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Three Physical Measurements of Male White-Tailed Deer in West Virginia Correlated with Soil Fertility and Population Density

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THREE PHYSICAL MEASUREMENTS OF MALE WHITE-TAILED DEER IN WEST VIRGINIA CORRELATED WITH SOIL FERTILITY AND POPULATION DENSITY

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C.C.C.

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CHAPTER I

INTRODUCTION

Differences in the physical size of male white-tailed deer from varying parts of West Virginia were known to exist a considerable number of years before any sophisticated attempts were made to explain them. Prior to 1940, the state's deer herd had been making a slow, but increasingly steady, comeback from a period of extreme scarcity around the turn of the century. To supplement the original remaining stock, shown in Figure 1, page 2, a deer restocking program was initiated in 1923. In 1937, federal legislation, in the form of the Federal Aid to Wildlife Restoration Act, gave added support to the restocking program. State legislation had also contributed to the increase in the number of deer by passage of what is now commonly known as "bucks-only" regulations.[1]

As deer became more numerous and as the legal kill of male deer began to grow, an increasing number of bucks were available for observation by state game personnel. Consequently, as more attention was given to individual deer being brought in by hunters, differences in physical size

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[1]W. R. DeGarmo and John Gill. 1958. West Virginia white-tails. Cons. Comm. W. Va., Div. Game, Bull. No. 4. pp. 1-5.

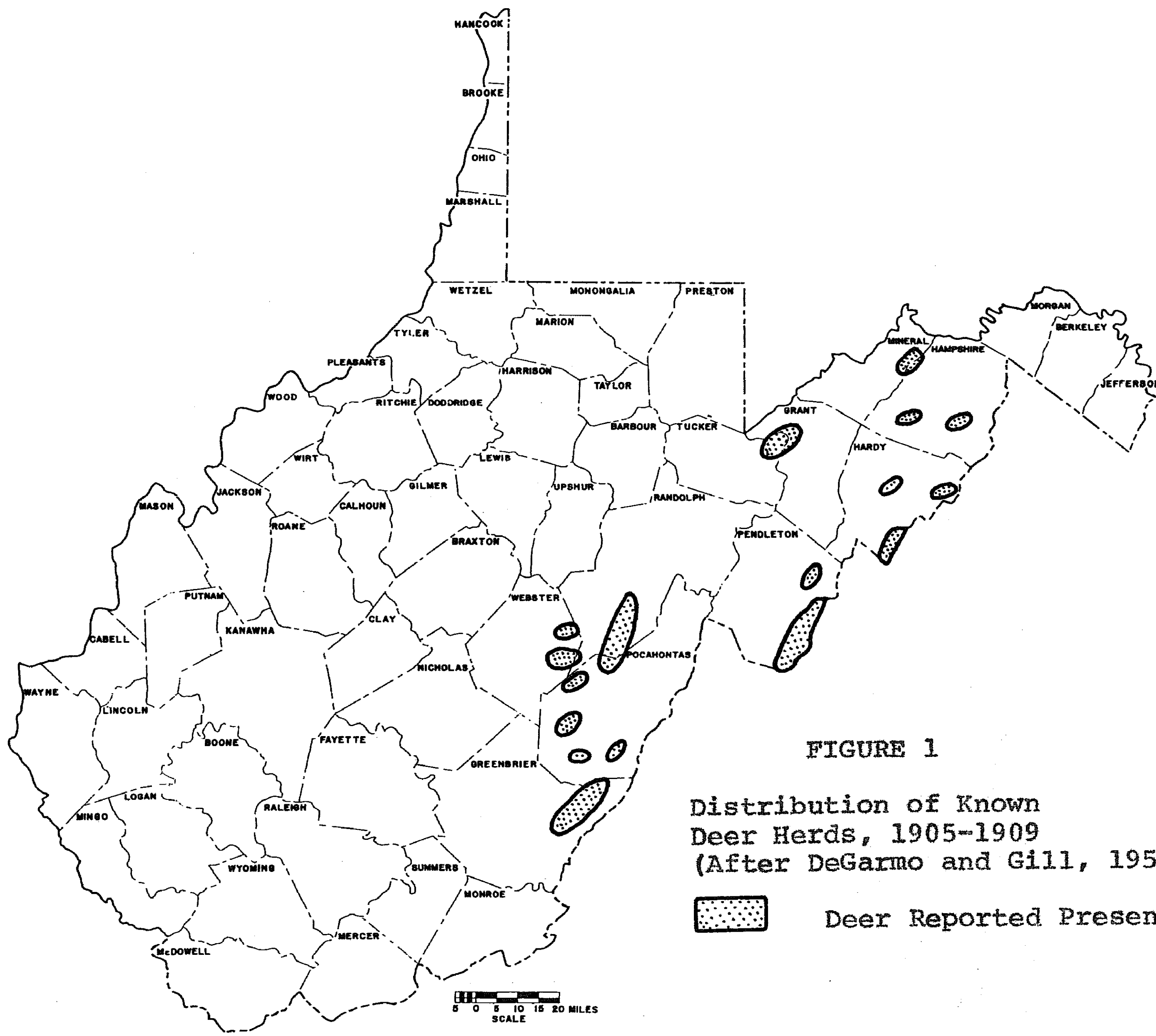

FIGURE 1

Distribution of Known
Deer Herds, 1905-1909
(After DeGarmo and Gill, 1958)

became more apparent. In 1941, West Virginia Conservation Commission personnel commented on the striking differences in the physical size of bucks killed on Seneca State Forest in Pocahontas County and Cooper's Rock State Forest in Monongalia and Preston Counties.[2] They concluded that the differences were due partly to stocking of a smaller subspecies on Seneca and partly to heavy hunting-pressure on Seneca. The heavy hunting-pressure resulted in a decrease in the number of deer in older age classes, accompanied by a corresponding decrease in the weight of deer being killed.

In 1950, DeGarmo and Chiavetta[3] reviewed particular areas of the state where hunters would be more likely to encounter bucks in the trophy class. At the same time they indicated that from an overall standpoint, the western part of the state was producing the best deer.

As a result of the rapid expansion of the deer population in the middle-to-late 1940's, the corresponding increase in legal kills provided a vast amount of deer data for analysis. These data provided the basis for what is considered the definitive work[4] on differences in physical

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[2]C. B. Pierle. 1941. West Virginia deer weights and measurements. W. Va. Cons. 5(5): 10-13, 21.

[3]W. R. DeGarmo and Kenneth Chiavetta. 1950. Where to seek finest bucks. W. Va. Cons. 14(7): 15-23.

[4]John Gill. 1956. Regional differences in size and productivity of deer in West Virginia. J. Wildl. Mgt. 20(3): 286-292.

size and productivity of deer in West Virginia. In this study the exact magnitude of differences in physical size and productivity of deer in the state was made known for the first time. The state was divided into four regions, as shown in Figure 2, page 5, that were based on physical size and productivity of deer. "The distribution of regions roughly resembles that for physiological subdivisions (McKeever, 1952)."[5] As is the case when imposing boundaries of this nature on animals, overlapping most certainly occurs; but the statistical significance of the results remained as a redeeming factor. Gill's[6] analysis of his data did not reveal any close relationships between his findings on size and productivity of deer and any particular range condition or conditions. He concluded, " . . . that the differences in deer characteristics between parts of the state probably are not attributable to any single ecological factor, but rather to a complex of factors."[7]

In an unpublished report,[8] Chambers refers to the regional differences in size and productivity of deer in

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[5]Ibid., p. 287, citing McKeever, S. 1952. A survey of West Virginia mammals. Cons. Comm. W. Va.

[6]Ibid., pp. 286-292.

[7]Ibid., p. 291.

[8]Robert E. Chambers. 1956. Job Completion Report. State of West Virginia. Proj. No. 25-R-7. Job No. III-A: Range quality. 6 pp. mimeo.

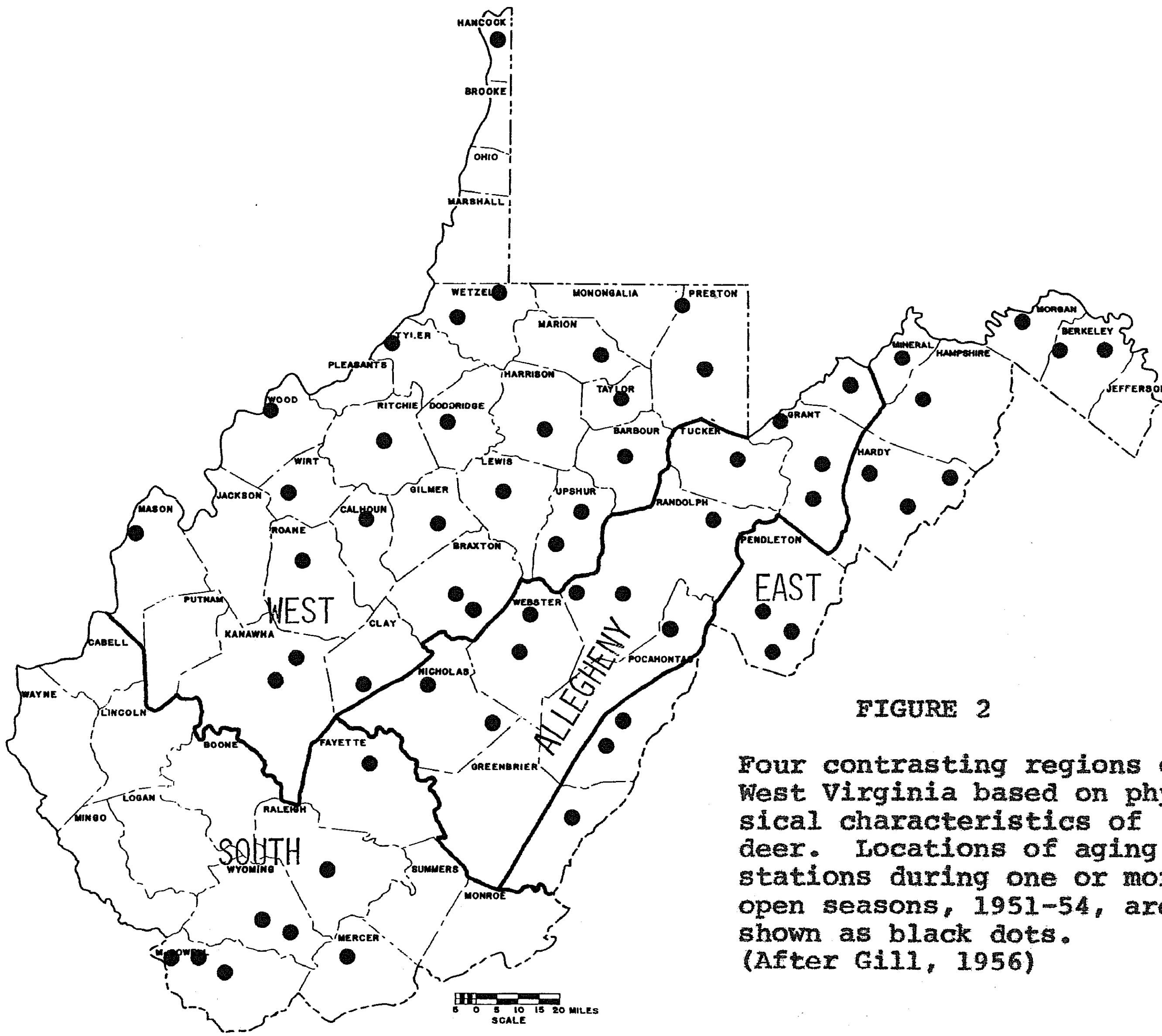

FIGURE 2

Four contrasting regions of West Virginia based on physical characteristics of deer. Locations of aging stations during one or more open seasons, 1951-54, are shown as black dots. (After Gill, 1956)

West Virginia (presumably the data reported by Gill[9]) and he recommended that comparisons be made between these differing areas. The recommendations included determining "(1) to what extent these differences are attributable to heredity or environment (2) the influence of environmental aspects which affect range quality."[10] There has been only one attempt[11] to pursue the hereditary aspect of the first recommendation and it will be referred to later. The second recommendation resulted in continued studies. In 1958, Chambers[12] demonstrated a direct relationship between available soil nutrients and size and productivity of deer from the Meadow Creek area of Greenbrier County and the Muddy Creek area of Tyler County. A review of some succeeding studies[13] showed that attention was focused

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[9]Gill, op. cit., pp. 286-292.

[10]Chambers, op. cit., p. 3.

[11]W. R. DeGarmo and John Gill. 1958. West Virginia white-tails. Cons. Comm. W. Va. Div. Game Bull. No. 4. pp. 13-14.

[12]Robert E. Chambers. 1958. Job Completion Report. State of West Virginia. Proj. No. 25-R-8: White-tailed deer investigations. Job No. III-A: Range quality. 13 pp. mimeo.

[13]Wallace E. Dean. 1959. Job Completion Report. State of West Virginia. Proj. No. 25-R-10: White-tailed deer investigations. Job No. III-A: Range quality. 11 pp. mimeo.; ________. 1960. Job Completion Report. State of West Virginia. Proj. No. 25-R-11: White-tailed deer investigations. Job No. III-A: Range evaluation. 23 pp. mimeo.; Leonard O. Walker. 1961. Job Completion Report. State of West Virginia. Proj. No. 25-R-12: White-tailed

primarily on an evaluation of existing range conditions, future range potential, and population trends. In many respects, these studies were hampered with regard to meaningful conclusions due to insufficient data. As a result, no further specific correlations involving the influence of environmental factors on deer size and productivity were forthcoming.

It was previously noted that DeGarmo and Gill[14] discussed the possibilities of hereditary influence on size and productivity of deer in the state. Their examination of the problem led them to believe that since the theoretical boundary[15] between the Virginia white-tailed deer (*Odocoileus virginianus virginianus*, Zimmerman) and the northern woodland white-tailed deer (*Odocoileus virginianus borealis*, Miller) passed through northern West Virginia, the original deer found in the state could hardly be said to be of one

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deer investigations. Job No. III-A: Range evaluation. 16 pp.; James W. Chadwick, James Ruckel, and Leonard Walker. 1963. Job Completion Report. State of West Virginia. Proj. No. 25-R-13: White-tailed deer investigations. Job No. III-A: range evaluation. 8 pp.; James M. Ruckel and James W. Chadwick. 1964. Job Completion Report. State of West Virginia. Proj. No. 25-R-15: White-tailed deer investigations. Job No. III-A: Range evaluation. 8 pp. 2 supplements.

[14] DeGarmo and Gill, *loc. cit.*

[15] Remington Kellogg. 1956. What and where are the white-tails? In: The Deer of North America. Walter P. Taylor, ed. The Stackpole Company, Harrisburg, Pa. pp. 35, 39-40.

subspecies. Deer that have been stocked in the state include deer from the ranges of both the northern white-tail and the Virginia white-tail. Under these circumstances, they concluded ". . . that if such a development has not already taken place, deer in West Virginia will soon become truly intergrades between northern and Virginia white-tails; their size and weight will be influenced by the land on which they live."[16]

In relation to environmental aspects which influence range quality, DeGarmo and Gill[17] indicated that, statewide, soil fertility and food quality are two of the most likely causes of differences in size and productivity of deer. More specifically, they considered some factor of nutrition, which is closely associated with soil fertility and food quality, to be responsible for the differences.

Not to be overlooked is the problem of over-population of deer range. An authoritative source[18] on the problem had this to say:

> Apparently deer men everywhere have found it hard to convince the average citizen, and especially the average deer hunter, that (1) delay in reduction of overpopulated deer ranges means ultimate shrinkage

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[16]DeGarmo and Gill, op. cit., p. 14.

[17]Ibid., 88 pp.

[18]A. Leopold, Lyle K. Sowls, and David L. Spencer. 1947. A survey of overpopulated deer ranges in the United States. J. Wildl. Mgt. 11(2): 162.

> of both the herd and the range; (2) reduction is the only remedy, nothing else works; (3) to accomplish a reduction, female deer must be killed.

In perfect harmony with the first of these observations is the fact that deer not only decrease in total numbers eventually on overpopulated ranges, their total condition is affected prior to die-off through malnutrition, disease, and reduced resistance to parasites and predation. Since overpopulation has been a problem in certain areas of West Virginia before,[19] it was logical to assume that population density might have been a partial cause at one time, of differences in size and productivity of deer in the state.

The problem then, that has existed in this state is the lack of a demonstrated correlation between any one or more of the previously discussed factors, i.e. heredity, soil fertility, food quality, population density, or any other undiscussed factor, and deer size and productivity, on a statewide basis. A thorough statistical demonstration of a direct relationship has never been accomplished. This study has been undertaken in an attempt to show that a direct correlation, on a statewide basis, does exist between the physical measurements of male white-tailed deer and soil fertility and population density.

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[19] Conservation Commission of West Virginia. 1951. West Virginia's deer problem. Division of Education and Publicity. 32 pp.

Male deer were chosen as the subjects for this study for three reasons: (1) their physical characteristics are of more interest to the average individual, (2) they continue to show gains in physical size a number of years after the growth of the female has leveled off, and (3) measurements from the female of the species follow qualitative patterns established by male deer,[20] since they are both governed by the same environmental conditions. Since females have been omitted from the study, no data on productivity were presented.

From an ecological point of view, the physical size of deer in their natural habitat is primarily controlled by the quality of their food chain. An illustration of this food chain is presented in Figure 3. Each layer of this pyramid supplies food (or energy) to the layer above it and the energy from all upper layers is eventually returned to the soil through death and decay.[21] The soil then, is the base of the food chain of deer. The importance of the soil to terrestrial wildlife has been well established. Leopold,[22]

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[20]A. J. Wood, I. McT. Cowan, and H. C. Nordan. 1962. Periodicity of growth in ungulates as shown by deer of the genus _Odocoileus_. _Canadian_ _J_. _Zool_. _40_: 600.

[21]Aldo Leopold. 1939. A biotic view of land. _J_. _For_. _37(9)_: 727-730.

[22]_Ibid_.

Allen,[23] and Edwards[24] are but three of the many writers who have devoted attention to the subject. An excellent example of a specific situation relating the condition of several kinds of wildlife with the fertility of the soils on which they lived was given by Crawford.[25]

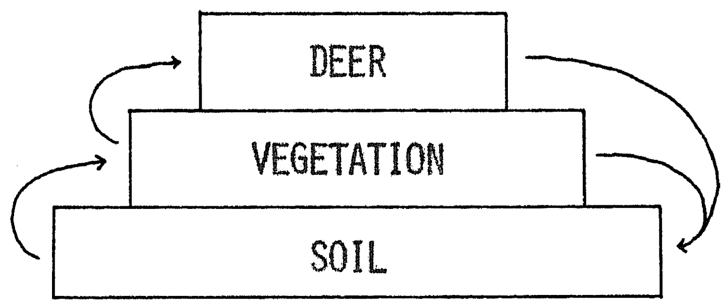

Figure 3. The food chain of deer presented as a subunit of the "biotic pyramid".*

*Aldo Leopold. 1939. A biotic view of land. J. For. 37(9): 728.

The importance of natural fertility, or nutrient status,[26] to wildlife is unquestionable. For this reason

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[23]Durward L. Allen. 1953. Wildlife history and the soil. Soil Cons. 18(6): 123-127.

[24]William R. Edwards. [n.d.]. Soils, nutrition, and wildlife. A contribution of Federal Aid Project W-103-R. Ohio.

[25]Bill T. Crawford. 1950. Some specific relationships between soils and wildlife management. J. Wildl. Mgt. 14: 115-123.

[26]Boyd J. Patten. 1955. A brief description of the major soils of West Virginia. U. S. Dept. Agr., Soil Cons. Serv., Morgantown, W. Va. p. 7.

and the reasons presented in the preceding paragraph, the decision was made to start at the bottom of the food chain and attempt to establish correlations between food chain factors and deer size. Furthermore, since positive results were obtained with natural soil fertility and time became a limiting factor in completion of the report, no attempt was made to include data on plants in the study.

As was previously noted, population density can and does have an effect on the overall condition of deer. When population increases, competition for food increases. Range conditions begin to deteriorate and the condition of the animals begins to deteriorate. Eventually a decrease in size of deer is noted in the legal kill. For these reasons an attempt was made to correlate deer size with population density. Positive results were obtained.

If positive correlations had not been found between natural soil fertility and deer size or population density and deer size, then an attempt would have been made to test for a correlation between the two combined factors and deer size. Although positive correlations were found for the separate factors, the test on the combined factors was conducted for further emphasis.

CHAPTER II

REVIEW OF THE LITERATURE

I. DEER NUTRITION STUDIES

The scope of this study does not permit a detailed description of literature involving deer nutrition studies. On the other hand, nutrition is an integral part of the relationship between soil, vegetation, and deer. Nutritional studies have led ultimately to the identification of specific deficiencies in deer diets and to the establishment of dietary requirements for growth and development.

Extensive studies into the aspects of deer nutrition appear to be of rather recent origin. The only exception, in an admittedly brief review of the subject, was a study by Hellmers.[27] These studies can be divided into two categories: (1) those that involve the quantitative and qualitative analysis of the nutritional value of deer foods and (2) those that involve the quantitative and qualitative nutritional requirements of the animals themselves for growth and development.

A review of this literature provided valuable insight

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[27] Henry Hellmers. 1940. A study of monthly variations in the nutritive value of several natural deer foods. J. Wildl. Mgt. 4(3): 315-325.

into the problems surrounding physical size of deer, their nutritional requirements, and the nutritive value of their foods. Specific references for those interested can be found in the bibliography.

II. STUDIES RELATING PHYSICAL CHARACTERISTICS OF DEER TO RANGE CONDITIONS

There has not been an endless stream of literature relating physical characteristics of deer to range conditions. However, improvements in methods and techniques of studying deer contributed to an increase in the number of these studies in the past fifteen to twenty years. The oldest literature reviewed consisted of three studies[28] over twenty-five years old.

In 1950, Severinghaus and co-workers[29] indicated that antler beam diameters of deer from different regions of New York varied significantly from one region to another. These differences were attributed to the adequacy of available

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[28] F. W. Johnson. 1937. Deer weights and antler measurements in relation to population density and hunting effort. Trans. N. Am. Wildl. Conf. 2:446-457; Barry C. Park. 1938. Deer weights and measurements on the Allegheny National Forest. Trans. N. Am. Wildl. Conf. 3:261-279; Roger Seamans. 1941. Deer weights and measurements. Vt. Fish and Game Serv. Bull. 3-2. 16 pp.

[29] C. W. Severinghaus et al. 1950. Variations by age class in the antler beam diameters of white-tailed deer related to range conditions. Trans. N. Am. Wildl. Conf. 15:551-568.

forage. In the same year Cheatum and Severinghaus[30] showed that deer had the highest fecundity where available forage most nearly met their dietary requirements.

Sweet and Wright[31] divided New Jersey into its various physiographical regions to study the physical development of deer in that state. The soils in the three northern regions had a high natural fertility and the deer in these regions did not appear to differ appreciably in their physical development. On the other hand, the soils in the two southern regions when considered together were less fertile. According to the authors, "this difference in soils has a pronounced effect on the quality of forage available to deer."[32] The overall physical development of deer from the respective regions reflected the difference in the quality of available forage. The lower soil fertility and lower quality forage in the southern regions were considered responsible for the less well-developed deer there. Northern deer were heavier and had more antler points, and larger antler beam diameters on the average than southern deer.

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[30]E. L. Cheatum and C. W. Severinghaus. 1950. Variations in fertility of white-tailed deer related to range conditions. Trans. N. Am. Wildl. Conf. 15:170-190.

[31]J. C. Sweet and Charles W. Wright. 1952. Soil and deer. N. J. Outdoors. 3(3): 3-8.

[32]Ibid., p. 5.

In Missouri, Steen[33] reported on the relationship between soil fertility and physical size of deer in that state. In this situation, deer of similar genetic origin were transferred from an area of low fertility to one of high fertility that had no deer in it. When the high fertility area was opened to hunting around five years later, a twenty-eight per cent increase in weight was noted for the immediate descendents of the released deer. Also noted in these deer was an increase in their rate of reproduction.

Severinghaus,[34] using deer weights as an index of range conditions, foudn that a direct relationship existed between the condition of a range and the weight of deer found on that range. Heavier deer were found on better range and lighter deer were found on poorer range.

An extensive study of deer in Wisconsin by Dahlberg and Guettinger[35] revealed, among other things, a direct relationship between weight and range conditions. Ranges

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[33]Melvin O. Steen. 1955. Not how much but how good. Mo. Conservationist. 16(1):1-3.

[34]C. W. Severinghaus. 1955. Deer weights as an index of range conditions on two wilderness areas in the Adirondack region. N. Y. Fish and Game J. 2(2):154-160.

[35]Burton L. Dahlberg and Ralph C. Guettinger. 1956. The white-tailed deer in Wisconsin. Game Mgt. Div., Wisconsin Cons. Dept. Tech. Wildl. Bull. No. 14. 282 pp.

were classified as "critical" or "non-critical"[36] depending on their condition. The average weight of deer taken from "non-critical" range was significantly greater statistically than the average weight of deer taken from "critical" range. The criterion for distinguishing "critical" from "non-critical" range was the amount of available winter food.

In 1959, Severinghaus and Gottlieb[37] reported on the cause of differences in physical size of deer in the state of New York. The smaller deer in the state were found on a range where the natural supply of nutritious forage was depleted and the larger deer were found where there was an adequate supply of nutritious forage. The depleted range was a result of overpopulation.

The physical condition of the deer herd in the New England state of Connecticut was the subject of a study by McDowell.[38] In this study the overall good physical condition of deer examined was attributed to ". . . a highly nutritious range . . ."[39] Physical characteristics used

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[36]*Ibid.*, p. 77.

[37]C. W. Severinghaus and Rosalind Gottlieb. 1959. Big deer vs. little deer. *N. Y. State Cons.* *14(2)*:30-31.

[38]Robert D. McDowell. 1962. The physical condition of Connecticut's deer herd. *Conn. Wildl. Cons. Bull.* *8(6)*:1, 6-8.

[39]*Ibid.*, p. 6.

included body weight, hind foot length, antler development, and rate of productivity.

Mackie[40] gave an account of deer weights in a Montana study in 1964. This investigation included both white-tailed deer and mule deer. His results indicated that deer from better range averaged heavier than deer from poorer range. Also, the weight of deer from overpopulated range averaged less than the weight of deer from range where food supply and population were balanced.

The ratio between femur length and hind foot length was used to measure growth differences in Sitka deer (Odocoileus hemionus sitkensis, Merriam) from two islands in southeastern Alaska by Klein.[41] Observed differences in femur/hind foot ratio of deer from the two areas studied were attributed to nutritional factors. The femur/hind foot ratio was developed to offset the small sample size of deer in the study, since it appeared that skeletal measurements were more reliable indicators of growth than body weight or linear measurements and were less affected by genetic influence.

An extensive study of physical characteristics of

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[40] Richard J. Mackie. 1964. Montana deer weights. Mont. Wildl. pp. 9-14.

[41] David R. Klein. 1964. Range related differences in growth of deer reflected in skeletal ratios. J. Mammalogy 45(2):226-235.

white-tailed deer in eastern Ohio was done by Nixon.[42] The area studied was divided into two physiographic regions. Within the northeast region a federal government installation, the Ravenna Arsenal, was considered as a distinct area, because it was characterized by overpopulation. Statistical analysis of data collected showed no significant physical differences between deer from the two physiographic regions. Even though no statistically significant differences were found between these deer, the feeling was that a slight edge in size of deer from the northeast region over those from the southern hill region was probably attributable to range fertility differences. When deer from the physiographic regions were compared with deer from the Ravenna Arsenal, the arsenal deer were consistently inferior to deer from the two regions in almost all cases. Specifically, the arsenal deer were inferior in hind foot length for all years of the study, in antler beam diameter for the last six years of the nine-year study, and in weight for the last five years of the study. Of the three measurements used, antler beam diameter was the best indicator of range conditions on the Ravenna Arsenal.

In the previous chapter it was noted that the original

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[42]Charles M. Nixon. 1965. White-tailed deer growth and productivity in eastern Ohio. <u>Game Res. Ohio</u>. <u>3</u>:123-136.

work delineating differences in physical size of deer in West Virginia was done by Gill.[43] Hind foot length was chosen as the primary characteristic to compare deer by in his study and on that basis the state was divided into the four regions already referred to in Figure 2, page 5. The west region produced deer with the longest hind foot length followed in order by the Allegheny, south, and east. The same order of regions was obtained when deer weights were compared. When antler beam diameters were compared the order was unchanged, with one exception, the south and east regions exchanged positions. These differences were not correlated with any single environmental factor or combination of factors.

In view of Gill's[44] findings, discussed in the preceding paragraph, the objective of this study was to determine whether or not the differences in size of deer in West Virginia could be traced to one or more single environmental factors.

III. STUDIES RELATING DIFFERENCES IN PHYSICAL CHARACTERISTICS OF DEER TO POPULATION DENSITY

When population density exceeds range carrying capacity

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[43]John Gill. 1956. Regional differences in size and productivity of deer in West Virginia. J. Wildl. Mgt. 20(3):286-292.

[44]Ibid.

the overall physical condition of the animals deteriorate. If deer density is allowed to go unchecked the ultimate result is starvation. These basic facts were set forth for consideration in Chapter I. In some of the studies in the previous section relating physical size of deer to range conditions, high population densities were responsible for the poor range conditions. Therefore, high population densities were indirectly responsible for poor physical condition of the deer. The studies reviewed that incriminate population density as a limiting factor on deer physical condition, either expressed or implied, include Johnson,[45] Park,[46] Severinghaus *et al.*,[47] Cheatum and Severinghaus,[48] Severinghaus,[49] Dahlberg and Guettinger,[50] Mackie,[51] Klein,[52] and Nixon.[53]

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[45]Johnson, *loc. cit.*

[46]Park, *loc. cit.*

[47]Severinghaus *et al.*, *loc. cit.*

[48]Cheatum and Severinghaus, *loc. cit.*

[49]Severinghaus, *loc. cit.*

[50]Burton L. Dahlberg and Ralph C. Guettinger. 1956. The white-tailed deer in Wisconsin. Game Mgt. Div., Wisconsin Cons. Dept. Tech. Wildl. Bull. No. 14. p. 82.

[51]Mackie, *loc. cit.*

[52]Klein, *loc. cit.*

[53]Nixon, *loc. cit.*

Studies of the type discussed in this chapter are sometimes limited in the application of statistical procedures for one reason or another. The lack of adequate numbers of competent, trained field personnel often makes it difficult to obtain a sample size large enough to lend itself to statistical procedures and/or justify any conclusions. Many times too it is difficult to obtain what could be considered a random sample from the population being studied. Problems such as these are not always easily solved and in some cases certain assumptions have to be made about data since it is the best obtainable under the circumstances. Many of the studies reviewed in this chapter admittedly have weaknesses in their statistical procedures, but in almost every situation where weaknesses occur the author(s) qualified them beforehand. One exception that warrants a word of caution is a procedure used by Nixon.[54] The procedure in question is the analysis-of-variance test for means. An analysis-of-variance does have advantages over separate analyses, which was pointed out by Nixon,[55] but when using the analysis-of-variance procedure it is a requirement that variances must be homogeneous if completely valid conclusions are to be made.

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[54] Ibid., p. 126.

[55] Ibid.

Homogeneity of variances can be proved or disproved using Bartlett's test.[56] If one variance is considerably larger than all others, this too can invalidate the results of the analysis-of-variance test for means and Cochran's test[57] can be used to determine whether or not this situation exists. Instead of trying to prove homogeneity of variances it would be possible to simply assume this and it is done, but any conclusions based on such tests would be open to question. Nixon[58] did not indicate whether he was assuming homogeneity of variances or whether he verified it.

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[56] Wilfrid J. Dixon and Frank J. Massey, Jr. 1957. Introduction to Statistical Analysis. 2d ed. McGraw-Hill Book Company, Inc., New York. p. 179.

[57] Ibid., p. 180.

[58] Nixon, loc. cit.

CHAPTER III

MATERIALS AND METHODS

I. SOURCES OF DATA

Specific information concerning soils in individual counties in West Virginia was supplied by the West Virginia Soil Conservation Service, United States Department of Agriculture. Particular offices that loaned or furnished materials that aided in the study include the state office in Morgantown, the area office in Parkersburg, the work unit office in Huntington, and the area office in Romney. Materials supplied included county soil surveys, information on major land resource areas in the United States, and West Virginia in particular, data from as yet unpublished county soil surveys, and miscellaneous pertinent soils information.

All data and considerable miscellaneous information on white-taled deer in West Virginia was provided by the West Virginia Department of Natural Resources office headquarters for deer research located at French Creek. Data supplied included a complete set of West Virginia deer survey tables compiled by the Service Bureau Corporation for the years 1955 through 1962. Data in these tables were raw data of age and physical measurements of deer compiled from aging station deer tags collected during legal gun hunting seasons. Aging station deer tags for particular counties were made available when needed. Other important information supplied included instructions issued to deer aging station technicians, a list of aging station locations for 1955 through 1962, and legal deer kill figures for 1944 through 1964. Local assistance was provided by the Department of Natural Resources district game biologist, in Huntington.

II. THE SAMPLE AREAS

In consultation with the West Virginia Soil Conservation Service, United States Department of Agriculture a method for dividing West Virginia into several broad regions that would reflect differences in soils was chosen. The primary divisions chosen are shown in Figure 4, page 26, and are based on the major land resource areas of the United States and West Virginia in particular as described by Austin.[59] The descriptions of these areas are given in terms of land use, elevation, topography, climate, water, and soil. One of the major advantages of these boundaries is that they are not restricted by state boundaries and therefore could provide a basis for similar studies in other states.

Four of the major land resource areas were further

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[59]Morris E. Austin. 1965. Land resource regions and major land resource areas of the United States. Agricultural Handbook 296. U. S. Dept. Agr., Soil Cons. Serv., Washington, D. C.

LEGEND*

Area 125-Cumberland Plateaus and Mountains (Southern Coal Fields)
Area 126-Central Allegheny Plateau (Ohio-Monomgahela Hills)
Area 127-Eastern Allegheny Plateaus and Mountains (Allegheny Plateau)
Area 128-Southern Appalachian Ridges and Valleys (Ridge and Valley-Southern)
Area 147-Northern Appalachian Ridges and Valleys (Ridge and Valley-Northern)

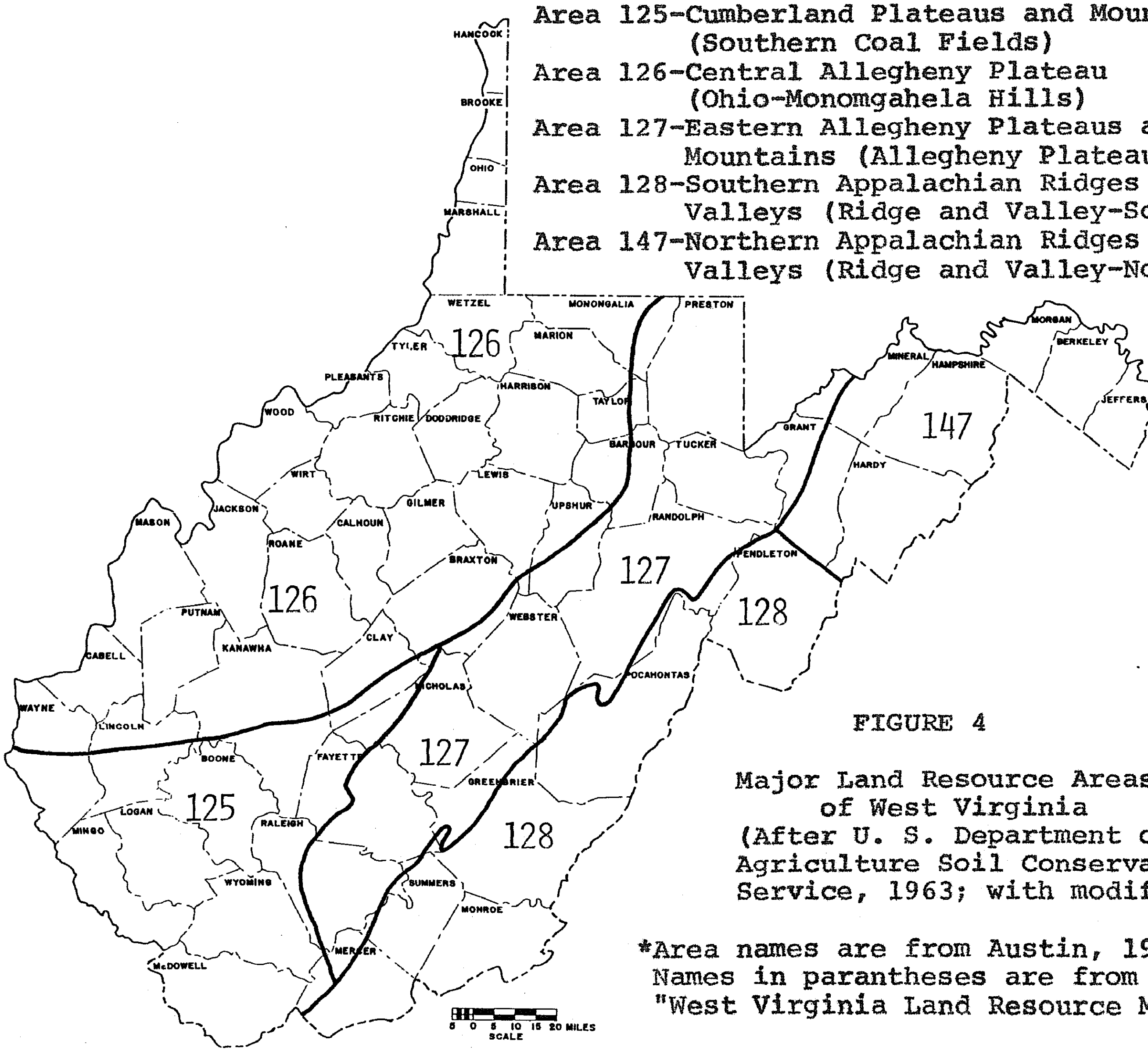

FIGURE 4

Major Land Resource Areas of West Virginia (After U. S. Department of Agriculture Soil Conservation Service, 1963; with modifications)

*Area names are from Austin, 1965. Names in parantheses are from the "West Virginia Land Resource Map" subdivided into smaller areas with boundaries governed by available data on deer. In other words, the counties included in these four areas were the only counties that provided pertinent data on male white-tailed deer. These four deer areas are outlined in Figure 5, page 28, and the location of deer aging stations for these counties are also represented. The appropriate major land resource area numbers were retained to designate these four deer areas. In counties where major land resource area boundaries divided large portions of the counties and where these boundaries, coupled with the size of the deer kill, warranted it, the location of individual deer kills were plotted. This was accomplished using aging station deer tags, general county highway maps, and topographic maps of the counties involved. Only a limited amount of deer data were available for Area 125 and it was consequently eliminated from the study entirely.

Within each deer area, county boundaries became the most logical basis for integrating soil fertility information into the study, since soil surveys are prepared on a county basis. Not all counties within the deer areas have been surveyed at this time and therefore the most up-to-date available soils information was chosen to represent each deer area. Soil fertility of deer areas is represented in the following manner: deer area 126 is represented by Mason, LEGEND

126 - Deer Area 126
127 - Deer Area 127
128 - Deer Area 128
147 - Deer Area 147

[hatched box] No deer data available

● Aging station locations for one or more gun hunting seasons 1955-1962

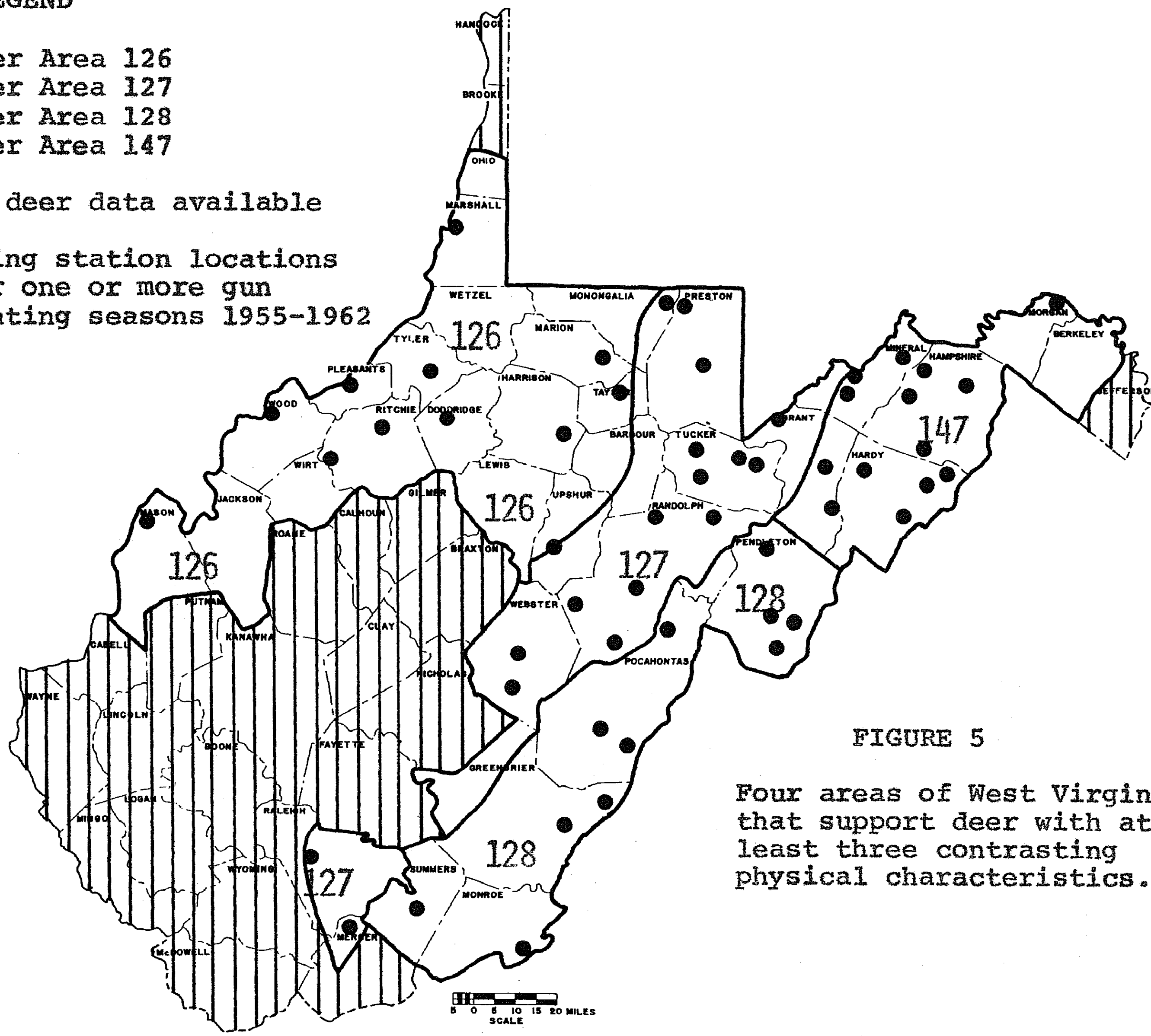

FIGURE 5

Four areas of West Virginia that support deer with at least three contrasting physical characteristics.

Jackson, Marshall, Wood, and Wirt counties; deer area 127 by part of northern Randolph County and Preston and Tucker counties; deer area 128 by Pocahontas and Monroe counties; and deer area 147 by Hampshire and Berkley counties.

III. METHODS OF PROCEDURE

Deer measurements and age classes. The physical characteristics by which deer were compared included antler beam diameter, hog-dressed weight, and hind foot length. Antler beam diameter was measured to the nearest millimeter one inch above the burr. If a diameter was irregular due to the presence of warts an average of two or more measurements was taken. Hog-dressed weight was measured to the nearest pound and as used here refers to weight after complete evisceration including heart, liver and lungs. Hind foot length was measured to the nearest one-quarter inch and was taken from the hock to the tip of the nail.[60]

Gill[61] has discussed the use of antler beam diameter as a basis for comparing deer on a regional basis and

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[60] Project leader, deer research. [n.d.]. Instructions for deer aging station technicians. Deer Research Headquarters, French Creek, West Virginia.

[61] John Gill. 1965. Using antler beam diameters to delineate herd-regions. In: A discussion of the criteria used by deer biologists to determine the physical condition of the animals. Robert D. McDowell (ed.). Trans. of the Initial Meetings of the Northeastern Deer Study Group (tentative title). University of Connecticut. Storrs, Connecticut. pp. 6-10.

concluded that it" . . . assumably would be a more sensitive index of range conditions"[62] (than body growth characteristics). French et al.[63] found that body growth in deer takes precedence over antler development which would seem to indicate that antler development would indeed be a more sensitive index to range conditions. Nixon[64] concluded in his study that, "Of the three variates tested, antler beam diameter provided the most consistent indication of deleterious range effects." In view of these findings antler beam diameter was chosen as the primary characteristic to compare deer by. This is in contrast with the use of hind foot length as the primary characteristic for comparing deer in West Virginia by Gill.[65]

At this point one might question the amount of variation in a particular measurement occuring from one deer to another within a particular age class. An answer to this question is given by the coefficient of variation of the particular measurement in question. The coefficient of

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[62] Ibid., p. 6.

[63] C. E. French et al. 1955. Nutritional requirements of white-tailed deer for growth and antler development. Pa. Agr. Exp. Sta. Bull. 600 p. 8 pp.

[64] Charles M. Nixon. 1965. White-tailed deer growth and productivity in eastern Ohio. Game Res. Ohio. 3:133.

[65] John Gill. 1956. Regional differences in size and productivity of deer in West Virginia. J. Wildl. Mgt. 20(3):287.

variation is a measure of the relative dispersion of a frequency distribution and it permits the dispersion of two frequency distributions to be compared.[66] For example, individual variation in antler beam diameter of deer of a particular age class can be compared with the individual variation in hog-dressed weight of deer of the same age class. The coefficient of variation of each measurement and age class used in this study was calculated solely to be compared with those obtained by Gill.[67] In general, hind foot length had the lowest coefficient of variation, followed by hog-dressed weight, and antler beam diameter respectively. These results agree with those reported by Gill.[68] A more detailed presentation of the coefficient of variation for each age class, measurement, and area studied can be found in Appendix A.

If the influence of heredity on West Virginia deer is as complex as is thought, the difficulties in appraising differences in physical size of the animals become compounded. However, since the influences of subspecific differences are not known, it was assumed, generally, that the deer in the state have roughly the same growth potential at birth. If

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[66] Taro Yamane. 1964. Statistics, an Introductory Analysis. Harper & Row, Publishers, New York. pp. 75-77.

[67] Gill, _loc. cit._

[68] _Ibid._

this general premise is accepted, then future growth and development would be influenced primarily by the nutritional condition of the range on which the animals lived. Further, the older the animals become, the more pronounced the differences would be in their physical development as influenced by range fertility. For this reason as many of the older age classes of deer were retained as sample size would allow. Unfortunately, the oldest age class that could be retained was three and one-half plus, but this proved to be sufficient since the influence of differences in range fertility on older deer was quite evident.

Statistical techniques. The processing of all data was carried out by hand on a Friden fully automatic calculator, model SRQ and a Friden 132 electronic calculator. Periodic reprocessing of data was done to minimize the possibility of error in calculations.

The mean, variance, and standard deviation for each deer area, age class, and physical measurement used was computed. The t-test[69] was used to test for significant differences among the computed sample means. Original plans for statistical analysis of these data included an analysis-

[69] H. D. Brunk. 1965. An Introduction to Mathematical Statistics. 2d ed. Blaisdell Publishing Company, New York. pp. 258-260.

of-variance test for two variables of classification, single observation, as described by Dixon and Massey.[70] A requirement of this test, however, is that variances must be homogeneous for valid conclusions to be drawn. A test for homogeneity of variances, using Bartlett's test,[71] was negative and therefore the analysis-of-variance test was discarded. To avoid making assumptions about the distributions of the populations being tested and still demonstrate a correlation between physical measurements of deer and the selected environmental factors, a nonparametric statistic was selected, the Spearman rank correlation coefficient.[72]

Each deer area was assigned a rank, based on the calculated soil fertility of the area, to be used in the Spearman rank correlation tests between physical characteristics of deer and soil fertility. The soil fertility rank of each deer area was calculated in the following manner.

A soil series is defined as, "A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the

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[70]Wilfrid J. Dixon and Frank J. Massey, Jr. 1957. Introduction to Statistical Analysis. 2d ed. McGraw-Hill Book Company, Inc., New York. pp. 155-163.

[71]Ibid., pp. 179-180.

[72]Yamane, op. cit., pp. 435-440.

surface layer, are similar in differentiating characteristics and in arrangement in the profile."[73] The natural fertility of most of the soil series encountered in West Virginia was described in varying degrees from high to low by Patton.[74] These descriptions were used as a basis for a soil series ranking system in which a number was assigned to each degree of natural fertility and subsequently to each soil series. This ranking system is presented in Appendix B. The approximate acreage of each soil series surveyed within individual counties is given in the respective county soil survey. Treating each county separately the rank of each soil series was multiplied by its approximate acreage and the resulting products were added. The acreages of each soil series were then totaled. Finally, the ratio between these two sums was used as a measure of the natural soil fertility of the county. An example of this procedure is given in Appendix C. In this way, soil fertility ratios were calculated for counties representing deer areas. Since two or more counties represented each deer area, their

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[73]John L. Gorman and Leonard S. Newman. 1965. Soil Survey of Monroe County, West Virginia. U. S. Dept. Agr., Soil Cons. Serv. in cooperation with W. Va. Agr. Exp. Sta. p. 111.

[74]Boyd J. Patton. 1955. A brief description of the major soils of West Virginia. U. S. Dept. Agr., Soil Cons. Serv., Morgantown, W. Va. p. 7.

respective soil fertility ratios were pooled to give a soil fertility ratio that represented an entire deer area. Soil fertility ratios for each county and for each deer area are listed in Appendix D. The smaller the soil fertility ratio, the more fertile the deer area was. Based on this, deer area 126 ranks number one in natural soil fertility followed in order by deer areas 127, 128, and 147.

Individual deer areas were also assigned ranks based on population density for the purpose of using them in the Spearman rank tests between physical characteristics of deer and population density. Population density ranks of deer areas were based on the legal kill of each area during the period covered by the study. Under this ranking system, deer area 147 had the highest population density, followed in order by deer areas 127, 128, and 126.

The ratio between the rank in natural soil fertility and the rank in population density for each deer area served as an index for a ranking system that combined the two range conditions. The most desirable range combination of these two factors would be to have the least number of deer on the most fertile soil, and so on, to the least desirable combination of having the highest number of deer on the poorest soil. The rank of each deer area with the most desirable first was as follows: 126, 127 and 128 (tie), and 147.

CHAPTER IV

REPORT OF THE STUDY

I. RESULTS

Antler beam diameter. The mean antler beam diameter for each deer area and age class is presented in Table I, page 37. The rank pattern established by yearling bucks was not altered in the two older age classes. For every age class, bucks in deer area 147 had the smallest antler beam diameters and progressively larger diameters were found for deer areas 128, 127, and 126 respectively. Bucks from the area where diameters were largest had main beams that averaged six millimeters more than the main beams of bucks from the area with smallest diameters. This amounts to a 28 per cent difference. Tests for significant differences revealed that means for all deer areas and age classes were significantly different at the 5 per cent level or greater, except for the difference between 127 and 126 three and one-half-plus year olds. There was no apparent biological explanation for this one exception and since it deviated from the results obtained for both hog-dressed weight and hind foot length it could possibly have been the result of weighted samples.

Hog-dressed weight. Mean hog-dressed weights placed

TABLE I

ANTLER BEAM DIAMETER OF WHITE-TAILED DEER FROM FOUR DIFFERENT AREAS OF WEST VIRGINIA

Deer Area	Age Class	Mean in Millimeters	Sample Size
147	Yearling	16.40	346
128	Yearling	17.11	271
127	Yearling	18.38	262
126	Yearling	21.61	136
147	2½	21.76	236
128	2½	23.98	165
127	2½	26.46	141
126	2½	28.44	45
147	3½+	26.47	236
128	3½+	29.81	179
127	3½+	31.66	132
126	3½+	32.74	58

deer areas in the same order that was found for antler beam diameters for all age classes except fawns. The average weight of fawns from deer area 147 was heavier than the average weight of fawns from 128. This is the reverse of what was anticipated for these two areas in view of weight results obtained for older age classes. An impulse to attribute this exception to the extremely small sample size (five) from deer area 147 or some other sampling error was not well-founded since fawn hind foot length exhibited the same difference in rank for these two areas as will be shown later. Table II, page 39, shows the mean hog-dressed weight of deer for each area and age class. By combining the three older age classes in the area where deer were heaviest and the area where deer were lightest, it was found that deer from area 126 averaged thirty-seven pounds heavier than deer from area 147. This represents a 36 per cent difference between these two areas. Significant differences existed between means for all deer areas and age classes at the 5 per cent level or greater with the exception of fawns from areas 147 and 128. The reason that this difference was not significant at the 5 per cent level can be traced to the small sample size.

Hind foot length. The same order relationship existed for hind foot lengths that existed for hog-dressed weights. Means for all deer areas and age classes are given in Table .

TABLE II

HOG-DRESSED WEIGHT OF WHITE-TAILED DEER FROM FOUR DIFFERENT AREAS OF WEST VIRGINIA

Deer Area	Age Class	Mean in Pounds	Sample Size
147	Fawn	61.20	5
128	Fawn	53.44	47
127	Fawn	62.85	69
126	Fawn	67.13	58
147	Yearling	87.62	127
128	Yearling	90.87	99
127	Yearling	100.46	156
126	Yearling	114.01	63
147	2½	100.92	105
128	2½	106.09	63
127	2½	128.36	66
126	2½	140.61	18
147	3½+	118.17	89
128	3½+	129.55	63
127	3½+	143.46	79
126	3½+	162.65	26

III, page 41. Close examination of this table will show that deer area 147 had the shortest average hind foot length followed in order of increasing size by deer areas 128, 127, and 126, for all age classes except fawns. Again deer areas 147 and 128 reversed position with respect to fawn hind foot length. The occurrence of this same exception for hog-dressed weight as well as hind foot length could very well be the result of subspecific heredity. In other words, the average deer from area 147 could possibly be genetically superior to the average deer from area 128 and therefore could be the cause of the difference. This explanation seemed more plausible when in succeeding age classes the order of mean hind foot lengths conformed to the influence of differing environmental conditions.

Deer areas 147 and 128 did not exhibit significant differences between mean hind foot lengths for any age class except yearlings. The influence of subspecific heredity could possibly be responsible for these results also. Further, the significant difference between yearling hind foot lengths could possibly be explained by the skeletal growth pattern of the animals. The second most rapid period of skeletal growth occurs during the second summer.[75] This

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[75]C. W. Severinghaus and E. L. Cheatum. 1956. Life and times of the white-tailed deer. In: The Deer of North America. Walter P. Taylor (ed.). The Stackpole Company, Harrisburg, Pa. p. 76.

TABLE III

HIND FOOT LENGTH OF WHITE-TAILED DEER FROM FOUR DIFFERENT AREAS OF WEST VIRGINIA

Deer Area	Age Class	Mean in Inches	Sample Size
147	Fawn	15.16	308
128	Fawn	15.06	176
127	Fawn	16.32	245
126	Fawn	16.85	184
147	Yearling	17.29	715
128	Yearling	17.54	296
127	Yearling	18.46	355
126	Yearling	19.15	184
147	2½	17.75	371
128	2½	17.85	180
127	2½	19.06	175
126	2½	19.51	51
147	3½+	17.90	423
128	3½+	18.10	196
127	3½+	19.23	158
126	3½+	19.56	67

rapid growth coupled with the difference in range fertility might be great enough to cause a significant difference in hind foot lengths for this particular age class. A further and more detailed study could possibly resolve the problems encountered here, but such a study was not within the scope of this work. All other deer areas and age classes had mean hind foot lengths that were significantly different at the 5 per cent level or greater.

Spearman rank correlation tests. Spearman rank correlation tests were conducted between antler beam diameter, hog-dressed weight, and hind foot length means and the following environmental variables: natural soil fertility, population density, and a combination of natural soil fertility and population density. The value of the Spearman rank correlation coefficient, R_s, ranges between negative one and positive one. A value of negative one means that perfect reverse, or negative, correlation exists between the variables being tested, a value of zero means that there is no correlation, and a value of positive one means that there is perfect positive correlation. Values between zero and negative one indicate varying degrees of negative correlation and values between zero and positive one indicate varying degrees of positive correlation.

Of the three environmental variables selected to correlate deer size with, the one chosen as the primary and most influential was natural soil fertility. The hypothesis concerning size of male deer and natural soil fertility was that a positive correlation would exist between these two variables, i.e. R_s would be greater than zero. Values for Spearman rank correlation coefficients obtained in tests between the natural soil fertility of each deer area and the mean of each deer measurement from each deer area for all age classes are given in Table IV, page 44. These results were highly significant. All values of R_s equal to one indicate perfect positive correlation. The value eight-tenths obtained for fawn hind foot length and fawn hog-dressed weight was significant at the 5 per cent level.

The second environmental variable correlated with deer size was population density. The hypothesis concerning size of male deer and population density was that a negative correlation would exist between these two variables. The reason for hypothesizing a negative correlation was that the deer area having the highest population density was expected to support the smallest deer on the average, which if true would yield a negative correlation coefficient. The respective Spearman rank correlation coefficients obtained for tests between population density and deer size are shown in Table V, page 45. A negative correlation coefficient was obtained in every case as shown in the table. The value

TABLE IV

SPEARMAN RANK CORRELATION COEFFICIENTS OBTAINED IN TESTS BETWEEN THE NATURAL SOIL FERTILITY OF EACH DEER AREA AND THE MEAN OF EACH DEER MEASUREMENT

Age Class	Measurement	R_s*
Yearling	Antler Beam Diameter	1.0
2½	Antler Beam Diameter	1.0
3½+	Antler Beam Diameter	1.0
Fawn	Hog-dressed Weight	0.8
Yearling	Hog-dressed Weight	1.0
2½	Hog-dressed Weight	1.0
3½+	Hog-dressed Weight	1.0
Fawn	Hind Foot Length	0.8
Yearling	Hind Foot Length	1.0
2½	Hind Foot Length	1.0
3½+	Hind Foot Length	1.0

*Spearman rank correlation coefficient.

TABLE V

SPEARMAN RANK CORRELATION COEFFICIENTS OBTAINED IN TESTS BETWEEN THE POPULATION DENSITY OF EACH DEER AREA AND THE MEAN OF EACH DEER MEASUREMENT

Age Class	Measurement	R_s
Yearling	Antler Beam Diameter	-0.8
2½	Antler Beam Diameter	-0.8
3½+	Antler Beam Diameter	-0.8
Fawn	Hog-dressed Weight	-0.4
Yearling	Hog-dressed Weight	-0.8
2½	Hog-dressed Weight	-0.8
3½+	Hog-dressed Weight	-0.8
Fawn	Hind Foot Length	-0.4
Yearling	Hind Foot Length	-0.8
2½	Hind Foot Length	-0.8
3½+	Hind Foot Length	-0.8

negative four-tenths obtained for fawn hind foot length and fawn hog-dressed weight was not significant at the 5 per cent level. The value negative eight-tenths found for all other cases was significant at the 5 per cent level, however.

The environmental variable combining deer area natural soil fertility and population density was the last to be correlated with deer size. The correlation between natural soil fertility and deer size could hardly be improved upon, since perfect correlation existed in all but two cases; however, by combining natural soil fertility and population density the correlation with deer size was improved over the correlation with population density alone. The hypothesis in this test was that a positive correlation would be obtained. The basis for this hypothesis was that the deer area having the highest natural soil fertility and the lowest population density was expected to produce the largest deer on the average. For every age class and measurement tested a positive correlation coefficient was obtained and these are presented in Table VI, page 47. The value ninety-five one-hundredths obtained in nine of the eleven cases was significant at the 5 per cent level; but the value sixty-five one-hundredths obtained in the two remaining cases, fawn hog-dressed weight and fawn hind foot length, was not.

TABLE VI

SPEARMAN RANK CORRELATION COEFFICIENTS OBTAINED IN TESTS BETWEEN THE NATURAL SOIL FERTILITY/POPULATION DENSITY RATIO OF EACH DEER AREA AND THE MEAN OF EACH DEER MEASUREMENT

Age Class	Measurement	R_s
Yearling	Antler Beam Diameter	0.95
2½	Antler Beam Diameter	0.95
3½+	Antler Beam Diameter	0.95
Fawn	Hog-dressed Weight	0.65
Yearling	Hog-dressed Weight	0.95
2½	Hog-dressed Weight	0.95
3½+	Hog-dressed Weight	0.95
Fawn	Hind Foot Length	0.65
Yearling	Hind Foot Length	0.95
2½	Hind Foot Length	0.95
3½+	Hind Foot Length	0.95

II. DISCUSSION

Of the three deer measurements used in this study, antler beam diameter and hog-dressed weight appeared to be slightly better indicators of the particular range conditions being considered than hind foot length. All three measurements exhibit the same order arrangement with respect to means from one deer area to another for all age classes except fawns. A reason for fewer significant differences between mean hind foot lengths could possibly be the influence of subspecific heredity as has already been suggested.

The relationship between the environmental variables, natural soil fertility and population density, and size of male deer was clearly established in the Spearman rank correlation coefficient tests. In general the differences in the size of bucks from different deer areas grew more pronounced as they grew older. This was especially evident in the antler beam diameter measurements and was further evidence of how real the differences were in range natural soil fertility as identified in the deer area natural soil fertility ranking system. On the basis of evidence accumulated and presented in this study, the differences in size of male white-tailed deer from the deer areas outlined in Figure 4, page 26, appear to be primarily the result of basic differences in natural soil fertility of these areas.

Earlier statements indicated that the most up-to-date, available soil data was included in this study. As more county soil surveys, are completed by the Soil Conservation Service and if deer data can be accumulated from areas where no or little information has been available before, an excellent opportunity would be available for further study to broaden and/or strengthen the premises on which the deer areas as defined in this study are based.

A second line of study that seems worth pursuing is the difference in hind foot length of deer from deer areas 147 and 128. However difficult it may seem, a study could be designed to determine if subspecific heredity is influencing hind foot length measurements from these two areas.

An attempt to remedy basic differences in natural soil fertility over areas as broad as those covered in this study would be highly impractical, if not impossible. These basic differences are inherent limitations in the natural environment that are not easily overcome; and a lack of time, money, and personnel does not permit a massive attack on the problem, even though significant results could probably be achieved. A more reasonable approach would be to deal with areas as large as personnel and present land management techniques would allow. The quality of deer, as well as other wildlife, on low-fertility range can be improved the same as the farmer improves his crop and livestock quality. The state of Missouri is one place where the aforegoing type of approach has apparently paid off. Steen[76] says, "In Missouri we have doubled and trebled the wildlife populations of low-fertility Ozark range by heavy fertilization and proper tillage of no more than one to two per cent of that range." The cooperation of interested, private land owners, if there are any, would be invaluable to such endeavors. Krefting, Hansen, and Hunt[77] described a technique that, although not originally intended for the purpose, could possibly be used in conjunction with soil fertilization to improve the quality of deer. This technique consisted of using aerial applications of 2,4-D to improve deer browse supply. Of course, a prerequisite, with regard to population density, for improving deer quality on poor range would be to keep herd levels well within the carrying capacity of the available food supply. If population stabilization is maintained and sound land management techniques employed, deer quality could be improved on some of West Virginia's low-fertility ranges.

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[76] Melvin O. Steen. 1955. Not how much but how good. Mo. Conservationist. 16(1):3.

[77] L. W. Krefting, H. L. Hansen, and R. W. Hunt. 1960. Improving the browse supply of deer with aerial applications of 2,4-D. Minn. For. Notes No. 95.

CHAPTER V

SUMMARY

The differences in physical size of white-tailed deer in West Virginia served as a basis for this study. In past studies these differences have gone uncorrelated with any specific range conditions over broad areas of the state. A re-examination of these differences using antler beam diameter, hog-dressed weight, and hind foot length measurements of male deer, as criteria of physical size, led to positive correlations between male deer size and specific environmental variables. The specific environmental variables were natural soil fertility and deer population density.

Significant differences in mean antler beam diameters existed between all deer areas identified in the study. With few exceptions differences in mean hog-dressed weights and mean hind foot lengths followed the pattern established by mean antler beam diameters. Differences in the mean antler beam diameter of deer from different deer areas correlated perfectly with differences in natural soil fertility of deer areas. Differences in mean hog-dressed weight and mean hind foot length of deer were also perfectly correlated with differences in natural soil fertility, except for the fawn age class. Correlations obtained between deer measurements and population density were not as good, but were still, in the majority of cases, significant at the 5 per cent level. When considered in combination with each other and correlated with deer size, correlations obtained were intermediate between those obtained for the two environmental variables separately.

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APPENDIXES

APPENDIX A

COEFFICIENTS OF VARIATION FOR DEER MEASUREMENTS

DEER AREA AND AGE CLASS

DEER AREA 147

Age Class	Antler Beam Diameter	Hog-dressed Weight	Hind Foot Length
Fawn		6.6%	9.8%
Yearling	21.4%	8.1%	9.7%
2½	22.3%	15.8%	5.4%
3½+	20.5%	15.9%	8.4%

DEER AREA 128

Age Class	Antler Beam Diameter	Hog-dressed Weight	Hind Foot Length
Fawn		19.7%	18.5%
Yearling	23.7%	17.3%	8.2%
2½	21.8%	20.7%	5.6%
3½+	19.6%	20.4%	9.5%

DEER AREA 127

Age Class	Antler Beam Diameter	Hog-dressed Weight	Hind Foot Length
Fawn		16.1%	9.1%
Yearling	21.2%	12.3%	6.7%
2½	18.2%	12.5%	4.8%
3½+	15.0%	14.6%	3.9%

DEER AREA 126

Age Class	Antler Beam Diameter	Hog-dressed Weight	Hind Foot Length
Fawn		8.0%	3.9%
Yearling	14.7%	11.2%	4.3%
2½	19.3%	12.6%	3.6%
3½+	19.8%	15.5%	5.0%

APPENDIX B

SOIL SERIES RANKING SYSTEM

Ranking system:

Very high natural fertility	9
High natural fertility	8
High to medium natural fertility	7
Medium to high natural fertility	6
Medium natural fertility	5
Medium to low natural fertility	4
Low to medium natural fertility	3
Low natural fertility	2
Very low natural fertility	1

Soil Series

Allbrights (5)

Allegheny (4)

Allen (4)

Andover (4)

Ashby (1)

Ashton (8)

Atkins (3)

Barbour (6)

Barbour-Pope (7)

Belmont (8)

Berkeley (8)

Soil Series

Berks (2)

Berks-Lehew (2)

Berks-Montevallo (1)

Blage (4)

Blairton (2)

Bodine (3)

Brinkerton (4)

Brinkerton-Lickdale (4)

Brinkerton-Nolo (4)

Brooke (7)

Brookside (6)

Soil Series	Soil Series
Buchanan (5)	Emory (8)
Calvin (2)	Ernest (5)
Calvin complex (2)	Ernest complex (5)
Captina (3)	Frankstown (6)
Carbe (7)	Frederick (8)
Cavode (5)	Frederick-Bodine (5)
Chavies (6)	Frederick-Dunmore (7)
Chilhowie (7)	Gilpin (5)
Chilhowie-Tumbez (7)	Ginat (6)
Chilo (5)	Guernsey (6)
Clarksburg (6)	Guthrie (6)
Clymer (2)	Habersham (2)
Cookport (2)	Hackers (8)
Cotaco (6)	Hagerstown (8)
Corydon (7)	Hartsells (2)
Dahmer (5)	Hayter (6)
Dekalb (2)	Hollywood (6)
Dekalb complex (2)	Holston (4)
Duffield (8)	Huntington (9)
Duncannon (5)	Klinesville (2)
Dunmore (6)	Klinesville-Weikert (2)
Edon (6)	Laidig (2)
Elkins (8)	Lakin (2)
Elliber (3)	Leadvale (5)

Soil Series	Soil Series
Leetonia (4)	Philo (6)
Leetonia complex (4)	Pope (8)
Lehew (2)	Purdy (2)
Lickdale (3)	Rayne (3)
Lindside (8)	Robertsville (6)
Litz (5)	Rushtown (3)
Lowell (8)	Sciotoville (8)
Lowell-Hagerstown (8)	Sees (6)
Markland (3)	Senecaville (8)
Markland-McGary (3)	Sequatchie (6)
McGary (3)	Shelecta (5)
Meckesville (5)	Summers (2)
Meigs (5)	Teas (5)
Melvin (7)	Teas-Calvin (3)
Monongahela (2)	Teas-Calvin-Litz (4)
Monongahela-Tilsit (2)	Tilsit (1)
Moshannon (9)	Tygart (2)
Montevallo (1)	Tyler (2)
Montevallo-Lehew (1)	Upshur (7)
Murrill (3)	Upshur-Muskingom (5)
Muskingom (2)	Vandalia (6)
Muskingom-Upshur (5)	Waynesboro (4)
Nolo (4)	Weikert (1)
Pickaway (5)	Wellston (2)

Soil Series

Westmoreland (6)

Wharton (3)

Wheeling (8)

Wyatt (3)

Zoar (2)

APPENDIX C

CALCULATION OF THE WIRT COUNTY

NATURAL SOIL FERTILITY RATIO

Soil Series*	Series Rank	Series Acreage*	Product of Series Rank x Series Acreage
Allen	4	600	2,400
Hackers	8	1,620	12,960
Markland	3	490	1,470
McGary	3	550	1,650
Melvin	7	660	4,620
Cotaco	6	1,370	8,220
Monongahela-Tilsit	2	7,410	14,820
Moshannon	9	5,470	49,230
Muskingom	2	5,250	10,500
Senecaville	8	2,610	20,880
Tygart	2	400	800
Upshur	7	1,510	10,570
Upshur-Muskingom comp.	5	103,900	519,500
Upshur-Brooke Complex	7	3,440	24,080
Vandalia	6	9,990	59,940
Zoar	2	250	500
TOTAL		145,520	742,140

Wirt County natural
soil fertility ratio = 145,520/742,140=0.196

*United States Department of Agriculture, Soil Conservation Service. [n.d.]. The approximate acreage of soils and miscellaneous land types in Wirt County, West Virginia. 2 pp. typed.

APPENDIX D

SOIL FERTILITY RATIOS FOR EACH DEER AREA AND COUNTY

Deer Area 126 = 0.184

Mason County = 0.187

Jackson County = 0.184

Marshall County = 0.165

Wirt County = 0.196

Wood County = 0.192

Deer Area 127 = 0.257

Preston County = 0.243

Tucker County = 0.275

Part of Northern Randolph County = 0.288

Deer Area 128 = 0.272

Monroe County = 0.286

Pocahontas County = 0.265

Deer Area 147 = 0.313

Berkeley County = 0.239

Hampshire County = 0.366

APPENDIX E

A COMPARISON OF MEAN MEASUREMENTS FROM THE FOUR DEER AREAS STUDIED

Measurement	Age Class	Deer Area	Mean	Standard Deviation	t	Level of Significance
Antler Beam diameter (mm)	Yearling	147	16.40	3.52	2.315	0.05
		128	17.11	4.06		
	2½	147	21.76	4.86	4.344	0.0005
		128	23.98	5.23		
	3½+	147	26.47	5.44	5.963	0.0005
		128	29.81	5.87		
Hog-dressed weight (lbs.)	Fawn	147	61.20	4.06	1.601	n.s.*
		128	53.44	10.53		
	Yearling	147	87.62	7.18	2.050	0.05
		128	90.87	15.80		
	2½	147	100.92	15.96	1.745	0.05
		128	106.09	22.02		
	3½+	147	118.17	18.87	3.073	0.005
		128	129.55	26.48		

*n.s. not significant at the 0.05 level

Measurement	Age Class	Deer Area	Mean	Standard Deviation	t	Level of Significance
Hind foot length (in.)	Fawn	147	15.16	1.49	0.510	n.s.
		128	15.06	2.80		
	Yearling	147	17.29	1.68	2.231	0.025
		128	17.54	1.45		
	2½	147	17.75	0.97	1.112	n.s.
		128	17.85	1.01		
	3½+	147	17.90	1.51	1.462	n.s.
		128	18.10	1.72		
Antler beam diameter (mm)	Yearling	128	17.11	4.06	3.669	0.0005
		127	18.38	3.90		
	2½	128	23.98	5.23	4.259	0.0005
		127	26.46	4.84		
	3½+	128	29.81	5.87	2.955	0.005
		127	31.66	4.77		

Measurement	Age Class	Deer Area	Mean	Standard Deviation	t	Level of Significance
Hog-dressed weight (lbs.)	Fawn	128	53.44	10.53	4.781	0.0005
		127	62.85	10.15		
	Yearling	128	90.87	15.80	5.311	0.0005
		127	100.46	12.45		
	2½	128	106.09	22.02	6.530	0.0005
		127	128.36	16.07		
	3½+	128	129.55	26.48	3.468	0.0005
		127	143.46	20.96		
Hind foot length (in.)	Fawn	128	15.06	2.80	5.939	0.0005
		127	16.32	1.49		
	Yearling	128	17.54	1.45	8.677	0.0005
		127	18.46	1.24		
	2½	128	17.85	1.01	11.654	0.0005
		127	19.06	0.93		
	3½+	128	18.10	1.72	7.639	0.0005
		127	19.23	0.76		

Measurement	Age Class	Deer Area	Mean	Standard Deviation	t	Level of Significance
Antler beam diameter (mm)	Yearling	127	18.38	3.90	8.297	0.0005
		126	21.61	3.18		
	2½	127	26.46	4.84	2.291	0.025
		126	28.44	5.51		
	3½+	127	31.66	4.77	1.272	n.s.
		126	32.74	6.50		
Hog-dressed weight (lbs.)	Fawn	127	62.85	10.15	2.857	0.005
		126	67.13	5.43		
	Yearling	127	100.46	12.45	7.197	0.0005
		126	114.01	12.80		
	2½	127	128.36	16.07	2.768	0.005
		126	140.61	17.72		
	3½+	127	143.46	20.96	3.803	0.0005
		126	162.65	25.23		

Measurement	Age Class	Deer Area	Mean	Standard Deviation	t	Level of Significance
Hind foot length (in.)	Fawn	127	16.32	1.49	4.469	0.0005
		126	16.85	0.67		
	Yearling	127	18.46	1.24	6.736	0.0005
		126	19.15	0.84		
	2½	127	19.06	0.93	3.170	0.005
		126	19.51	0.71		
	3½+	127	19.23	0.76	2.695	0.005
		126	19.56	0.99		