.

To help insure data are precisely recorded and accurately compiled, a new tally sheet, or data form, is recommended. It should be comparatively simple and easy to understand with space available only for relevant material. Fig. 15 is a sample of such a form.

The suggested form emphasizes Broad Run's compartmentization. Total hunter-hours for each hunting party is to be compiled on the spot. Total hunter-hours is simply the number of hours spent on the road and hunting

Date _____ BROAD RUN HUNTER PRESSURE FORM Data recorded by: _____

Time entered _____; departed_____: Total time _____

Name of driver _____ No. hunters in party _____

COMPARTMENT A

Road HH	Game seen by party (deer sex)	Game killed
Hunting HH	Game seen by party (deer sex)	Game killed

COMPARTMENT B (if not visited, check)

Road HH	Game seen by party (deer sex)	Game killed
Hunting HH	Game seen by party (deer sex)	Game killed

COMPARTMENT C (if not visited, check)

Road HH	Game seen by party (deer sex)	Game killed
Hunting HH	Game seen by party (deer sex)	Game killed

Fig. 15. New data form for collecting harvesting information at Broad Run Management Area check station.

multiplied by the number of hunters in a party. If a party does not visit Compartments B and/or C, then the "not visited" slot is checked. Also, for instance, should a party finish hunting in A, and then move through B and C compartments, perhaps just to sight-see from its vehicle before departing, this can be recorded on the suggested form, erasing any assumption that the last compartment a hunting party visits is necessarily that compartment in which it hunts. This was the assumption made by this investigator in interpreting some of the data coming off the present form. Example: a party of 3 hunting 3 hours in Compartment A and subsequently moving through B and C before turning around and coming back through the compartments prior to leaving, would be credited with $1\frac{1}{2}$ (3 x $\frac{1}{2}$) road hours and 9 (3 x 3) hunter-hours in A. Recording hunter-hours of hunting parties on the spot should make subsequent data compilation easily discernable and faster than is the case presently.

Because the recorder is required, in the suggested form, to write out the game species and their number seen and/or killed, there should be little chance that an animal could be marked incorrectly by accident. Also, hunters should be asked to report the sex (antlered of not) of the deer they see so a handle on sex ratio could be deduced.

It is essential that game seen be recorded for a hunting party <u>as a whole</u>. Check station operators should question hunting parties as carefully as possible in order to avoid duplication of recorded sightings. Duplication poses a threat where 2 or more hunters are questioned together. To illustrate: where there are 3 persons hunting together, one may see game, the other 2 none; or 2 may see game, the third none; or all 3 may see the same game. When a party's sightings are recorded at the

check station, it is hoped each hunter will know whether his companions saw, or did not see, the same animal he himself saw at the same instant. Any criterion involving hunter sightings as an index of relative game numbers does contain one acknowledged weakness. Certainly it is possible a given animal could be counted twice by different persons hunting alone, or by one person at different instances. The shortcoming can be mitigated somewhat if care is taken in questioning each hunting party and having it pool its sightings on an individual basis at the check station.

Should there later be any doubt about what has been written on these suggested forms, a compiler should be able to contact the recorder or maybe even the hunter. Space is allowed for both names. The driver's name is also essential for identifying the hunting party to verify when it has entered and left the management area. Whether or not a hunting party camped is irrelevant to this report, except as a means of explaining particularly long stays at the management area. Animals seen while camping, therefore, should be disregarded.

Uniform Kill Data

Throughout the seasons inconsistencies have been apparent in information furnished on harvested deer. It is important deer measurements, weights, and ages be recorded. The annual age structure of harvested deer can be an index to the age structure of the deer herd. Age structure could indicate whether a herd is growing, is stable, or decreasing in number. Weights and measurements of harvested deer indirectly reflect habitat quality. These indices are important tools in game management.

Data, of one kind or another, have been preserved for 156 of the 203 deer killed at Broad Run since 1957. Of these 156 deer, 19, or 12%, were not aged. Deer weights were recorded each season, but dressed and live weights were many times mixed. Of the deer killed during 13 seasons, 14, or 13%, were not weighed. Antler beam dimensions were not tabulated during 6 seasons. Antler points were not counted in 1971 and 1972, and heart girth data were omitted during 9 seasons. Of the 133 dead bucks on which at least some data have been preserved since 1957, 14 were not old enough to have antlers. Of the remaining 119, 19 animals, or only 16%, had had their antlers measured, while 80 deer, or 67%, had their antler points counted and recorded. Shoulder height and total body length have been included in kill statistics only during a few seasons. Of the 156 recorded killed deer, 32 animals, or only 21%, had their tarsus bone measured. Tail lengths were tallied during only 2 seasons.

Another aspect in data recording must be noted. In order for measurements and weights be significant, they must be classified according to age. The reason for this is obvious: animals of different ages are physically diverse. Age classification enables animals of the same age group to be compared year by year. If there are enough harvested animals in each annual crop, significant comparisons can be made. Where the number of killed deer is insufficient, data on them are of little use. This can be the case where there have simply not been enough deer killed. This can also be the case where data are incomplete.

Of the 156 deer on which kill information has been preserved, 52 animals, or only 33%, have evidenced complete data, during specific years. Clearly, there is a dire need for consistency and constancy in the type

of data which are to be collected on harvested deer. Such consistency and constancy is essential to provide information in sufficient quantity to be useful to researchers in future evaluations of the Broad Run deer herd and its habitat.

Data Preservation

Only about 75% of the Broad Run kill cards of deer have been preserved. Hunter pressure and success data for November 29, 1967 are missing and cannot be incorporated in this thesis. Where many different people handle and use the same data and reports over the years, there is danger this material will be lost or misplaced. For this reason, it is imperative recorded data be compiled as quickly as possible and incorporated in the Virginia Cooperative Wildlife Research Unit's quarterly progress report. This would be insurance against eventual misplacement of raw data. Not now incorporated in the quarterly progress reports are hunter pressure and success for each compartment, and kill card information on the important species—deer and turkey.

Use of Control Area

To appreciate the significance of wildlife and silvicultural treatments to game populations, one should be given a comparison with areas not treated. To ask what difference treatments make is also to ask how game fares in habitat devoid of treatment.

Compartments A, B, and C have been treated differently and data were gathered in an attempt to evaluate these differences. Very little data have been gathered from hunters in the Brush Mountain Control Area. In

the early years of the Broad Run study, it was stated that the Control Area deer herd was too small for making an evaluation. Also, Control Area hunting pressure has always been light. This was one reason for discontinuing the mobile runs. Now, after 16 years, it should be time that hunters be encouraged to hunt in the Brush Mountain area. It should be time that Control Area data be gathered and recorded--minimal though it may be in the beginning.

To implement this decision, this investigator recommends a study be made of the feasibility of constructing a small parking lot for Control Area hunters on Control Area land adjacent Rt. 620, the Craig Creek Road (Fig. 16). A small check station stand should be set up at the parking lot entrance and manned during the hunting season. Signs should be placed along Rt. 620 and at the intersection of Rt. 620 and Rt. 311 directing hunters to the area. This parking lot should greatly enhance hunting pressure at the Control Area and funnel hunter information.

To insure the completeness of Broad Run and Brush Mountain hunting data, a regulation should be passed by county and state legislative bodies to the effect that game harvested at either of these 2 locations MUST be checked in at the check stations located in these areas.

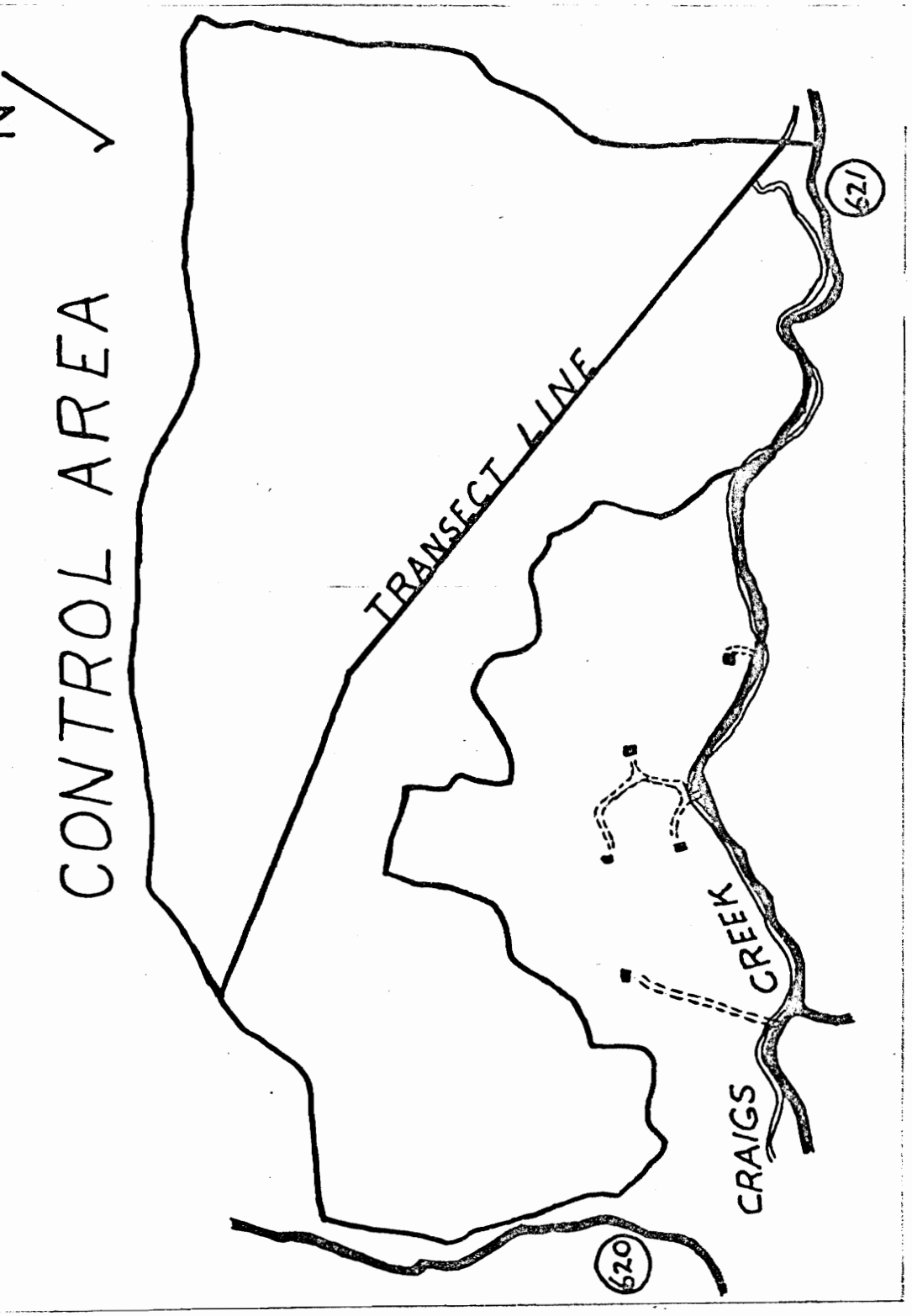

Fig. 16. Map of the Brush Mountain Control Area, Craig County.

SUMMARY AND CONCLUSIONS

This thesis is serving as a study report on 15 years of wildlife research performed at the 11,422-acre Broad Run Wildlife Research Area, also known at the Broad Run Management Area, in Craig County, Virginia. Incorporated in this thesis is a synthesis of all pertinent data, conclusions, evaluations, and recommendations emanating from the 17 theses written from studies undertaken at Broad Run. From these 17 theses there has been gleaned 193 results which are included in this thesis. These results took the form as either facts, summary conclusions, distilled background discussions, or as evaluations on information unearthed or research performed.

Five works emanating from studies at Broad Run, concerned attempts to quantify browse and mast. Four theses concerned the wild turkey, its movements, distribution, and abundance as influenced by wildlife management practices. Three theses concerned deer, its abundance and the influence, if any, on its population by dogs. Two theses were concerned with such wildlife practices as agricultural clearings and herbicide use, while the remaining theses were on the subjects of wild grapes, birth control in foxes, climate as an influence on the deer hunter, and the influence of forest habitat on songbird populations.

A second major part of this thesis is aimed at determining the influence, if any, of wildlife practices (installation of agricultural clearings and water holes) and silvicultural practices (clearcutting and intermediate cuts) on the populations of deer and turkey at Broad Run. In other words, do these practices increase the carrying capacity

of the range, an increase manifested by more sightings of animals that are using portions of Broad Run as their home range.

To determine the influence of these practices on wildlife populations, the research area, in 1957, was divided into compartments. Three of the compartments--A, B, and C--were treated in specific ways: Compartment A--silvicultural practices only; Compartment B--wildlife and silvicultural practices; Compartment C--wildlife practices only.

The index used to relate the effects of these practices was eyewitness accounts of November hunters--more specifically, the number of hunter-hours required to see a deer or a turkey.

Over the years since 1964 the hunter-hours/animal seen were recorded for each compartment and averaged for each of the species--deer, turkey, squirrel, and grouse. Analysis of variance and Duncan's new multiple range test were run to determine whether there were significantly more or less hunter-hours/animals seen among the compartments. Theoretically, the greater number of hunter-hours/animal seen, the lower the population of that animal. The results of these tests showed that:

(1) Silvicultural and wildlife practices may both be necessary in providing a deer range with maximum carrying capacity (Compartment B has significantly less hunter-hours/deer seen than Compartment A, and less, but still not significantly less, hunter-hours/deer seen than Compartment C).

(2) Wildlife practices alone appears to be the best means of improving turkey range (Compartment C has significantly less hunter-hours/turkey seen than either Compartments A or B).

(3) Neither wildlife nor silvicultural practices appear to affect

the carrying capacity of the squirrel or ruffed grouse range (no significant difference in hunter-hours/animals seen between the compartments).

Physical measurements of harvested deer, over the years, indicate the Broad Run herd to be in a condition comparable to herds found elsewhere.

The gathering, recording, and preservation of hunting pressure and success data need to be consistent and uniform in order to insure that hunting-hour and game-seen information is more accurate for future statistical analysis. Data should also be gathered from the Control Area, where there is neither wildlife nor silvicultural treatments practiced.

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Appendix Table I. Scientific names of taxa mentioned in the thesis.

Scientific name	Common name
Quercus velutina	Black oak
Quercus prinus	Chestnut oak
Quercus coccinea	Scarlet oak
Quercus ilicifolia	Bear oak
Pinus rigida	Pitch pine
Pinus pungens	Table Mountain pine
Quercus borealis	N. Red oak
Liriodendron tulipifera	Yellow poplar
Pinus strobus	White pine
Pinus virginiana	Virginia pine
Cornus florida	Flowering dogwood
Hamamelis virginia	Witch hazel
Rhododendron nudiflorum	Honeysuckle
Rubus spp.	Dewberry
Vaccinium stamineum	Deerberry
Magnolia acuminate	Cucumber tree
Kalmia latifolia	Mountain laurel
Gaylussacia spp.	Huckleberry
Vaccinium spp.	Blueberry
Quercus alba	White oak
Nyssa sylvatica	Black gum
Sassafras albidem	Sassafras
Acer pennsylvanicum	Striped maple
Betula lenta	Sweet birch
Oxydendron arboreum	Sourwood
Trifolium repens	White Dutch clover
Malus spp.	Apple
Gleditsia triacanthos	Honeylocust
Trifolium repens latum	Ladino clover
Setaria italica	Millet
Brassica napus	Rape
Glycine max	Soybeans
Vigna sinensis	Cowpeas
Lespedeza spp	Lespedeza
Pinus taeda	Shortleaf pine
Festuca arundinacea	Ky. 31 fescue
Lolium multiforum	Italian ryegrass
Goodyera spp.	Rattlesnake plantain
Galax aphylla	Galax
Smilax spp.	Greenbriar
Rhododendron spp.	Azalea
Acer rubrum	Red maple
Chimophila umbellata	Pipsissewa
Viburum acerifolium	Maple-leafed viburnum

Appendix Table I. Scientic names of taxa mentioned in the thesis (continued).

Scientific name	Common name
Lonicera japonica	Japanese honeysuckle
Vitas spp.	Grape
Poa pratensis	Kentucky bluegrass
Trifolium spp.	Kenland clover
Gaultheria procumbens	Teaberry
Hepatica	Liverleaf

Appendix Table II. Overall deer kill and hunter pressure statistics for all compartments at Broad Run Management Area, 1957-1972.

Year	Hunter visits	Hunter[a] hours	Number deer Seen	Killed	Hunter-hours/deer Seen	Killed
1957[b]	60	248	71	9	3	28
1958	366	1434	66	6	22	239
1959	210	776	72	6	11	129
1960	285	1158	64	6	18	193
1961	258	877	27	6	33	146
1962	331	1477	65	9	23	164
1963	335	2008	96	7	21	287
1964	484	1923	91	5	21	385
1965[c]	437	1958	90	7	22	280
1966	718	3752	222	13	17	289
1967	884	5201	244	19	21	274
1968	920	4875	217	18	22	271
1969	780	4351	188	12	23	363
1970	1042	5121	313	23	16	223
1971	843	5401	258	22	21	245
1972	1135	6604	534	35	12	189

[a] This total includes time spent on the road and hunting time; it does not include camping time.

[b] Data on file, Virginia Cooperative Wildlife Research Unit, Blacksburg, Virginia.

[c] Data on file, SEFES, Blacksburg, Virginia.

Appendix Table III. Total hunting pressure, hunter success, and game seen on the Broad Run Management Area, all compartments, for turkey and small game, 1957-1972.

Year	Hunter hours	Grouse Seen	Grouse Killed	Squirrel Seen	Squirrel Killed	Turkey Seen	Turkey Killed
1957[a]	249	47	2	29	3	3	0
1958	1434	70	7	129	5	3	0
1959	776	54	1	103	3	68	0
1960	1159	166	9	113	4	29	0
1961[b]	877	81	2	73	4	44	2
1962	1477	100	1	219	5	34	2
1963	2008	36	1	903	4	29	2
1964	1923	86	2	135	4	42	3
1965	1958	42	0	69	5	13	0
1966	3752	111	1	654	5	185	0
1967[c]	4689	73	0	830	14	118	5
1968	4875	200	1	279	5	107	1
1969	4351	215	9	211	10	113	0
1970	5121	109	0	456	4	65	3
1971	5401	71	0	467	6	43	2
1972	6604	76	0	122	9	22	0
Total	46,654	1,537	36	4,792	90	918	20

[a] Data (1957-1960) from Seneca (1961:79).
[b] Data (1961-1966) from Hooper (1967a:10, 15, 17).
[c] Data for November 29, 1967 not available; other data on file, Virginia Cooperative Wildlife Research Unit, Blacksburg, Virginia.

Appendix Table IV. Average hunter-hours/grouse, squirrel, and turkey seen, each year, all compartments, Broad Run Management Area, 1957-1972.

Year	Grouse	Squirrel	Turkey
1957	5	9	83
1958	21	11	478
1959	14	7	11
1960	7	10	40
1961	11	12	20
1962	15	7	43
1963	56	2	69
1964	22	14	46
1965	47	29	151
1966	34	6	20
1967	64	6	40
1968	24	14	46
1969	20	21	39
1970	47	11	79
1971	76	12	126
1972	70	45	246

Appendix Table V. Hunter-hours and deer seen, by compartments, at Broad Run Management Area, 1964-1972.

Year	Compartment A		Compartment B		Compartment C	
	Hunter hours	Deer seen	Hunter hours	Deer seen	Hunter hours	Deer seen
1964[a]	396	7	797	38	729	46
1965	489	35	895	45	574	10
1966	798	42	1720	133	1234	47
1967[b]	785	5	3601	224	303	11
1968	1045	26	2300	120	1621	73
1969	750	13	2433	97	1145	69
1970	949	25	2210	202	1803	110
1971	1187	26	1941	109	2265	105
1972	1204	119	2700	203	2642	192
Total	7603	298	18,597	1171	12,316	662

[a] Data (1964-1966) from Hooper (1967a).
[b] Data for November 29, 1967 is not available.

Appendix Table VI. Hunter-hours and turkey seen, by compartments, at Broad Run Management Area, 1964-1972.

Year	Compartment A		Compartment B		Compartment C	
	Hunter hours	Turkey seen	Hunter hours	Turkey seen	Hunter hours	Turkey seen
1964[a]	396	1	797	6	729	35
1965	489	4	895	2	574	7
1966	798	11	1720	27	1234	147
1967[b]	785	2	3601	102	303	14
1968	1045	6	2300	20	1621	81
1969	750	9	2433	14	1145	90
1970	949	4	2210	26	1803	35
1971	1187	4	1941	13	2265	26
1972	1204	2	2700	9	2642	6
Total	7603	43	18,597	219	12,316	441

[a] Data (1964-1966) from Hooper (1967a).
[b] Data for November 29, 1967 is not available.

Appendix Table VII. Hunter-hours and squirrels seen, by compartments, at Broad Run Management Area, 1964-1972.

Year	Compartment A		Compartment B		Compartment C	
	Hunter hours	Squirrels seen	Hunter hours	Squirrels seen	Hunter hours	Squirrels seen
1964[a]	396	5	797	54	729	35
1965	489	19	895	38	574	12
1966	798	155	1720	190	1234	309
1967[b]	785	70	3601	688	303	72
1968	1045	39	2300	127	1621	113
1969	750	43	2433	99	1145	69
1970	949	66	2210	117	1803	273
1971	1187	61	1941	232	2265	174
1972	1204	15	2700	46	2642	52
Total	7603	473	18,597	1571	12,316	1150

[a] Data (1964-1966) from Hooper (1967a).
[b] Data for November 29, 1967 is not available.

Appendix Table VIII. Hunter-hours and grouse seen, by compartments, at Broad Run Management Area, 1964-1972.

Year	Compartment A		Compartment B		Compartment C	
	Hunter hours	Grouse seen	Hunter hours	Grouse seen	Hunter hours	Grouse seen
1964[a]	396	19	797	23	729	44
1965	489	20	895	6	574	16
1966	798	16	1720	62	1234	33
1967[b]	785	2	3601	71	303	0
1968	1045	41	2300	116	1621	43
1969	750	27	2433	147	1145	41
1970	949	14	2210	62	1803	33
1971	1187	28	1941	31	2265	12
1972	1204	18	2700	36	2642	49

[a] Data (1964-1966) from Hooper (1967a).
[b] Data for November 29, 1967 is not available.

Appendix Table IX. Age, sex, weight, and measurements of deer harvested, Broad Run Management Area, 1957. [b]

Age (years)	Sex	Dressed weight (pounds)	Tarsus length (inches)	Antler points L	Antler points R	Antler beam diameter (inches) L	Antler beam diameter (inches) R
½	M	35	14.38	0	0	—	—
½	M	47	15.50	0	0	—	—
½	F	37	11.75	—	—	—	—
1½	M	69	16.00	1	1	0.63	0.63
1½	F	60	15.50	—	—	—	—
2½ [a]	M	—	—	2	2	—	—
2½	F	75	13.00	—	—	—	—
6½	M	135	18.00	4	4	1.35	1.43
8½	M	118	16.75	5	6	1.47	1.55

[a] Deer not available for complete examination.
[b] Data from Quillen (1959:89).

Appendix Table X. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1958.[b]

Age (years)	Sex	Dressed weight (pounds)	Tarsus length (inches)	Antler points L	Antler points R	Antler beam diameter (inches) L	Antler beam diameter (inches) R
2½	M	92	12.00	1	1	0.88	0.88
2½	M	91	17.00	2	2	0.75	0.75
2½	M	100	17.50	3	3	0.75	0.75
3½	M	140	14.00	3	3	1.44	1.31
3½	M	118	18.25	4	4	1.00	1.13
—[a]	M	151	—	4	4	—	—

[a] Deer not available for complete examination.
[b] Data from Quillen (1959:93).

Appendix Table XI. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1959.[a]

Age (years)	Sex	Dressed weight (pounds)	Tarsus length (inches)	Antler points L	Antler points R	Antler beam diameter (inches) L	Antler beam diameter (inches) R
1½	M	110	--	2	4	0.60	0.70
1½	M	80	17.25	1	2	--	--
1½	M	91	17.75	1	1	--	--
2½	M	113	18.00	4	4	--	--
3½	M	152	--	5	5	--	--
3½	F	84	16.50	--	--	--	--

[a] Data from Seneca (1961:115).

Appendix Table XII. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1960.[a]

Age (years)	Sex	Dressed weight (pounds)	Tarsus length (inches)	Antler points L	Antler points R	Antler beam diameter (inches) L	Antler beam diameter (inches) R
½	M	--	--	4	4	--	--
½	M	54	14.25	0	0	--	--
1½	M	--	--	1	1	--	--
1½	M	--	--	1	1	--	--
1½	M	90	17.00	4	3	0.94	1.00
4½	F	78	17.00	--	--	--	--

[a] Data from Seneca (1961:116).

Appendix Table XIII. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1961.

Age (years)	Sex	Body weight (pounds)	Tarsus length (inches)	Antler points L	Antler points R
½	M	61[a]	15.00	buttons	
1½	M	--	--	2	2
--	F	73[b]	16.50	--	--
--	M	--	--	12	
--	M	--	--	1	1
--	M	--	--	2	2

[a] Live weight.
[b] Hog dressed.

Appendix Table XIV. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1962.

Age (years)	Sex	Live weight (pounds)	Tarsus length (inches)	Antler points L	Antler points R	Antler bean diameter (inches) L	Antler bean diameter (inches) R	Heart girth (inches)
½	F	80	15.00	--	--	--	--	27
½	M[a]	55	--	button		--	--	--
1½	M	72	15.75	2	2	0.75	0.75	34
1½	M	113	17.00	2	4	0.75	0.75	34½
2½	M	--	--	4	4	--	--	--
2½	M	88	17.00	2	1	0.75	0.75	33½
3½	M	130	18.00	5	4	1.31	1.25	37¼
3½	M	136	17.75	5	4	1.25	1.25	--
--	M	--	--	3	3	--	--	--

[a] Illegal kill.

Appendix Table XV. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1964.[a]

Age (years)	Sex	Live weight (pounds)	Antler points L	Antler points R
1½	M	123	1	2
1½	M	85	--	--
1½	M	104	2	2
3½	M	--	3	4

[a] Data on one deer reported killed was not recorded.

Appendix Table XVI. Age, sex, and measurements for deer harvested, Broad Run Management Area, 1965.

Age (years)	Sex	Live weight (pounds)	Antler points L	Antler points R	Antler beam diameter (inches) L	Antler beam diameter (inches) R	Heart girth (inches)	Body length (feet)
½	M	70	1	1	—	—	—	—
1½	M	110[a]	1	1	—	—	—	—
2½	F	85	—	—	—	—	—	—
3½	F	85	—	—	—	—	—	—
—	M	80	2	3	—	—	—	—
—	M	190	5	4	0,50	0.50	32.50	5.7
—	F	—	—	—	—	—	—	—

[a] Dressed weight.

Appendix Table XVII. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1968.

Age (years)	Sex	Live weight (pounds)	Tarsus length (inches)	Antler points	Antler circumference
½	M	71	—	buttons	—
½	F	61	—	—	—
½	M	102[b]	17.75	4	2½
1½	M	124	17.25	4	2¼
1½	M	108	—	2	—
1½	M	92	—	2	—
1½	M	137	—	4	—
1½	M	113	—	2	—
1½	M	99	—	5	—
1½	M	108[b]	—	4	—
1½	M	108	—	2	—
2½	M	160	—	7	—
2½	F[a]	93	—	—	—
3½	M	195	21.50	10	5
3½	M	188	—	10	—
3½	F[a]	111	—	—	—
3½	M	176	—	9	—

[a] Doe was lactating.
[b] Dressed weight.

Appendix Table XVIII. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1969.[b]

Age (years)	Sex	Live weight (pounds)	Antler points	Body length (feet)	Shoulder height (feet)
1½	M	125	6	4.9	2.8
1½	M	105	2	4.4	2.8
1½	M	105	3	4.3	2.8
1½	M	130	5	4.8	2.9
1½	M	80[a]	—	4.3	2.6
1½	M	128	3	4.7	2.9
1½	M	106	3	4.1	2.6
1½	M	81	2	4.7	2.0
1½	M	73	2	3.7	2.6
1½	F	86	—	4.4	2.8
3½	M	53[a]	9	5.9	—

[a] Dressed weight.
[b] Data on one deer missing.

Appendix Table XIX. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1970.

Age (years)	Sex	Dressed weight (pounds)	Antler points	Body length (feet)	Shoulder height (feet)	Heart girth (inches)
½	M	74[b]	buttons	3.8	2.7	31.00
½	M	65[b]	—	3.6	2.6	27.75
½	F	47[b]	—	3.0	2.3	—
1½	M	70	2	4.1	2.8	—
1½	M	104	3	4.5	3.2	—
1½	M	80	2	4.0	3.2	33.00
1½	M	120	2	4.0	3.2	35.00
1½	M	60	2	4.8	2.8	—
1½	M	78	2	5.0	2.8	—
1½	M	80	2	4.0	3.0	—
1½	M	82	2	4.0	2.8	—
1½	M	82	6	4.0	2.8	—
1½	M	66	—	4.1	2.8	—
1½	M	80	2	—	—	—
2½	M	103[b]	8	4.6	3.0	31.50
2½	M	80	—	4.3	3.0	—
2½	M	90	6	5.3	3.0	—
3½	M	135	11	5.2	3.1	—
3½	M	130	8	5.4	2.9	39.00
3½	M	75	6	5.0	2.6	—
3½	F[a]	100	—	4.4	2.8	32.50

Appendix Table XIX. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1970 (continued).

Age (years)	Sex	Dressed weight (pounds)	Antler points	Body length (feet)	Shoulder height (feet)	Heart girth (inches)
$4\frac{1}{2}$	M	176[b]	—	5.1	3.2	36.75
—	M	140	9	4.8	3.2	—

[a] Does are lactating.
[b] Live weight.

Appendix Table XX. Age, sex, weight, and measurements for deer harvested, Broad Run Management Area, 1971.

Age (years)	Sex	Live weight (pounds)	Dressed weight (pounds)	Body length (feet)	Shoulder height (feet)	Heart girth (inches)[a]
½	M	—	—	—	—	—
½	M	—	51	—	—	—
1½	M	—	60	4.0	2.6	—
1½	M	—	83	4.4	3.0	—
1½	M	135	110	4.3	2.8	34
1½	M	—	80	4.3	2.8	31
1½	M	115	92	4.3	2.9	32
1½	M	100	80	4.4	3.0	32½
1½	M	130	102	4.6	2.8	33¼
1½	M	—	83	4.3	2.9	—
1½	M	—	95	3.9	2.7	—
1½	M	—	82½	4.3	2.9	—
2½	M	140	109	4.5	2.8	35
2½	M	—	100	4.6	2.5	34
2½	M	150	123	4.6	2.9	36
2½	M	140	110	4.4	2.8	37
2½	M	—	93½	4.3	2.9	—
2½	M	—	102½	4.7	2.9	—
2½	M	—	95½	4.4	3.0	34¼
3½	M	—	160	5.1	3.4	41½
—	M	139	—	4.9	—	34½
—	M	—	85	4.0	2.3	33½

[a] Dressed carcus.

Appendix Table XXI. Age, sex, and weights of deer harvested, Broad Run Management Area, 1972.[a]

Age (years)	Sex	Dressed weight (pounds)	Live weight (pounds)	Age (years)	Sex	Dressed weight (pounds)	Live weight (pounds)
½	F	45	—	2½	F	96	—
½	M	40	53	2½	M	—	127
½	M	43	60	2½	M	90	—
½	M	63	79	2½	M	120	146
½	F	46	62	2½	M	100	130
1½	F	65	—	2½	M	80	105
1½	M	85	—	2½	M	150	190
1½	M	85	—	2½	F	69	92
1½	M	107	—	2½	M	120	144
1½	M	70	95	2½	M	100	125
1½	F	71	90	2½	M	120	—
1½	M	90	110	3½	M	115	152
1½	F	75	100	3½	M	115	—
1½	M	—	118	3½	M	—	140
1½	M	125	—				

[a] Data on 6 harvested deer were not reported.

Appendix Table XXII. Dressed weight by age of Broad Run harvested male deer.[c]

Year	½ Year (average pounds)	1½ Years (average pounds)	2½ Years (average pounds)	3½ Years (average pounds)
1957[a]	42 (2-82)	69 (1-69)	—	—
1958	—	—	96 (3-283)	129 (2-258)
1959	—	94 (3-281)	113 (1-113)	152 (1-152)
1960	54 (1-54)	90 (1-90)	—	—
1961	50 (1-50)	—	—	—
1962	44 (1-44)	85 (2-171)	70 (1-70)	106 (1-106)
1964	—	83 (3-249)	—	—
1965	56 (1-56)	110 (1-110)	—	—
1968	57 (2-114)	93 (9-834)	128 (1-128)	149 (3-447)
1969	—	84 (9-762)	—	153 (1-153)
1970[b]	62 (2-124)	82 (12-984)	80 (2-170)	112 (3-335)
1971	51 (1-51)	79 (11-868)	105 (7-735)	160 (1-160)
1972	49 (3-146)	94 (7-657)	109 (9-982)	114 (3-342)

Appendix Table XXII. Dressed weight by age of Broad Run harvested male deer.[c]

	½ Year (average pounds)	1½ Years (average pounds)	2½ Years (average pounds)	3½ Years (average pounds)
Total deer	14	59	24	16
Total pounds	721	5075	2481	2060
Average pounds	51	86	103	128

[a] Other harvested deer this year included one 6½-year-old (135 pounds), and one 8½-year-old (118 pounds).
[b] Other harvested deer this year was one 4½-year-old (141 pounds).
[c] Data from 1963, 1966-1967 is missing; numbers in parentheses are total deer-total pounds.

Appendix Table XXIII. Antler diameter by age of Broad Run harvested male deer.[b]

Year	½ Year (average inches)	1½ Years (average inches)	2½ Years (average inches)	3½ Years (average inches)
1957[a]	—	0.63 (1-0.63)	—	—
1958	—	—	0.79 (3-2.38)	1.21 (2-2.43)
1959	0.65 (1-0.65)	—	—	—
1960	—	0.97 (1-0.97)	—	—
1962	—	0.75 (2-1.50)	0.75 (1-0.75)	1.27 (2-2.56)
1968	—	0.75 (2-1.50)	—	1.60 (1-1.60)
Total deer	1	6	4	5
Total inches	0.65	4.60	3.13	6.59
Average inches	0.65	0.77	0.78	1.79

[a] Other harvested deer included one 6½-year-old (1.39 inch diameter) and one 8½-year-old (1.51 inch diameter).

[b] Data from 1963, 1966-1967 is missing; data not taken in 1961, 1964-1965, and 1969-1972. In parentheses numbers are total deer-total inches.

Appendix Table XXIV. Antler points by age of Broad Run harvested male deer.[b]

Year	½ Year (average number)	1½ Years (average number)	2½ Years (average number)	3½ Years (average number)
1957[a]	0 (2-0)	2 (1-2)	—	—
1958	—	—	4 (3-12)	7 (2-14)
1959	—	4 (3-11)	8 (1-8)	10 (1-10)
1960	0 (1-0)	4 (3-14)	—	—
1961	0 (1-0)	4 (1-4)	—	—
1962	0 (1-0)	5 (2-10)	6 (2-11)	9 (2-18)
1964	—	3 (2-7)	—	7 (1-7)
1965	2 (1-2)	2 (1-2)	—	—
1968	0 (2-0)	3 (9-29)	7 (1-7)	10 (3-29)
1969	—	3 (8-26)	—	9 (1-9)
1970	0 (2-0)	3 (12-33)	6 (1-6)	8 (3-25)
Total deer	10	42	8	13
Total points	2	135	44	112
Average points	0	3	6	8

[a] Other harvested deer: one 6½-year-old (8 points); one 8½-year-old (11 points).

[b] Data from 1963, 1966-1967 missing; data not taken 1971-1972. In parentheses are number of total deer-total points.

Appendix Table XXV. Total body length by age of Broad Run harvested male deer.[a]

Year	½ Year (average feet)	1½ Years (average feet)	2½ Years (average feet)	3½ Years (average feet)	4½ Years (average feet)
1969	—	4.4 (9-39.9)	—	5.9 (1-5.9)	—
1970	3.7 (2-7.4)	4.3 (11-47.1)	4.8 (2-9.6)	5.2 (3-15.6)	5.1 (1-5.1)
1971	—	4.3 (10-42.8)	4.5 (7-31.5)	5.1 (1-5.1)	—
Total deer	2	30	9	5	1
Total feet	7.4	129.8	41.1	26.6	5.1
Average feet	3.7	4.3	4.5	5.3	5.1

[a] Data for 1963, 1966-1967 is missing.

Appendix Table XXVI. Shoulder height by age of Broad Run harvested male deer.[a]

Year	½ Year (average feet)	1½ Years (average feet)	2½ Years (average feet)	3½ Years (average feet)	4½ Years (average feet)
1969	—	2.7 (9-24.0)	—	—	—
1970	2.6 (2-5.3)	2.9 (11-32.4)	3.0 (2-6.0)	2.9 (3-8.6)	3.2 (1-3.2)
1971	—	2.8 (10-28.4)	2.8 (7-19.8)	3.4 (1-3.4)	
Total deer	2	30	9	4	1
Total feet	5.3	84.8	25.8	12	3.2
Average feet	2.6	2.8	2.8	3	3.2

[a] Data from 1963, 1966-1967 is missing; numbers in parentheses are total deer-total feet.

Appendix Table XXVII. Heart girth by age of Broad Run harvested male deer.[a]

Year	½ Year (average inches)	1½ Years (average inches)	2½ Years (average inches)	3½ Years (average inches)	4½ Years (average inches)
1962	—	34.25 (2-64.5)	33.50 (1-33.5)	37.25 (1-37.25)	—
1970	28.08 (2-59.75)	33.17 (3-99.5)	—	39.00 (1-39.0)	36.75 (1-36.75)
1971	—	32.55 (5-162.75)	34.80 (5-174)	38.00 (1-38.00)	—
Total deer	2	10	6	3	1
Total inches	59.75	326.75	207.50	114.25	36.75
Average inches	28.08	32.75	34.58	38.08	36.75

[a] Data from 1963, 1966-1967 is missing; numbers in parentheses denote total-deer-total inches.

Appendix Table XXVIII. Tarsus length by age of Broad Run harvested male deer.[b]

Year	½ Year (average inches)	1½ Years (average inches)	2½ Years (average inches)	3½ Years (average inches)
1957[a]	14.94 (2-29.88)	15.75 (2-31.50)	—	—
1958	—	—	15.50 (3-46.50)	16.12 (2-32.25)
1959	—	17.50 (3-35.00)	18.00 (1-18.00)	—
1960	14.25 (1-14.25)	17.00 (1-17.00)	—	—
1961	15.00 (1-15.00)	—	—	—
1962	—	16.87 (2-33.75)	17.00 (1-17.00)	17.87 (2-35.75)
1968	—	17.50 (2-35.00)	—	21.50 (1-21.50)
Total deer	4	9	5	5
Total inches	59.13	152.25	81.50	89.50
Average inches	14.78	16.91	16.30	17.90

[a] Other harvested deer include one 6½-year-old (18 inches); one 8½-year-old (16.75 inches).

[b] Data from 1963, 1966-1967 is missing; no data taken in 1964-1965, 1969-1972.

VITA

The author of this thesis was born in Chicago, Illinois on September 21, 1934. In 1942 his family moved to Milwaukee, Wisconsin where he attended public school and was graduated from Riverside High School in June 1952. He attended the University of Wisconsin for 2 years before moving to the South where he resumed his studies at the University of North Carolina, Chapel Hill, N.C. in 1956-1957. He entered the U.S. Navy in July 1957 and was honorably discharged in June 1961 with a rating of Journalist 2nd Class. He returned to Chapel Hill where he received an A.B. in Journalism in June 1962. Subsequently he worked on 4 newspapers. While completing this thesis Weekes was outdoor editor of the Spartanburg (S.C.) Herald-Journal.

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He married the former Miss Sarah Louise Mullins of Spartanburg, S.C. on July 28, 1962 and the couple have 2 children, a son, William Jr., and a daughter, Lynn Marie. He is the son of the late William Andrew and Helen Dickey Weekes.

The writer, since 1969, has been the author of more than 30 articles appearing in Virginia Wildlife magazine, and he has had stories in other magazines, such as Fur-Fish-and-Game, Tennessee Conservationist, South Carolina Wildlife, and American Forests.

Wm D Weekes

A 15-YEAR RESEARCH SUMMARY AND HUNTING HARVEST DATA EVALUATION OF THE BROAD RUN MANAGEMENT AREA

by

William D. Weekes

(ABSTRACT)

Seventeen theses have been written from studies undertaken at the Broad Run Wildlife Research Area since 1957. A portion of this thesis is a distillation of these 17 theses, a distillation comprising an expansive review of nearly 200 results gleaned from 15 years of Broad Run research.

The other portion of this thesis evaluates the hunting harvest data gathered at the Broad Run check station from the time hunting was permitted at the management area in 1957. Hunter-hours/game seen was the index used to determine relative population abundance of deer, turkey, gray squirrel, and ruffed grouse between Broad Run's Compartments A, B, and C. The less hunter-hours required to see game, the greater the game's population numbers.

The hunter-hour index indicated the carrying capacity for deer was greatest in that compartment treated with silvicultural and wildlife practices; while, for turkey, carrying capacity was greatest in that compartment treated with wildlife practices alone. Such treatments apparently did not affect the populations of squirrel or ruffed grouse.