November 16, 1973

To the Graduate Council:

I am submitting herewith a thesis written by Elizabeth Estill Howard entitled "Interactions Between White-Tailed Deer and Habitat on the Ft. Rucker Army Aviation Center Reservation, Alabama." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

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INTERACTIONS BETWEEN WHITE-TAILED DEER AND HABITAT ON THE FT. RUCKER ARMY AVIATION CENTER RESERVATION, ALABAMA

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Elizabeth Estill Howard

December 1973

ACKNOWLEDGMENTS

The author wishes to thank the members of her committee who helped to edit the manuscript, especially Dr. E. E. C. Clebsch whose suggestions were both timely and helpful. Thanks are to be given to the Land Management Branch at Ft. Rucker, Alabama, for its encouragement and support in the collection of data, and to the wildlife biologist, Larry La Plant, for the use of his hunt reports.

Special thanks go to the Ft. Rucker forester, Edward Ward, for his information on the history of the study area and his cooperation and assistance in the collection of data.

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ABSTRACT

The ability of the 53,000 acres of wildlife habitat to support the present white-tailed deer population on the Ft. Rucker Army Aviation Center Reservation in southeastern Alabama was investigated, as were the inter-relationships between the habitat and a historically increasing deer population. Mast and browse surveys were conducted from April through September, 1973, to evaluate both the quantity and quality of available deer foods. The changes in the deer herd and habitat were evaluated from nine years of kill data and condition reports. The response of the deer to its changing environment was determined from condition reports and evaluation of the population dynamics of the herd.

The inherent soil fertility on the area is low, and is reflected in the low productivity of browse and mast. By applying analyses from other coastal plain sites to the local food species, both protein levels and phosphorus content were found to be at or below maintenance levels for the current deer population.

Of the other factors important in regulating deer populations, predation is unimportant. Food and cover components of the habitat are adequately interspersed. Climate provides periods of late summer and early fall heat stress for the deer. Water does not seem to be limiting.

Average weights, physical condition, and antler development have become lower through the past nine years. Survivorship has shown a trend from Type I to Type II curves. Age-class pyramids have shifted from those typical of expanding populations to those typical of decreasing populations. The estimated herd size of 2,300 animals appears to be well above the optimum carrying capacity of the range.

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CHAPTER I

INTRODUCTION

At the time of the discovery of North America, white-tailed deer ranged in vast numbers throughout the continent. They were subject to normal fluctuations in the balance of nature, but were relatively unaffected by the activities of North America's aboriginal inhabitants. With the European settlers came profound changes in both the deer habitat and the deer population. At first there was an increase in deer numbers in response to the opening of the forest canopy to agriculture. This was followed, however, by terrific exploitation of the deer resource. In many sections of the United States, including southeastern Alabama, between 1875 and 1915 (Taylor, 1956), the lack of protective laws resulted in near extirpation of the animals. Presently a combination of protective laws and restocking programs has not only restored deer to their prior numbers but has actually caused increased population levels in many areas.

Of the larger game animals on this continent, deer are the most adaptable, most widely distributed, most heavily hunted, best loved and about the most misunderstood (Taylor, 1956). The white-tailed deer can make its home in suburban woodlots within sight and sound of roaring traffic and bustling human activity. Hunting pressure that would exterminate less adaptable species hardly affects the population levels of deer. These characteristics help to make the white-tailed

deer North America's number one big game animal (Taylor, 1956). They also make it quite responsive to wildlife management. Unfortunately, however, a lack of understanding of the population dynamics of deer herds often causes public resistance to sound management methods. In the Mosaic Law (Deuteronomy 22:6,7) it is stipulated:

> If a bird's nest chance to be before thee in the way in any tree, or on the ground, whether they be young ones, or eggs, and the dam sitting upon the young, or upon the eggs, thou shalt not take the dam with the young: But thou shalt in any wise let the dam go, and take the young to thee; that it may be well with thee, and that thou mayest prolong thy days.

With many species of game animals it is necessary to restrict hunting pressure to prevent trouble. With white-tailed deer the opposite frequently is true. "Buck only" laws have led to deer populations out of balance with their habitat and food supply. The prevalent problems with deer herds in southeastern Alabama are the result of too many, rather than too few, deer.

The present study considers a deer herd located at Ft. Rucker, Alabama, in the ecotone between shortleaf-loblolly and longleaf-slash pine forest types. Such ecotones generally support high wildlife densities.

This thesis investigates the ability of the habitat to support the present deer population, the effect that increasing deer numbers have had on the habitat, and the effect that the changing habitat has had on the deer. Mast and browse surveys were conducted from April through September, 1973, to evaluate both the quantity and the quality of available deer foods. The change in habitat was determined through the evaluation of nine years of kill data and condition reports made

available through the Ft. Rucker wildlife biologist. The response of the deer to their changing environment was determined by both condition reports and evaluation of the population dynamics of the herd.

CHAPTER II

THE HABITAT

I. DESCRIPTION AND HISTORY

Ft. Rucker, an Army flight training installation in southeastern Alabama, is on the Coastal Plain in the area commonly called the "Wiregrass Section." It encompasses 60,149 acres of which 43,549 are timbered, 9,700 located in impact areas, and 6,820 in cantonments. The wildlife habitat is estimated to cover 53,329 acres.

The land is characterized by wide hilltops that break rapidly from slope crests down to ravines. The grades of these slopes average from 5 to 15 percent. The largest hills run north and south with east to west side ridges. Major drainage is to the south into the Choctawhatchee River. (See Plate 1 in Pocket.)

Early settlers in the Ft. Rucker area built their houses and barns with virgin timber taken from pure stands of longleaf, loblolly, and shortleaf pines, or mixed stands of pines and hardwoods. Magnolia, ash, bamboo, cypress, and an undergrowth of gallberries and briers grew where there was abundant moisture (Henry et al., 1960). As the settlement grew, all the original stands were cut. Many acres were planted in cash crops, especially cotton. Severe erosion and the devastating boll weevil followed. Much of the landscape is now marred by deep erosion gullies. Many areas once in pine are occupied by thick stands of scrub oak (Henry et al., 1960).

The land that is now Ft. Rucker was purchased to create the Pea River Land Utilization Project, under the auspices of the Department of Agriculture, in 1933, 1935, and 1937. By an executive order dated August 15, 1942, the land was transferred to the jurisdiction of the Department of the Army for military purposes. Secondarily, the land was to be managed to carry out the land-conservation and land-utilization program for which the land was originally acquired. The Department of the Army finished the acquisition of all lands within the present boundary in 1942 (Anonymous, 1954).

Following the establishment of Ft. Rucker as a military post, the land was intensively used for the training of armored and infantry division troops. Area requirements for the training of troops were such that large areas were cleared of all tree growth. In addition, weapons were fired in many of the remaining timber areas resulting in wildfires and heavily damaged trees. Fires occurred in most of the timbered areas between 1942 and 1946. There was a short period of deactivation after World War II, but training resumed in 1950 and more fires occurred. In 1954 the post became a flight training area. Land was cleared for eight permanent heliports and many emergency landing areas (Anonymous, 1973). Ft. Rucker is now the largest Army flight training area in the United States.

The old erosion gullies are, for the most part, inactive due to approximately 25 years of gentle forest management. New gullies continue to form, however, as a result of runoff from roads or newly cleared areas. Land management is supervised by two foresters, an agronomist, and a wildlife biologist.

II. HABITAT APPRAISAL FOR WHITE-TAILED DEER

The white-tailed deer is an opportunistic ruminant well adapted to a "boom and bust" economy. Consequently, it is able to survive in every forest type in the South. The high degree of adaptability of the white-tailed deer causes difficulty in precise enumeration of all the factors limiting habitat quality. However, the most frequently identified criteria in appraising habitat are:

1. inherent soil fertility
2. resistance of habitat to severe weather stress
3. water
4. abundance and variety of palatable forage
5. degree of interspersion of food and cover components
6. nature and extent of escape cover serving to reduce legal or illegal hunting harvest and predation by dogs (Zeedyk, 1969).

An effort has been made to analyze each of these criteria for the Ft. Rucker area.

III. SOILS

A soil survey (Henry, 1960) classified the soils into the Norfolk-Ruston-Shubuta Association and the Shubuta-Cuthbert Association. The former consists of well drained and moderately well drained soils, most of which are deep. The surface soils are sandy loam to loamy sand in texture and were developed from unconsolidated beds of clay, sand, and sandy clay. These medium to strongly acid (pH 4 to 6) soils contain

very small amounts of plant nutrients and organic matter. The Shubuta-Cuthbert Association consists of moderately well drained to somewhat poorly drained soils with a clayey subsoil. These soils are also low in fertility and organic matter and are also medium acid to strongly acid. It is apparent that the soils of the Ft. Rucker area are not conducive to excellent deer habitat since they can neither support quantity nor quality vegetation. The soils generally respond well to fertilizer amendments and can be made more productive (Henry et al., 1960). But it is questionable whether the increase in productivity of the forests would merit the economic expenditure necessary for the gain.

IV. CLIMATE

The climate of the Ft. Rucker area is characterized by a fairly short, mild winter and a long, hot, humid summer. Although periods of dry weather and periods of excessive rainfall do occur, precipitation is usually both ample and well distributed for plant production (Table I). Frost is common but extremely cold weather is rare. The winter prior to this study (1973) was unusual in that the area suffered from an extensive glaze storm in February. It was the first severe glaze storm on record. The dry period, which occurs in the fall, may contribute to the common late summer stress period noted to occur in southern deer herds (Short et al., 1969; Goodrum and Reid, 1962; Lay, 1969). The fall droughts often hinder the growth of forage seeded in the fall and retard the growth of established plants (Henry et al., 1960).

TABLE 1. Climatic summary, Ft. Rucker, Alabama.

1954-1973	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Av. max. temp. (°F.)	59.0	62.2	68.5	78.5	85.0	88.4	89.8	89.4	85.9	77.6	68.5	61.5
Av. min. temp.	37.8	41.5	46.9	56.2	63.3	69.2	71.6	71.1	67.2	56.4	45.9	40.2
Extreme max. temp.	81.0	85.0	89.0	91.0	98.0	101.0	100.0	101.0	98.0	92.0	88.0	83.0
Extreme min. temp.	8.0	16.0	24.0	33.0	42.0	50.0	57.0	59.0	38.0	34.0	18.0	7.0
Av. Precip. (inches)	4.10	5.49	4.94	4.57	3.15	4.51	5.10	4.47	4.81	3.25	2.97	4.50
Max. Precip.	7.90	9.97	11.52	8.56	10.67	9.09	8.65	12.97	11.57	10.71	6.72	9.11
Min. Precip.	.70	1.81	.64	.50	.05	.63	1.68	1.00	1.11	.00	.13	.84

V. WATER

Availability of surface water for deer was determined by examination of both topographic maps and aerial photographs. The reservation is topographically mature, with many permanent and few intermittent streams. Cypress and tupelo swamps are present in some of the low areas. The streams do not appear to be excessively polluted as there is an abundance of both plant and animal life present in them. It may be concluded that water quality and water availability are not problematic for the white-tailed deer in the study area.

VI. FORAGES

The relative abundance and variety of palatable forage were determined by field work from April through September, 1973. From casual observations it was concluded that the deer in the study area use a great variety of vegetable material, the proportions of which vary with the season. Included in the list of possible deer foods are forbs, grasses, mushrooms, fruit, acorns, and browse. Table 2 describes percent of total volume of deer forage by seasons in the coastal plains. Browse was selected as an indicator of range carrying capacity because (1) it is the most abundant food source in mid-winter and (2) it is generally accepted that, as the density of white-tails increases, herds tend to turn more toward woody browse materials (More et al., 1960). A browse survey was taken on a representative compartment of Ft. Rucker in July, 1973.

TABLE 2. Deer forage by seasons in the Coastal Plains.

Season	Leaves	Fruit and Acorns	Twigs	Mushrooms
		PERCENT OF TOTAL VOLUME		
Spring	64.2	0	25.3	1.3
Summer	65.3	0	14.4	11.9
Fall	9.0	73.5	5.8	2.2
Winter	89.9	0	5.5	2.4

SOURCE: Cushwa et al., 1970.

VII. BROWSE SURVEY

Methods

A survey of species of deer browse was compiled from lists furnished by the Southern and Southeastern Forest Experiment Stations and the Cooperative Extension Service of Auburn University. A few species were added as past observations indicated they were browsed in the study area during stress periods (Ward, personal communication). The browse was then surveyed using 40, 100-foot line transects and the line intercept method described by Greig-Smith (1964). Random selection of grid coordinates on a map of the study area located the starting points for each of the ten lines. These positions were located in the field using a compass and topographic maps. Four samples were taken at regular intervals across the topography on each line. The height of of the line was limited to five feet following an acceptable precedent (Stiteler et al., 1966). In addition to frequency and coverage, degree of browse, canopy composition, and site location were recorded at each

sampling site. The browse was estimated using an Aldous (1944) survey modified to a line transect.

Results and Implications

Results of the deer browse survey are summarized in Table 3. The survey indicates that few of the available deer browse species in the study area were significantly utilized. Of the 32 species which could be expected to occur at Ft. Rucker, 23 were present on at least one line transect. Each of these species was ranked as either excellent, good, or fair browse with respect to palatibility by previous surveys in the South (Goodrum and Reid, 1959; Lay, 1965). Palatibility varies greatly with location (Maynard and Loosli, 1962) and may be partially a function of "herd habit" or preferences passed over generations from doe to fawn through observation (Carhart, 1948). Of the 23 browse plants found in the study area, only 12 showed any indication of deer browsing. Moderate to heavy browsing was noted on only 2 species, sweetleaf (Symplocos tinctoria) and fringetree (Chioranthus virginicus) and the browsing could not definitely be attributed to deer. Sweetleaf was found on only one transect and fringetree was present on four.

There were seven browse species which occurred on at least half of the line transects, and of these relatively abundant browse plants, only four, greenbrier (Smilax spp.), red maple (Acer rubrum), blueberry (Vaccinium spp.), and oak (Quercus spp.), were recorded as showing signs of deer use. Greenbrier was the only deer browse with both a high palatibility ranking and a relatively high percent cover.

The utilization factor of the deer browse plants is the product of the average density of the species over the line transects and the

TABLE 3. Results of the browse survey.

	No. of plots where present	Av. density	Av. deg. of browsing	Utilization factor	Palatibility rank	Utilization rank
Red Maple	20	2.5	7.5	18.75	7	4
Am. Beautyberry	13	1.625	0	0		
Fringetree	4	.5	20.0	10.0	2	
Sweet Pepperbush	1	.75	0	0		
Dogwood	16	2.0	13.75	27.50	3	3
Hawthorne	5	.625	7.5	4.6875	8	
Yellow Jassmine	26	6.87	0	0		
Hollies	12	2.125	8.75	18.59	5	5
Yellow Poplar	2	.25	0	0		
Sweetbay	1	.125	0	0		
Blackgum	18	2.0	7.77	15.55	6	6
Sourwood	11	2.0	6.81	13.636	9	7
Redbay	3	1.0		0		
Black Cherry	6	1.375	.833	1.1458	12	
Oaks	26	5.0	1.15	5.769	11	
Rubus	17	2.75	0	0		
Greenbriers	30	5.0	13.0	65.0	4	1
Sweetleaf	1	.125	70	8.75	1	
Blueberries	37	13.37	3.91	52.395	10	2
Viburnum	9	1.125	0	0		
Summer Grape	24	4.25	0	0		
Sassafras	5	.625	0	0		
Sweetgum	30	9.12	0	0		

NOTE: The following items were represented by zero (0) across the face of the table: Swamp Cyrilla; Va. Sweetspice; Trumpet Creeper; Buttonbush; Buckwheat Tree (rare); Strawberry Bush; Smooth Hydrangea; E. Redcedar; and Japanese Honeysuckle. Common names were taken from U.S.D.A. (1961).

average degree of browsing over the same area. The utilization factors differ greatly from the preference rankings indicating a scarcity of preferred browse plants, a condition often associated with deer herds exceeding range carrying capacity (Cowan et al., 1970).

The total cover of browse species was low at 40 percent. Cover exceeding 100 percent is possible and is not at all uncommon in layered vegetation (Greig-Smith, 1964). Low percent cover of browse species can be partly attributed to (1) competition with non-browse species (myrtle and winged sumac were present in many areas in high densities), (2) low soil fertility, (3) mature condition of most of the forest, (4) climax vegetation, (5) droughty soils, and (6) previous history of over-browsing.

Range deterioration in much of the United States is generally caused by overpopulations of deer which eliminate, through overuse, the most preferred and nutritious deer foods (Murphy & Coates, 1966). Japanese honeysuckle which was once abundant on the reservation (Ward, personal communication) was not present in any of the samples. Other browse species, including Eastern red cedar and fringetree, have also decreased in abundance (Ward, personal communication). However, the low utilization of the available browse species indicates that the quality of the deer foods is so low that deer die-offs, possibly in the form of high fawn mortality, occur before any plants are completely eliminated from the range (Murphy & Coates, 1966). In order to determine whether this is a probability at Ft. Rucker, percent levels of the protein and phosphorus content of the most heavily utilized browse plants were researched.

Phosphorous is needed for metabolism in herbivores and is a major constituent of bones, antlers, and soft tissue (Short et al., 1969). Phosphorus deficiencies in herbivores affect estrus and therefore influence productivity (Maynard & Loosli, 1962).

Protein content alone is a good indicator of nutritive value because the amounts of browse consumed and the energy availability are closely related to the stage of maturity and succulence of the plants, which, in turn, are associated with nitrogen levels or plant protein content (Cowan, 1970). There is also a strong positive correlation between nitrogen content and digestibility (Lay, 1957b). Therefore, it is reasonable to predict that if the combination of natural foods contains adequate crude protein, other nutritional requirements will be incidentally covered (Cowan et al., 1970). It is recognized that the composition of deer browse plants will be affected by such variables as soil chemistry, geography, origin of growth on the plant, and season of the year. However, it is possible to make some gross generalizations about how particular species supply the nutritional requirements of deer.

White-tailed deer require a diet containing 13 to 16 percent protein for optimal growth and development. They require at least 8 percent protein for body maintenance. Phosphorus levels in deer food should be above .25 percent for body maintenance (French et al., 1955).

Greenbrier, with the highest utilization factor (65 percent) in the study area, has a leaf protein content seasonally fluctuating at just below 10 percent and a stem protein content fluctuating at about 7 percent (Blair & Halls, 1967). Protein levels in the leaves and stem

tips of greenbrier reached levels necessary for deer growth during the spring growth flush. Protein levels in the leaves exceeded the minimum for maintenance. Greenbrier is deciduous and leaves are not present in the winter. Stems, which are available year round, have protein levels below those necessary for maintenance except, again, during the spring flush (April and May). Phosphorus levels in greenbrier reached the level necessary for maintenance in April and continued at .35 percent during May (Blair & Halls, 1967). Levels of phosphorous were submaintenance during the other ten months.

Several species of blueberries were the second most utilized source of deer browse (52 percent) in the study area. The high utilization factor resulted from high coverage rather than from high palatability. Blueberry leaves and twigs have a low protein content averaging around 6.5 percent (Lay, 1957). This is below deer maintenance levels. Phosphorus levels range from .02 percent to .01 percent depending on the season (Lay, 1957). Even during the spring growth flush both protein and phosphorus levels are below the necessary levels for body maintenance.

The twigs of flowering dogwood (Cornus florida), a deciduous species with a utilization factor roughly half that of the blueberries (27 percent), contain 4.5 percent crude protein and .17 percent phosphorus during the winter (Lay, 1957). Again these levels are considerably below those necessary for deer maintenance.

The fourth most utilized browse in the study area was red maple (Acer rubrum). It has a high spring protein content of 23.5 percent and an adequate spring phosphorous content of .35 percent (Smith et al, 1956).

Winter protein levels drop below 7.5 percent (Segelquist & Green, 1968) and phosphorous levels may also drop below those necessary for body maintenance.

Other browse plants of importance include the hollies (Ilex spp.) with protein and phosphorous contents again below maintenance levels, at 6.73 percent and .03 percent, respectively (Lay, 1957). Blackgum contains 3.19 percent crude protein and .02 percent phosphorus (Lay, 1957). Sourwood (Harshbarger & McGinnes, 1971) has protein levels ranging seasonally from 12.6 to 4.8 and exceeds maintenance levels in all months except November and December. Phosphorus content ranges from .21 percent to .31 percent and is above maintenance levels in all but the winter months (Harshbarger and McGinnes, 1971).

From examination of the protein and phosphorous content of the browse foods with the greatest utilization in the study area, it seems likely that the deer are not receiving the necessary amounts of crude protein and phosphorous from browse plants for maintenance, and certainly not enough nutrients for growth and development. Winter browse plants are all deficient in protein, phosphorous, and probably in other necessary nutrients. The situation improves with the spring growth flush but is still far from optimal. Therefore it is safe to assume that an overpopulation of deer in the study area would result in deer die-offs before more severe range deterioration could occur.

Although browse is an important deer food, mast and fruit cannot be overlooked as a possible source of nutrients. In order to estimate the availability of these items to the diet of the white-tailed deer, canopy composition was sampled.

VIII. MAST SURVEY

Methods

Canopy composition of the study area was determined by using the Bitterlich variable-radius sampling method as described in Greig-Smith (1964). Basal area was estimated using a 10-factor prism at the starting point of each of the forty browse lines. Trees tallied were classified by species, diameter, crown position, and vigor. Basal area for the mast producing species was computed individually with respect to species, crown position, and vigor. Basal area for other hardwoods and pines was computed similarly but without regard to individual species. Crown cover for each mast group, for pines, and for other hardwoods was estimated from formulas which relate stem diameter to crown diameter (Spurr, 1966).

Results

The total basal area of live trees of at least four inches diameter at breast height (DBH) is 77.22 sq. ft. per acre. Of this, pine species predominate with a basal area of 43.75 sq. ft. per acre or 56.6 percent of the total basal area. Most of the pines are classified as overstory and they contribute 64 percent to the forest overstory. The understory contains only 38 percent pines indicating the successional shift from predominantly pine types to hardwood forest types. The coefficient of correlation between basal area of trees and percent cover of browse species was calculated to be -.27. A strong negative correlation approaching -1 would be expected if light were a limiting factor on the browse cover. Therefore, it appears that some other factor or

combination of factors such as low soil fertility, water availability, competition with non-browse species or prior range deterioration due to overbrowsing is exerting a limiting effect.

The important mast producing trees in the study area are listed in the Ft. Rucker Woodland Management Plan as dogwood (Cornus florida), hickory (Carya spp.), magnolia (Magnolia spp.), tupelo (Nyssa spp.), and oak (Quercus spp.). Combined they provide 22.50 sq. ft. of basal area per acre or 28.9 percent of the total basal area. Non-mast producing hardwoods provide 11.25 sq. ft. or 14.5 percent of the total basal area. Table 4 shows the composition of the mast producing trees by species, crown position, and vigor. Distinction was made between trees greater than 15 inches DBH and smaller trees since the management plan of the area makes this distinction.

The guide in the Ft. Rucker Woodland Management Plan suggests that 200 sq. ft. of mast producing species per 40 acres (5 sq. ft. per acre), of which 80 sq. ft. per 40 acres (2 sq. ft. per acre) should be composed of trees 15 inches DBH and greater, will provide adequate mast for mast consuming species of wildlife. The study area has an average of 590 sq. ft. per 40 acres (14.75 sq. ft. per acre) and 160 sq. ft. per 40 acres (4 sq. ft. per acre) of mast producing trees in diameter classes 15 inches and larger. The study area has almost three times the advised basal area and over twice as much basal area in the large diameter classes as is recommended as minimal by the current management plan.

Seventy-one percent of the mast producing trees in the sample area are oaks. It is doubtful that the other mast species, hickory (Carya spp.), tupelo (Nyssa spp.), magnolia (Magnolia spp.), and dogwood

TABLE 4. Basal area of mast producing species by crown position vigor.

Group	DOMINANT			CODOMINANT			INTERMEDIATE			SUPPRESSED			Total
	V	T	D	V	T	D	V	T	D	V	T	D	
WATER OAK													
4-14" DBH	.50	1.25	.25	.25	3.25	.50	-	.25	-	-	1.25	-	9.75
15"+ DBH	.25	.75	-	-	.25	-	-	-	-	-	-	-	1.25
WHITE OAK													
4-14"	-	.25	-	-	2.0	-	-	.50	-	-	-	-	2.75
15" +	.50	.75	-	-	-	-	-	-	-	-	-	-	1.25
OTHER OAK SPECIES													
4-14"	-	.75	-	-	.25	-	-	-	-	-	-	-	1.00
15" +	-	-	-	-	-	-	-	-	-	-	-	-	.00
TUPELO SPECIES													
4-14"	.25	-	-	-	-	-	-	.25	-	-	.25	-	.75
15" +	.25	.50	-	.25	-	-	-	-	-	-	-	-	1.00
MAGNOLIA SPECIES													
4-14"	-	.25	-	-	.50	-	-	.75	-	-	.50	1.00	3.00
15" +	.25	.25	-	-	-	-	-	-	-	-	-	-	.50
HICKORY SPECIES													
5-15"	-	.50	-	-	.25	-	-	.25	-	-	-	-	1.00
15 +	-	-	-	-	-	-	-	-	-	-	-	-	.00
DOGWOOD SPECIES													
4-14" +	-	-	-	-	-	-	-	-	-	-	-	.25	.25
15" +	-	-	-	-	-	-	-	-	-	-	-	-	.00

NOTE: V = Vigorous; T = Thrifty; and D = Decadent.

(Cornus spp.) are basic to the deer diet. White-tailed deer stomach content analysis support this opinion (Short et al., 1969). Of the mast producing species, black tupelo (Nyssa sylvatica) apparently has genetic strains common to the Ft. Rucker area that inhibit mast production in a large proportion of seemingly suitable trees (U.S.D.A., 1971). Mockernut hickory (Carya tomentosa) and pignut hickory (Carya ovata) do not reach optimum mast production until 40 to 125 years old and 75 to 200 years old, respectively (U.S.D.A., 1971). Most mast producing trees at Ft. Rucker are between 40 and 50 years of age. Magnolia, which is listed as producing desirable mast for wildlife in the Ft. Rucker management plan is not listed as an important mast producer in the U.S.D.A. Forest Service Handbook, 1971. Dogwood probably does provide palatible mast for deer, but less than 2 percent of the basal area in the sample is attributed to dogwood. Therefore, an estimation of acorn yields by species and DBH for all the oaks sampled compared with the expected consumption of acorns by acorn dependent species of wildlife should give some indication of whether mast requirements are being met in the representative sample.

According to Cushwa et al. (1970) acorns compose 73.5 percent of the white-tailed deer's diet on the Coastal Plains in the fall. A 100 pound deer can be expected to consume 6 to 8 pounds of fresh vegetable material per day (U.S.D.A., 1971). Using the low 6 pound figure, one white-tailed deer would be expected to consume 4.41 pounds of acorns per day during the fall (90 day) period. Ft. Rucker has a density of one deer per 23 acres estimated from the track count taken in July and September, 1973. Therefore, 17.3 pounds of acorns per acre must be

made available for deer consumption to accommodate the existing deer herd. Goodrum (1959) computed pounds of acorns required by wildlife species in Nacogdoches, Texas, all of which are present at Ft. Rucker in similar densities. Using Goodrum's numbers for acorn consumption by wildlife species other than deer, the necessary poundage of sound, fallen acorns per acre is calculated to be 35.37 pounds. Further, Goodrum estimates that 48 percent of all acorns produced are not usable or available to ground feeding wildlife as a result of weevils, fungi, and arboreal feeders. It follows that 52.2 pounds of acorns per acre must be produced to satisfy wildlife needs.

Using tables which correlate the expected yield of fresh and air-dry acorns in pounds with oak species and diameter class (Goodrum, 1959), it is estimated that an average acre in the sample area can potentially produce 51.44 pounds of fresh acorns. This is just under the estimated wildlife demand. Further, it is doubtful that this yield is realized over consecutive years since acorn yields appear to be cyclic and mast rankings from Alabama (Alabama Dept. Cons. and Natural Resources, 1972) rate oaks on a three-point system (0 = no mast to 3 = plentiful) at .97. Consequently, it appears that the Ft. Rucker Wildlife Management Plan's recommendations for basal area of mast producing species, which the sample area exceeded three-fold, should be revised upward before valuable mast producing trees are removed.

There is an adequate acorn supply at Ft. Rucker to provide almost 70 percent of the white-tailed deer's diet during the fall. Acorns, then, are probably an important food source at least during the fall season and their nutritional value merits examination. The gross energy

of acorns is relatively high (5.4 kcal./g.) as compared with common deer browse species (4.4 to 4.6 kcal./g.) and grasses and forbs (3.9 to 4.3 kcal./g.) (Short et al., 1969). The protein content of acorns is only 6 percent (Short et al., 1969), which is below deer maintenance levels. Acorns are clearly deficient in phosphorus (0.1 percent) (King & McClure, 1944). Therefore, it appears that mast generally does not meet nutrient requirements for white-tailed deer.

IX. PINE BROWSE SURVEY

Methods

The forestry section of the land management branch conducted, upon request, a survey which describes the extent of deer browsing to areas planted in shortleaf pine (Pinus echinata) in 1972 and 1973. Trees located on 35 randomly located 100-ft. line transets were examined for deer damage to the 20-acre 1972 planting. Eighty 100-ft. randomly located lines were examined for browse evidence on the 98 acres planted in 1973. The number of trees originally planted was known, and survival was calculated. The percent of surviving trees damaged by deer browsing was also calculated.

Results

Survival in the 1972 planting was 83 percent. Survival in the 1973 planting was 82 percent. The percent mortality due to deer browsing could not be determined. However, 25 percent of the surviving trees from the 1972 planting and 43 percent of the surviving trees from the 1973 planting were damaged by deer. From observation deer do not

browse natural pine reproduction. This is supported by low palatability rankings by Lay (1965) and Goodrum and Reid (1959). The high degree of browsing on the planted pines can then be attributed to increased palatability of the nursery grown seedlings due to increased nitrogen (protein) content. This is based on the well supported hypothesis that deer choose the most nutritious forages (Short, 1971; Swift, 1948). Since Ft. Rucker deer seem to be nutrient limited on an unsupplemented diet of naturally occurring foodstuffs rather than energy (calorie) limited, it is doubtful that a decrease in the deer herd would relieve browse pressure to planted tree crops. The location of the sampled pine plantings seems to support this hypothesis since they occur in the area of lowest deer population density (one deer per 42.1 acres as opposed to the average of one deer per 23.2 acres).

X. DEGREE OF INTERSPERSION OF FOOD AND COVER COMPONENTS

Since the daily range of deer is small, and since they require a great variety of foods (Zeedyk, 1969), quality deer habitat must possess a high interspersion of food and cover components. Among the factors controlling the degree of interspersion are physiography, land use patterns, and forest management practices.

Ft. Rucker lies in an ecotone between shortleaf-loblolly and longleaf-slash pine forest types. Other major forest types present include oak-hickory, scrub oak, and beech-magnolia. It is obvious that conditions exist for extensive vegetational diversity. Clearings of various sizes and shapes are used for emergency landing areas, forestry practices create clear cut areas, and wildlife openings and plantings

are also present. Openings increase diversity and compensate for seasonal and yearly fluctuations in food supply, especially mast (U.S.D.A., 1971). The percentage of open area in each of 45 wildlife compartments was estimated by interpretation of aerial photographs (U.S.D.A., 1969, 1/20,000) combined with ground reconnaissance. Existing vegetation cover maps (Pomeroy-McGavin, 1962) were of some use in the analysis.

The average percentage of open area in each of the compartments was 4.61. The suggested percentage of openings (U.S.D.A., 1971) varies from 2 to 3 percent. The percent of open area in individual compartments varies from 0 to 26. Twenty-six compartments have less than 2 percent clearings. Of the 14 compartments with high percent openings, 7 contain permanent airfields. The average compartment size is just over 2 sq. miles; deer range is approximately 1 sq. mile. This indicates that some deer may not have access to clearings within their home range. Actually the shape and distribution of openings is more important than the size since perimeter (edge effect) is the desired product (McGinnes, 1969). Nevertheless, opening areas in the compartments with few or no existing clearings would increase diversity and thus increase carrying capacity of the deer habitat.

CHAPTER III

THE HERD

I. DESCRIPTION AND HISTORY

During the precolonial period, travelers through the South wrote extensive accounts of the abundance of deer (DuPratz, 1774; Bartram, 1792). The dependence of the Indians and the early settlers on deer is well known. In 1771, the combined export of deer hides from Pensacola, Florida, and Mobile, Alabama, was 250,000 pounds of hides (Strecker, 1927).

During this era, most of the forested areas of the South were virgin wilderness, characterized by mature forest with relatively clean floors and little understory of value to deer (Newsome, 1969). The study area, however, was inhabited by agricultural Indians, primarily Creek tribes, who periodically burned abandoned fields and forested areas (Prunty, 1965). Deer habitat must have remained relatively stable subject only to the effects of natural (lightning) fires, those occasionally set by Indians, and other natural phenomena (Newsome, 1969).

It is likely that deer increased in numbers shortly after the settlers moved in and began creating breaks in the canopy with land clearing activities (Adams, 1960). The settlers, however, sought wildlife as a medium of trade in addition to its use for food and clothing and exploitation began (Newsome, 1969). Unrestricted harvest of wildlife continued until 1907 when laws were passed setting seasons and bag

limits on deer and restricting their kill to bucks only (Allen, 1965). In spite of seasons and bag limits, the deer population continued to decline throughout Alabama (Allen, 1965). In 1908 there were no deer in the Dale-Coffee County region which encompasses Ft. Rucker. Population estimates remained at zero until a restocking program began for the two counties at Ft. Rucker in 1946.

Ten bucks and six does from sanctuaries in Clarke County, Alabama, were released into the study area. In 1953 the warden's estimate of the deer population was 42 and in 1958 the population was estimated to have risen to 340. Buck only hunting was initiated in 1958. The population continued to grow rapidly and in 1967 the population was estimated to be 2,561 deer. Limited doe hunting, by permit only, was initiated at Ft. Rucker in 1967 and has continued with increased doe kills each year. The 1973 population was estimated by a track count at 2,302 deer.

II. DEER HERD APPRAISAL

An evaluation of a deer herd should encompass information on the physical condition of the herd, the population composition, and the rate of change. Data pertaining to the physical condition of the deer herd is usually the easiest to obtain. Such things as live weights, antler form, and amount of tail fat are normally recorded during hunting seasons at designated check-in stations.

III. PHYSICAL CONDITION

Methods

Records of deer killed since 1964 were utilized in determining physical condition of the herd. Live weights were recorded for all harvested bucks since 1964. Random samples of the doe harvest have been weighed since 1967 with the exception of 1971 when no doe weights were recorded.

General conditions based on the amount of tail fat (Leuth, 1965) was also recorded. This method requires a gross inspection and feel of the tail in order to grade the external condition of the animal. Three classes are listed on all kill records in Alabama. They are:

1. Tail boney, each bone felt separately;
2. Some bones felt, fat present: and
3. No bones felt at base of tail.

Antler diameter and number of points, or spike diameter and length, were measured on a random sample of harvested bucks each year. Antler development was correlated with age class of the bucks. Unfortunately only bucks of the 1-1/2 year age class were examined for antler development in some years.

In addition to hunt records, a small sample of the population was sacrificed and intensively studied with respect to condition in March, 1973 by the state wildlife biologist, Francis Leuth. Bone marrow was examined for color and texture (Cheatum, 1949) and for amount of fat (Leuth, personal communication). Amount of kidney fat was determined and rated (Riney, 1955). Inspections of the lungs and digestive tracts were also made.

Results

The average live weights of bucks in each age class for each year over the nine-year study period are shown in Figure 1. Although steps between years are not equal, it is evident that average weights in each age class have been decreasing over the study period. Fluctuations between years may result from yearly differences in weather stress (Short et al., 1969), mast crops (Harlow and Tyson, 1959), and/or intraspecific competition for available resources (Dasmann, 1971). The apparent trend of decreasing weights is indicative of population levels exceeding the optimum carrying capacity.

Leuth (1971) stated that in Alabama, one and one-half year old bucks harvested from areas of low deer populations will average more than 100 pounds. Weights less than 100 pounds indicate that the optimal carrying capacity of the range has been exceeded. The average weight of one and one-half year bucks was 100 pounds in 1964, but has been below 100 pounds in the eight subsequent years. The average one and one-half year buck weight between 1965 and 1972 was 90 pounds. Tables 5 through 12 compare weights by age class of the Ft. Rucker deer to those in other Alabama management areas. Ft. Rucker is shown to be below the Alabama average in buck weights in all years. Doe weights over a five-year period are shown in Figure 2. Weights are low, but do not appear to be decreasing. However, Ft. Rucker weights are below the Alabama average for does in each age class.

The low weights which have prevailed over the study period indicate that the deer herd is out of balance with the available resources of the range. When such a condition exists, the herd will increase

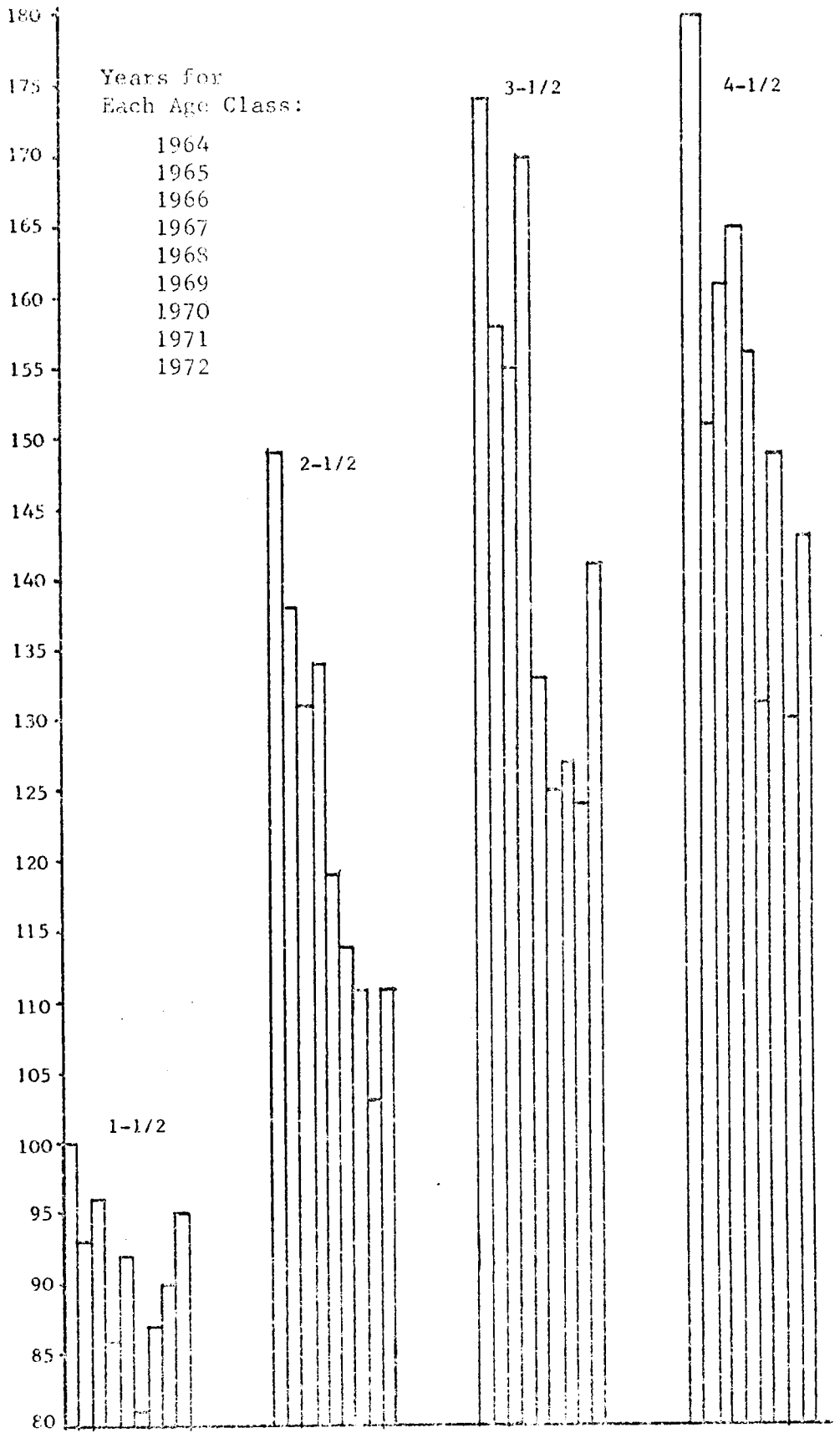


FIGURE 1. Average buck weight by age class.

TABLE 5. Average live weights of deer in each age class, Alabama, 1964-1965.

Area	AGE CLASS				
	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 & +
Ft. Rucker	100	149	174	187	162
Skyline	88	156	183		
Lauderdale	125	127	194		
Thomas	105	132	147	166	175
Black Warrior	112	138	137		
Choccolocco	85	108	121	124	
Oakmulgee	88	105	125	152	175
Wolf Creek					
Barbour Co.	119	138	193	171	
Hollins	83	179			
Coosa	95	136	162	189	175
Butler	102	131		195	
Blue Spring	105	131	183		
Covington	104	144	182		
Scotch	90	115	130	161	183
Rob Boykin	94	110	130	142	157
Totai Mgt. Areas	95	124	138	161	165
GSPC - Pickens	112	142	170	201	218
District 5	106	113	143	156	180

TABLE 6. Average live weights of deer in each age class, Alabama, 1965-1966.

Area	AGE CLASS						
	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2	6-1/2	7-1/2 & +
Ft. Rucker	93	138	158	151	197	168	
Skyline	102	170	175				
Lauderdale	115	133	172	182	206	205	235
Thomas	105	125	160	168	175	198	225
Black Warrior	117	141		180			
Choccolocco	84	117	126	120			
Oakmulgee	86	112	117	133	154	140	142
Wolf Creek			189	181			
Barbour County	108	149	194		184		
Hollins		138	220	160			
Coosa	97	142	162	183	195	180	175
Butler County	111	157	195	194			
Blue Spring	108	136	160	188			
Covington County	121	129					
Scotch	97	112	148	180	182		170
Rob Boykin	99	116	134	131			
Fayette County	126						
Oak Mountain	66						
Westervelt	121	135	149	198			
District 5	99	132	138	153		156	170
Baldwin-Monroe*	85	121	138	141			
Baldwin-Monroe Females	76	89	83	85	84	85	84

*Special Hunter's Choice Season.

TABLE 7. Average live weights of deer in each age class, Alabama, 1966-1967.

Area	AGE CLASS				
	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 & +
Ft. Rucker	96	131	155	161	197
Skyline	115	159	175	187	
Lauderdale	134	147	201	129	182
Thomas	81	102	102	111	115
	108	132	155	180	170
Black Warrior	126	160			
Choccolocco	86	105	124	143	
Oakmulgee	96	115	139	151	
Barbour County	106	163	181	199	193
Hollins	107	131		182	
Coosa	76	88	103	101	
	88	119	144	177	192
Butler County	101	139	190		
Blue Spring	103	121	147	157	
Covington County	100	135			
Scotch	77	107	129	126	162
Rob Boykin	91	114	119	145	144
Westervelt	88	100	94	95	109
	107	133	154	168	
Pioneer	93	131	134	156	179
Marengo GP	78	76		95	94
	90	133			163
District 5	73				95
	99		135	112	
I.P. Lands	68	61	79	75	78
	85		121	136	

TABLE 8. Average live weights of deer in each age class, Alabama, 1967-1968.

Area	MALES					FEMALES				
	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 & +	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 & +
Ft. Rucker	86	134	170	165	180	68	90		94	
Lauderdale	128	147	189	202	202					
Skyline	113	178	194	203						
Black Warrior	130	171	188							
Thomas	110	145	164	202		90	93		90	120
Choccolocco	90	117	129	160	171					106
Wolf Creek	114	150		150						
Cahaba	100									
Oakmulgee	90	122	124	138	148	70	80	88	85	92
Hollins	117	152	165	217						
Coosa	92	128	149	163	180	74	90	96	105	106
Barbour	109	155	178	200	197	94	96	109	105	90
Butler	97	143	177			73	91	95		
Blue Spring	103	140	156							
Covington	98	131	161	185						
Scotch	80	106	128	151	160	67	79	87	91	89
Rob Boykin	86	109	119	121	142	72	84	85	89	97
Westervelt	96	136	130	180	215	87	99	105	109	112
District 5	108	158	172	178		74	96			

TABLE 9. Average live weights of deer examined in each age class, Alabama, 1968-1969.

Area	MALES					FEMALES				
	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2
Ft. Rucker	92.5	119.8	132.9	156.5	165.0	66.8	78.7	93.0	86.3	78.8
Lauderdale	113.1	144.3	164.5	177.0*	211.0*	104.0*				
Skyline	112.5	154.1	177.4	208.0	175.0*					
Thomas	91.7	123.2	154.2	159.6	135.7*	90.0*	84.6		90.0*	93.5
Black Warrior	126.9	176.6	173.0	191.0*						
Choccolocco	81.5	104.3	115.9		189.0*			70.0*	80.0*	95.0*
Little River										
Wolf Creek	95.8	137.5	153.0		164.0*			105.0*		
Oakmulgee	78.4	109.5	127.9	128.5	151.0*			81.5		
Cahaba	116.3	124.5	133.0*		180.0*					
Bollins	112.6	130.6	173.0	150.0*	168.0*			91.0*		
Coosa	83.4	117.1	124.7	168.7	176.0*		92.0			
Barbour	110.2	160.1	186.5	194.6	207.0	81.8	97.9	100.3	83.0	106.2
Butler	98.6	133.5	166.5	180.0	174.5	73.6	85.0	86.3	98.0	94.5
Blue Spring	107.3	139.4	176.2				92.0*	89.0*		
Scotch	74.9	91.7	105.9	121.5	139.5	52.5	62.0	73.2	75.0	72.0
Rob Boykin	92.8	120.8	130.0	128.8	151.6	91.0	72.0	78.0		98.0
District V	93.5	130.2	131.3	162.0	170.0*		104.0*	110.0*		92.0*
American Can	98.0	123.0	132.0	137.0	157.9	73.0	92.0	92.4	83.4	88.5
Gulf States	120.6	134.4	157.4		172.0*					

*Less than three animals.

TABLE 10. Live weights of deer examined in each age class, Alabama, 1969-1970.

Area	MALES					FEMALES				
	1-1/2	2-1/2	3-1/2	4-1/2	5 & -	1-1/2	2-1/2	3-1/2	4-1/2	5 & -
Ft. Rucker	81	114	125	131	160					
Lauderdale	103	136	163	192	172					
Skyline	105	145	185	214	222		91	109		
Black Warrior	110	153	189	189	189					
Thomas	82	114	139	162			86	108	110	
Choccolocco	81	111	137		135	58	86	111		
Little River	117	173	161							
Wolf Creek	110	118	167	164	210					
Lamarion										
Oakmulgee	86	112	124	149	147					
Cahaba	100									
Hollins	100	129	151	146						
Coosa	87	120	143	172	159	76	88	93	107	92
Barbour	107	141	170	173	183	91	92	104	98	95
Kinterbish	87	116	120	159	166					
Butler	95	124	160		171	80	90	88	96	102
Blue Spring	102	136	146							
Scotch	68	106	112	128	150	70				
Bob Boykin	92	117	126	135	161	80				
Ala. Ordinance	92	129	136	162	166	81	94	83	97	98
Westervelt	104	127	152	152						

TABLE 11. Average live weights of deer in each age class, Alabama, 1970-1971.

Area	MALES					FEMALES				
	1-1/2	2-1/2	3-1/2	4-1/2	5 & +	1-1/2	2-1/2	3-1/2	4-1/2	5 & +
Ft. Rucker	87	111	127	149	176	71	80	86	105*	94
Lauderdale	113	144	177	210	216*	103*	105		91*	
Skyline	106	139	161	184	195	93				
Black Warrior	116	150	189	193						
Thomas	102	127	155	160*	206*			87*		
Choccolocco	92	102	143	129*			83	94	86	
Little River	115*	102*	137							
Wolf Creek	106	131	191*	194*	173*					
Oakmulgee	90	116	125	134	127*			70*		
Cahaba	120	164*	164*	180*						
Bailins	112	147	161	192					115*	
Coosa	91	119	143	169	164	95*				
Barbour	112	146	160	196		91	104	102*		100
Kinterbish	93	104	134	156	161	88*		91*		73*
Butler	101	134	141	166*		78	93	93	97	94
Blue Spring	101	129	171	150*						
Covington	100*	135*								
Scotch	71	99	116	123	144	61	77	73	71	78
Rob Boykin	99	111	126	88*		68	80	87	89	98
Ala. Ordinance	99	117	123	142	171*	84	90	87*	88	98
Westervelt	113	139	162							

*Less than three animals.

TABLE 12. Average live weights of deer in each age class, Alabama, 1971-1972

Area	MALES					FEMALES				
	1-1/2	2-1/2	3-1/2	4-1/3	5-1/2 & +	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 & +
Ft. Rucker	90	103	124	130	130					
Lauderdale	121	141	150	189	170*					
Skyline	106	145	174	205	182*					
Black Warrior	121	147	174	197	205*					
Thomas	112	136	146	152	185*					
Chocolocco	90	116	126			60*		75	85	85
Little River	112*									
Wolf Creek	100	136	145	155*	190*					
Lamarion										
Oakmulgee	91	114	132	140		58*	80*	83*	79	86
Cahaba	104	180*	200*	175*	185*				94	
Hollins	107	122	163	188						
Coosa	78	105	126	130	154			85*		
Barbour	107	149	170	200						
Kinterbish	85	121	149	148	148					
Butler	108	130	136	160	165					
Blue Spring	103	123	135	170						
Scotch	80	115	117	144	159					
Rob Boykin	86	121	125	144						
Ala. Ordinance Works	99	133	145	158*		75	85	97	99	98
Westervelt	109	139	163	148						
Marengo	90		152			65		75		
Redstone	117		197*				94*		75*	

*Less than three animals.

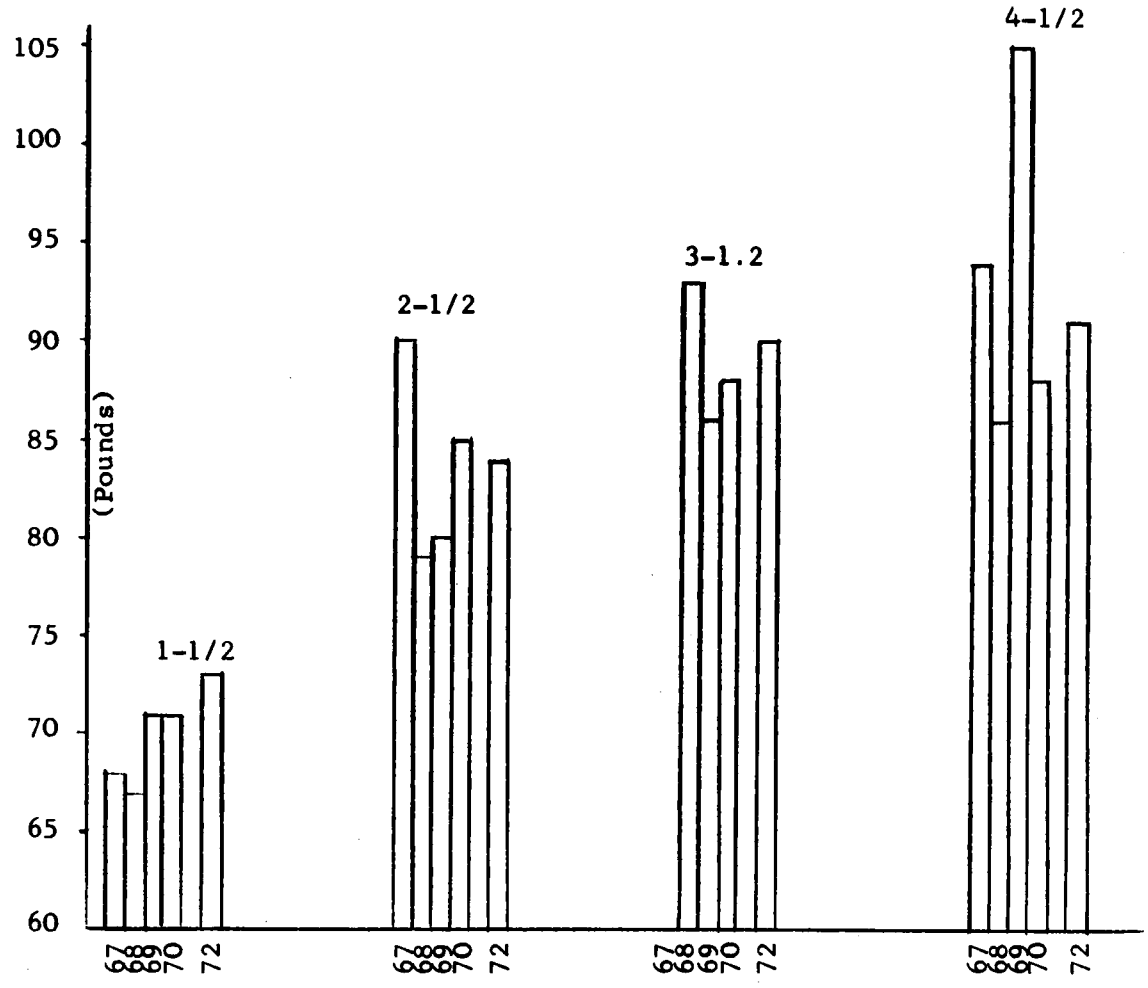


FIGURE 2. Average doe weight by age class.

during a succession of favorable years to a population level much higher than the normal ceiling, only to face severe readjustment when changing conditions result in a rapid drop in maximum carrying capacity. During such adjustment periods, severe range damage may occur (Dasmann, 1971).

The general condition of the Ft. Rucker deer herd, based on the amount of tail fat present, also indicates that the optimal range carrying capacity has been exceeded. A herd at optimum population levels should have a tail fat index of 3. Values less than 3 indicate "poor range" (Leuth, 1972). The average tail fat index of the Ft. Rucker herd consistently ranks below 3 and also below the Alabama average. For example, the Alabama average over all age classes of bucks in 1966 was 2.7. The Ft. Rucker average was 2.3 (Leuth, 1967). However, a comparison of herds throughout the state is of questionable value since breeding seasons differ and bucks tend to loose fat during the rut (Leuth, 1972). Comparison of the same area between years may serve as a gross indicator of population trends since condition is expected to deteriorate as optimum range carrying capacity is exceeded (Dasmann, 1971). The average condition of one and one-half year bucks over five years is shown in Table 13. No significant trend is apparent, but it is obvious that the optimum range carrying capacity was exceeded in all years. Differences between years is probably due to fluctuation of the carrying capacity caused by mast cycles, weather, etc.

Overall doe condition based on tail fat is considerably poorer than buck condition. The 1973 data show average buck condition at 2.6 while doe condition is 1.6. A decided decline in doe condition occurs between the third and fifth years, while condition of bucks improves

TABLE 13. Condition of one and one-half year bucks.

Year	Condition
1963-1964	1.7
1966-1967	1.5
1969-1970	1.7
1970-1971	2.2
1972-1973	1.9

with each year. This may indicate some differences in natural mortality between sexes on an overpopulated range since deer in poor condition are more susceptible to stresses such as parasites, disease, extreme weather, and food shortages (French et al., 1955).

Antler development, form, and size, are governed largely by the quality of food eaten by the buck while his antlers are developing (Cowan & Long, 1962). Antlers develop normally during spring and summer as long as forage is plentiful even though that of the previous winter may have been inadequate (Dasmann, 1971). Genetic or hereditary factors undoubtably have some effect on ultimate antler size (Huxley, 1931) but when poor quality food or limited amounts of good food are consumed, both body stature and weight and antler growth are seriously restricted regardless of the potential. This has been shown by experimental feeding (Severinghaus, 1951), and by field studies (Severinghaus et al., 1950).

The presence of "spike" bucks and adult antlerless males is a direct sign of malnutrition, for a well-fed white-tailed deer normally developes medium-sized antlers with from four to ten points when it

reaches maturity at approximately 18 months of age (French et al., 1955). According to Gwynn (1965) spike yearlings on the best ranges average only about 5 percent of the herd; on average range the percent of spikes is around 30. If spike yearlings make up more than 30 percent of the buck population, there is an imbalance between deer numbers and food supply.

Table 14 shows the percent of the buck harvest that was spikes over an eight year period. In all but one year, 1967, the percent of spikes indicated an imbalance between herd and habitat.

TABLE 14. Percent spikes in harvest.

Year	1964	1965	1966	1967	1968	1969	1970	1971	1972
Percent Spikes	38	-	32	26	35	32	30	35	38

According to Leuth (1972), it is assumed that the healthy one and one-half year old Alabama white-tailed buck will have antlers one-half inch in diameter and older bucks will have antlers one inch in diameter. It is further assumed that all one and one-half year olds should have four points and all older animals should have eight points, though even the one and one-half year age class would have eight points where range and genetics had not altered the situation. The four point figure was chosen to be realistic as the standard. As shown in Table 15, Ft. Rucker deer consistently fall below these criteria.

TABLE 15. Antler development.

Year	Average No. Points Per Age Class					Average Diameter in Inches Per Age Class				
	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 +	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2 +
1964-1965	2.4	6.5	7.4	7.6	5.8	.49	.97	1.23	1.39	-
1969-1970	2.3	-	-	-	-	.43	-	-	-	-
1970-1971	2.4	-	-	-	-	.39	-	-	-	-
1971-1972	2.1	3.7	5.6	6.9	8.0	.41	.58	.92	.95	1.18
1972-1973	2.2	4.5	5.5	6.3	-	.47	.75	.96	1.06	-

The results of the intensive, internal examination by the district wildlife biologist of six deer sacrificed in March, 1973 also indicate that the deer of Ft. Rucker are generally in poor to fair condition. Of the six deer examined, overall internal condition of two was poor, of three was fair, and one was in good condition. It is interesting that the one animal listed in good condition had atrophied ovaries and apparently was sterile. One of the animals listed in poor condition would probably have died of natural causes before the next hunting season according to Leuth (personal communication).

The weights, tail fat indices, antler development, and internal examination all indicate that the Ft. Rucker deer herd is out of balance with the resources. The population composition coupled with the population dynamics of the herd support this conclusion and possibly make reasonable projections as to the future of the herd.

IV. POPULATION COMPOSITION AND DYNAMICS

Methods

In order to determine the population composition, accurate aging techniques are necessary. Since 1953 technicians and wildlife biologists have been aging the deer killed on Alabama management areas (Leuth, 1966), by the jaw-bone technique (Severinghaus, 1949).

It was possible to follow four complete buck cohorts through the kill data from the one and one-half age class, when the cohort first entered the hunting picture, to extinction. Pyramids were constructed based on the number of animals harvested from a cohort at each age class.

Sex ratios were determined by comparing the numbers of bucks and does harvested in "either sex" hunts and road kills. Stalk hunts were used to determine sex ratios from 1967--1969. Deer drives were evaluated for this information from 1970 to 1972. Information from road kills was also used in 1972 to determine sex ratio.

The reproductive rate of the Ft. Rucker deer herd was estimated from sacrificed does examined by the district wildlife biologist in 1972 and 1973. The age, general condition, number of fetuses, estimated date of conception and estimated date of birth were recorded. Some of the fetuses were sexed.

Fawn-doe ratios were determined by comparing the numbers of fawns and does harvested in "either sex hunts." Fawn-doe ratios were also indirectly derived from existing kill data by using Lauckhart's (1950) formula:

$$\frac{\frac{2S}{1-S}}{X} = F$$

where S is the proportion of one and one-half year olds in the kill, X is the doe-buck ratio, and F is the number of fawns per doe.

The population density was determined by track counts taken in October, 1968 by the resident wildlife biologist and in July and September, 1973 by the forestry section. The track count method was considered the only feasible technique that would produce significant results with the limited man power available in 1968. Track counting was repeated in 1973 to maintain comparability in data. The total wildlife area was divided into three sections roughly based on vegetation. A representative road was chosen in each area on the basis of

availability, soil structure, and amount of travel. Each road was dragged on the afternoon prior to the track count. The route was traveled at approximately 8:00 a.m. the following morning and the number of deer tracks across the road was recorded. Three samples were taken in 1968. Six samples were taken in 1973, but two were discarded because unusual weather conditions affected deer movement. The number of tracks was divided by the length of the road to determine tracks per mile of road. This number was converted to acres per deer and the total population of each of the three sections was computed, by dividing acres per deer into the total acreage of the section.

Age-class pyramids were constructed and analyzed according to the method described by Dasmann (1964). These age class structures were used to determine general trends in population.

Survivorship curves based on the percent of the cohort surviving at the beginning of each hunting season were graphed. The 1964 through 1967 survivorship curves are based solely on kill data and do not include fawn survival since it was not possible to make fawn-doe estimates from kill data prior to either sex hunting. The 1968-1971 survivorship curves incorporate fawn survival.

Estimations of total deer population from 1968 through 1973 were made. The population estimate from the 1968 track count was used as a known pre-hunt population. The sex ratio in 1968 was used to divide the total population into buck and doe segments. The number of animals removed by hunting was subtracted. The number of fawns which could be expected to live to the next hunting season was computed from the 1968 fawn-doe ratio. An estimated 15 percent of the adult population was

subtracted to account for natural mortality. Assuming an equal sex ratio among the surviving fawns, half were added to the buck population and half to the doe population. The new total represents an estimate of the next year's population. The average of the sex ratio derived from the above process and the observed sex ratio as computed from kill data were used to readjust the total population between bucks and does. The process was repeated through 1973.

Results

The age structure of the kill is graphed in Figure 3. It is evident that the one and one-half age class had diminished in importance in the kill while the older age classes had increased in importance. Reduction in antler development, which is strongly correlated with nutritional level (French et al., 1955), might cause the age structure of the kill to shift to older age classes as the range carrying capacity is exceeded. This is a probable explanation for the decrease between 1964 and 1967. The 1963, 1964, and 1965 cohorts, which correspond to the one and one-half year age class in the 1965, 1966, and 1967 hunts (Figure 4), illustrate that the one and one-half year age class was not represented fully in the hunt. If equal vulnerability were assumed, an impossible situation, whereby more deer were alive at the end of their second year than at the end of their first year, would exist. From the graphs it is apparent that there is an annual decrease in representation in the hunts between 1964 and 1967. However, since either sex hunts were initiated in 1967, and either sex hunts allow antlerless deer to enter the hunting picture, it is doubtful that a decreased rate

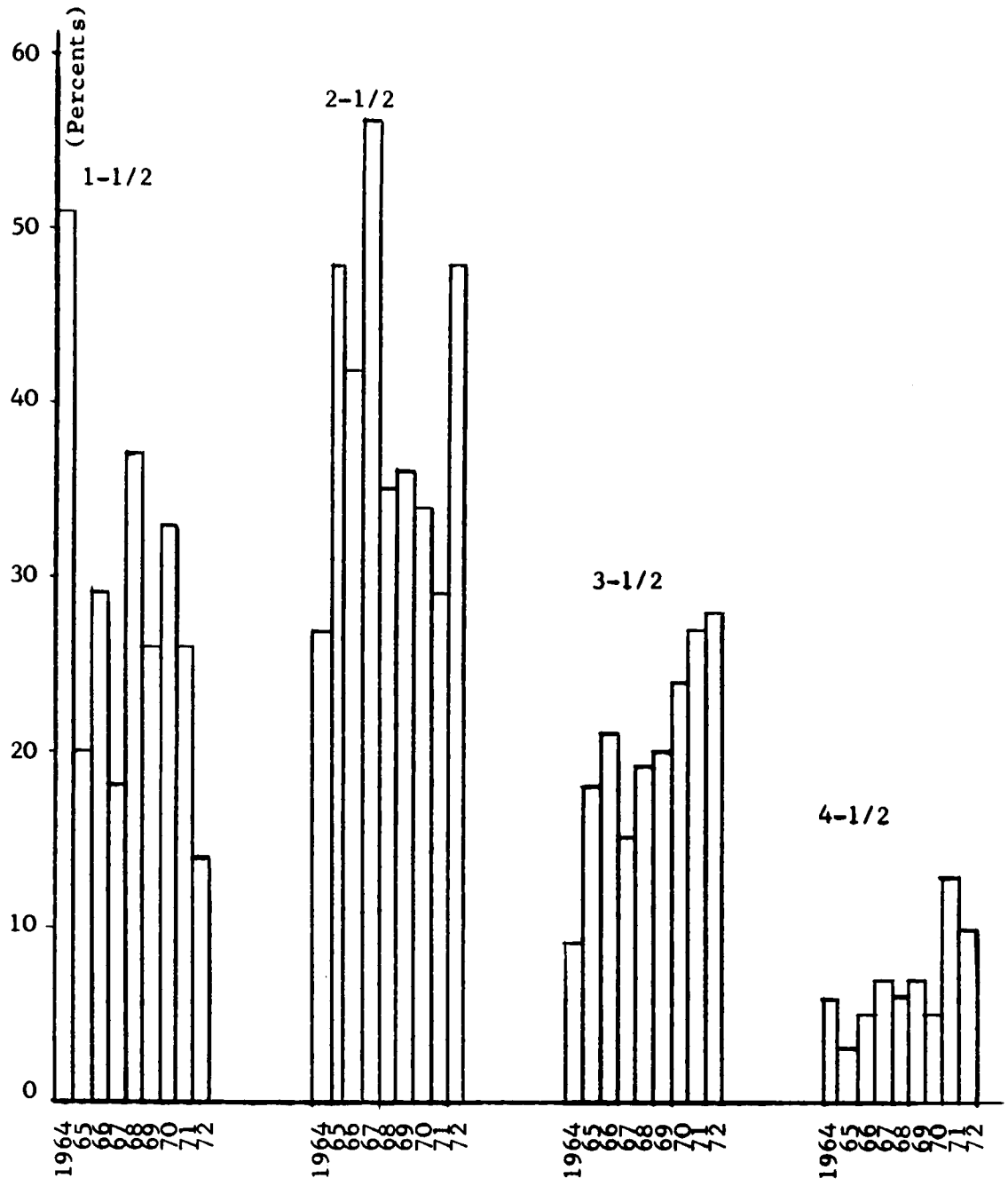


FIGURE 3. Age structure (percent) of the annual buck harvest, 1964-1972.

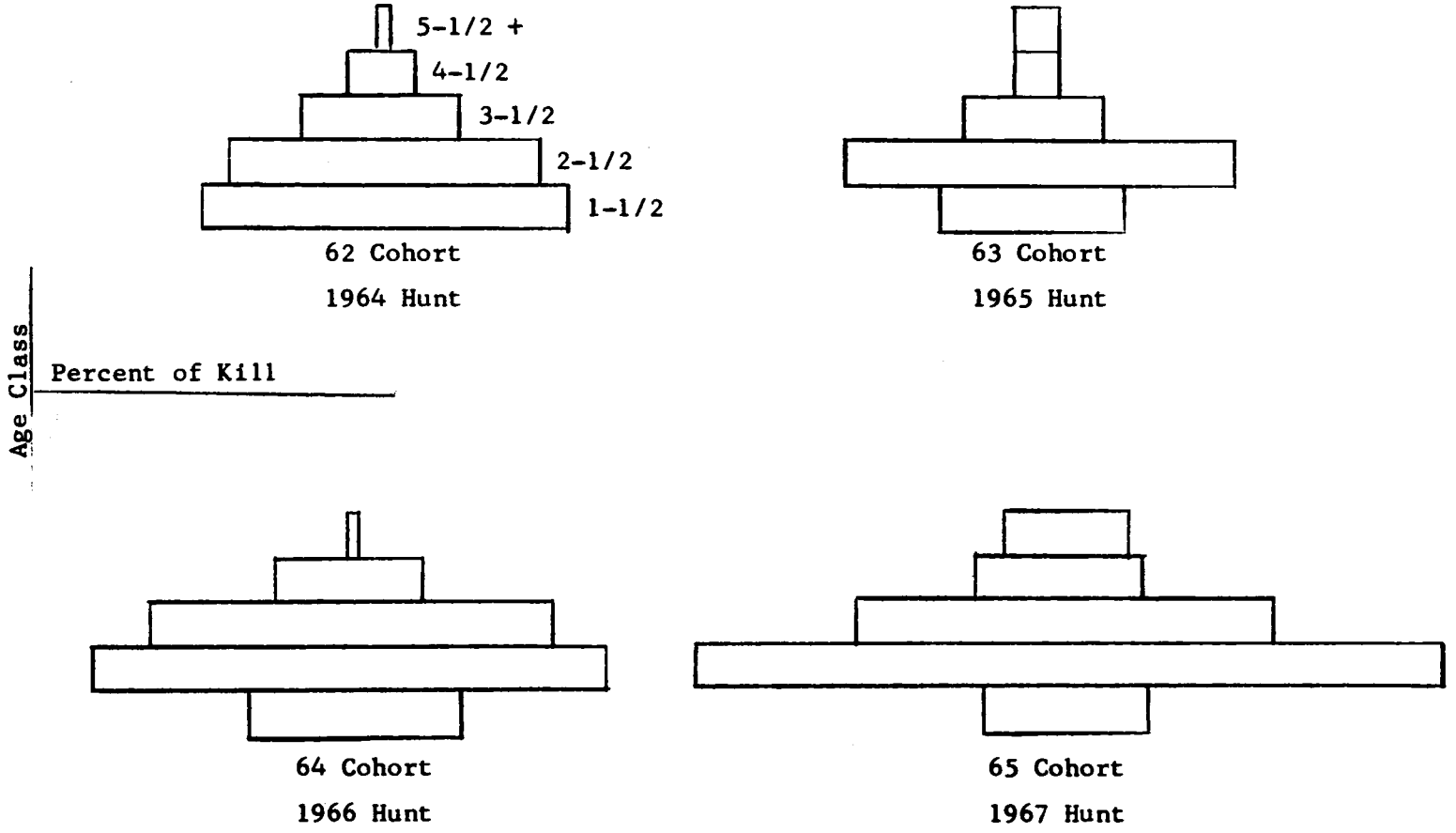


FIGURE 4. Percent of cohorts killed in age classes, 1962-1965.

of antler development is responsible for the shift between 1968 and 1972. It is more likely that a decrease in numbers of fawns surviving to the one and one-half age class has caused the age shift in more recent years. Leuth (1966) states that if less than 50 percent of the kill is in the one and one-half age class, either poor reproduction or low hunter utilization of the herd is indicated. The last year that 50 percent of the kill came from the one and one-half age class was 1964. Utilization of this age class in 1972 was 14 percent (see Figure 3).

The sex ratios as determined by either sex hunts are shown in Table 16. Hunter preference for bucks may affect the sex ratio to an appreciable extent, especially when data are gathered from stalk hunts. Hunter preference is less likely to be expressed in deer drives, but may influence results (Taylor, 1956). Road kill data also are likely to overestimate the contribution of bucks to the population since bucks are generally more mobile than does, especially during the rut. The sex ratios from all sources indicate that the herd is composed of more does than bucks. The drive data are probably the most reliable of the available methods to determine sex ratio.

The reproductive rate of the herd was determined to be 1.2 fawns per doe. According to Leuth (1968), production per adult doe varies in Alabama from 1.1 to 2.0 depending upon the range conditions. Though the number of does sacrificed for the reproductive studies was small, the results in Table 17 are in general agreement with the findings of other reproductive studies in the state (Leuth, 1966, 1967, 1968).

TABLE 16. Buck:doe ratio.

Year	Either Sex Hunts	Road Kill
STALK		
1967-1968	45.4:100	
1968-1969	66.6:100	
1969-1970	58.8:100	
DRIVE		
1970-1971	--	
1971-1972	36.3:100	
1972-1973	50:100	87.7:100

TABLE 17. Results of studies on reproduction.

Date Killed	Age	Condition	Fetus No.	Sex	Conceived	Birth	Age Fetus
5/16/72	6-1/2	Poor	1	M	Feb. 7	Aug. 28	14 weeks
6/28/72	2-1/2	Poor	1	F	Feb. 14	Sept. 4	19 weeks
7/24/72	2-1/2	Poor	1	F	Feb. 1	Aug. 21	25 weeks
7/24/72	2-1/2	Fair	1	M	Feb. 14	Sept. 4	23 weeks
3/13/72	5-1/2	Fair	2		Feb. 16	Sept. 4	7 weeks
3/13/73	5-1/2	Poor	2		Jan. 27	Aug. 15	6 weeks
3/13/73	6-1/2	Fair	1		Feb. 6	Aug. 25	5 weeks
3/13/73	4-1/2	Fair	Ovaries atrophied; no egg production				

Fawn-doe ratios obtained from kill data during either sex hunts and derived indirectly from Lauckhart's formula are shown in Table 18. The low fawn-doe ratios taken directly from either sex hunts reflect hunter selection for larger animals. By using Lauckhart's formula, which substitutes the percent of kill in the one and one-half age class for the percent of animals that survived in the previous year's fawn crop, hunter selection is avoided. As expected, the number of fawns per doe increases. Although the ratios differ by the two methods, the trends of decreasing or increasing ratios of fawns per doe are consistent. The ratios derived from Lauckhart's formula are probably close to the actual ratios. In any case, it appears that the number of fawns surviving to the first hunt is extremely low.

It is generally thought that fawn-doe ratios on good range average a little over 1:1 (Dasmann, 1971; Taylor, 1956). However, it is also thought that dietary deficiencies limit deer numbers by increasing fawn mortality (Short et al., 1969; Cook & White, 1971). High temperatures, common to the Ft. Rucker area, can directly affect the survival of fawns (Short et al., 1969). Range deterioration, which is generally caused by overpopulations of deer, may cause fawn mortality to become so high that the population actually stabilizes or declines (Murphy & Coates, 1966). On overpopulated deer ranges in south Texas, a loss of over half of the annual fawn crop during the first summer of life is not uncommon (Cook, 1971). Harlow and Tyson (1959) found statistically significant correlations between the annual scrub acorn crop and the numbers of one and one-half year bucks harvested in central Florida. The relationship between fawn mortality and nutrition was further explored

TABLE 18. Fawn:doe ratio.

Year	Either Sex Hunts	$\frac{2S}{1-S}$ X
STALK HUNT		
1967-1968	22.5:100	53:100
1968-1969	15.3:100	47:100
1969-1970	32.4:100	58:100
DRIVE HUNT		
1970-1971	29.8:100	40:100*
1971-1972	34.0:100	24:100
1972-1973	20.6:100	16:100

*Assuming 50:100 buck:doe ratio.

by Verme (1962). Verme found that as the prenatal protein content in the diet of does decreased, the size of offspring decreased and the mortality rates increased sharply. Verme reports fawn mortality rates as high as 93 percent among offspring of malnourished does.

Although the reproductive rate has been shown to drop at high deer densities (Severinghaus, 1951), the effect of environment on the rate of reproduction requires longer to manifest itself than the effect of environment on physical condition, stamina, and resistance to disease (Adams, 1960). By holding the reproductive rate constant it is possible to determine the fawn mortality from the fawn-doe ratio. The fawn mortality at Ft. Rucker in 1967 was 55 percent. In 1972 it had risen to 87 percent. Slight fluctuation in mortality between years could be attributed to a particularly unfavorable year, but steady increases in mortality over time indicate overpopulation and range deterioration. The fawn-doe ratio serves as one more indication that the deer herd at Ft. Rucker has outstripped its habitat potentialities. It also indicates that natural processes, such as fawn mortality, are limiting the population rather than hunting.

The number of deer in the Ft. Rucker herd was estimated by the track count method in 1968 and 1973. The reservation was divided into three wildlife compartments and the deer density was determined for each area. The results are shown in Table 19. Although most wildlife biologists agree that population trends can be determined by track counts (Downing, 1965b), the method as a census technique has been questioned (Taylor, 1956). Tyson's (1959) work in northwest Florida indicates a nearly 1:1 relationship between deer crossings of a mile strip and the

TABLE 19. Results of 1968 and 1973 track counts.

Unit	1968 Density	1968 Population	1973 Density	1973 Population
Unit I	1/25.6	934	1/21.6	1,113
Unit II	1/14.8	1,294	1/20.2	947
Unit III	1/32	318	1/42.1	242
TOTAL	1/20.9	2,546	1/23.18	2,302

number of deer inhabiting the adjacent square mile. The physiography and vegetation of the Ft. Rucker area are quite similar to those of northwest Florida. The overall densities derived from the Ft. Rucker track counts also seem reasonable. Leuth (personal communication) stated that most of Alabama can optimally support one deer on 30 acres. The U.S.F.S. (1971) suggests optimum carrying capacity as one deer per 20-45 acres in shortleaf-loblolly pines, one deer per 55-70 acres in longleaf-slash pine types, and one deer per 10-35 acres in oak-hickory types. The majority of Ft. Rucker is composed of these types.

The track counts taken at Ft. Rucker indicate that deer densities have decreased since 1968. The track counts also indicate that a shift in population from units II and III to unit I has occurred. This can be attributed, in part, to hunting pressure. Unit I contains a refuge in the form of a military weapons range which encompasses 875 of the 10,193 acres in the compartment. The range is always restricted to hunters and also provides excellent wildlife openings. Unit III consistently has the highest hunting pressure and it is noted that the greatest

density shift, from one deer to 42.1 acres to one deer to 32 acres, occurred in this area.

Unfortunately with only two censuses it is impossible to determine directly what population changes did take place. This information was finessed from age pyramids, survivorship curves, and life equations.

Age pyramids, based on the percent of kill by age class, are shown in Figure 5. The 1964-1967 hunts are not representative of the actual population dynamics due to unequal representation of the one and one-half age class, as previously mentioned. The 1968-1972 hunts are more indicative of the population dynamics since doe hunting increased the vulnerability of the one and one-half year age class to the hunt. The one and one-half year age class is probably still slightly underrepresented. The pyramids between 1968 and 1972 indicate a relatively stable population. The 1972-1973 pyramid indicates a rapidly declining population.

The survivorship curves, shown in Figure 6, indicate a trend from Type I to Type II curves. This corresponds to an increased rate of mortality among the younger age classes.

The total population, estimated from life equations and kill data (Table 20) shows a stable population (1967-1968) followed by a slight increase in 1970. There was a decline in 1971, followed by a year of stability, and then an extreme decrease. The trends roughly correspond with those arrived at through observation of the age class pyramids. The final 1972-1973 population estimate is within a 5 percent standard deviation of the 1973 track count.

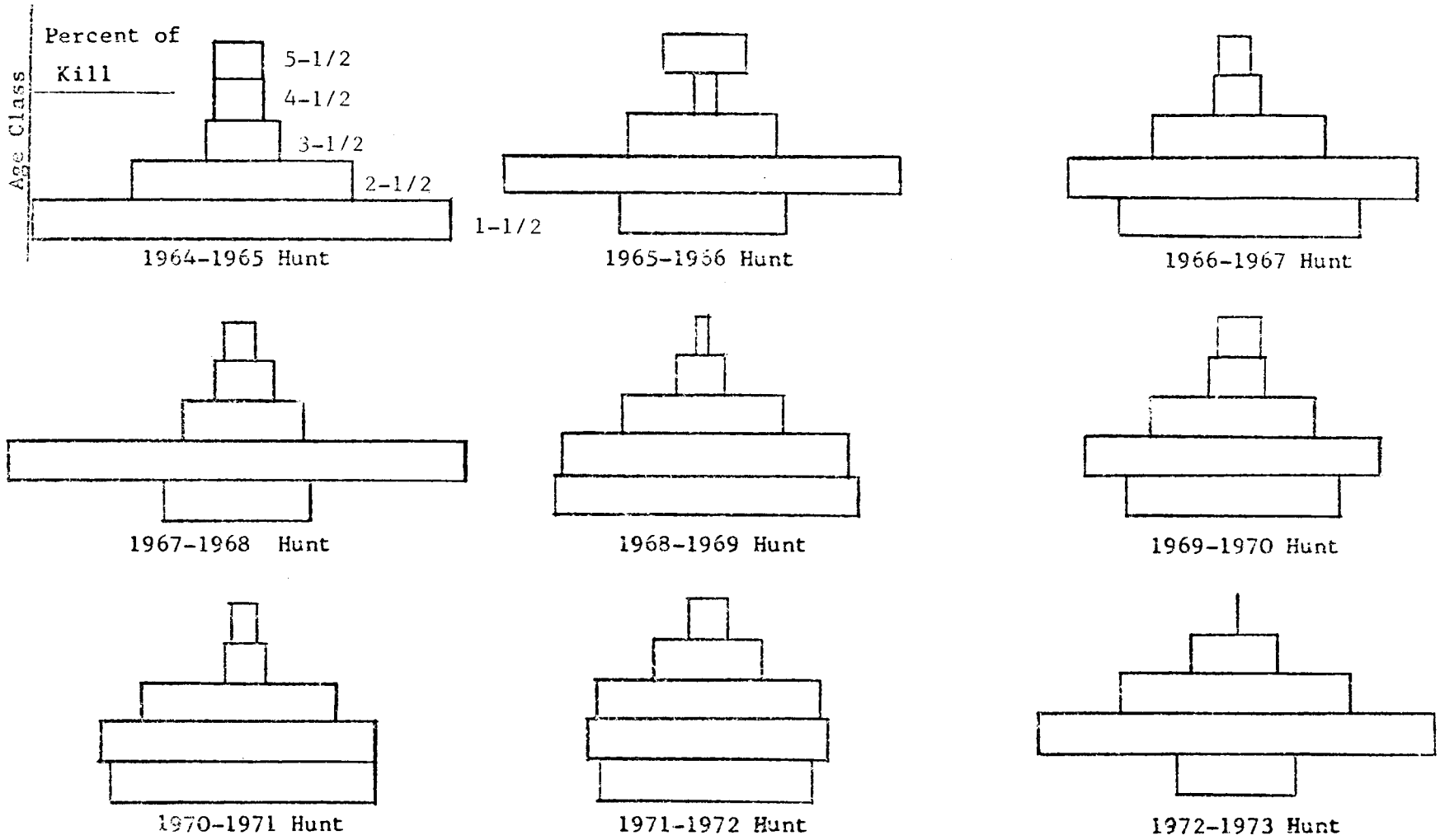


FIGURE 5. Age pyramids for the Ft. Rucker white-tailed deer herd, 1964-1972.

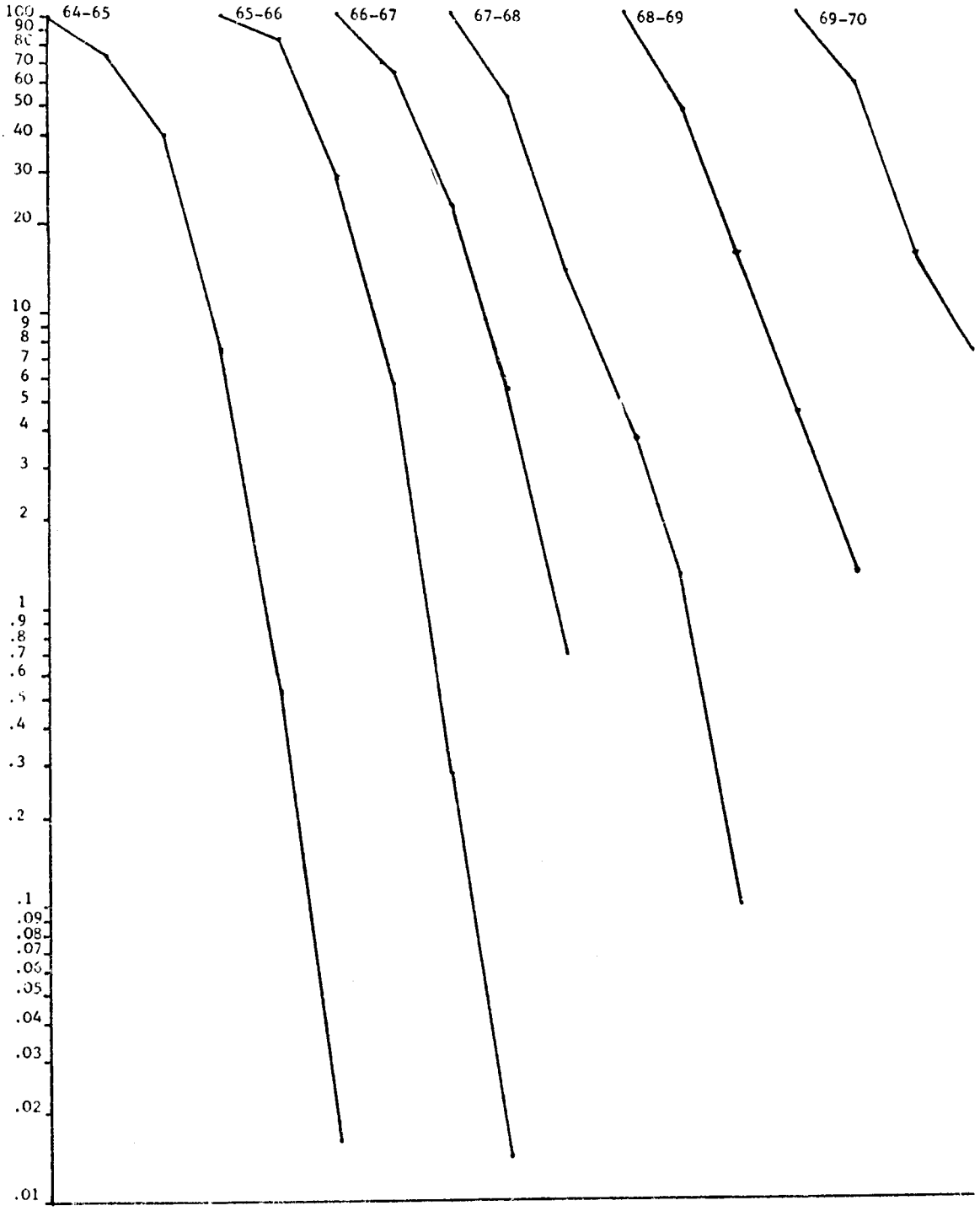


FIGURE 6. Survivorship curves for the Ft. Rucker white-tailed deer herd, 1967 - 1972.

TABLE 20. Population estimates by life equations.

	Total	Bucks	Does	Fawns	Buck:Doe	Fawn:Doe
1968 Count	2546	1018	1528	681	66:100	47:100
Loss by Hunt		-225	- 78			
15% Natural Loss		-118	-217			
Add Fawns by Sex		+340	+340			
TOTAL	2588	1015	1645			
1969 Count	2588	890	1780	1032	50:100	58:100
Loss by Hunt		-248	- 77			
15% Natural Loss		- 96	-225			
Add Fawns by Sex		+516	+516			
TOTAL	3048	1062	1964			
1970 Count	3048	1062	1964	737	33:100	40:100
Loss by Hunt		-470	-121			
Loss by Natural Causes		- 89	-276			
Add Fawns by Sex		+368	+368			
TOTAL	2806	871	1935			
1971 Count	2806	804	2439	550	33:100	24:100
Loss by Hunt		-328	-146			
15% Natural Loss		-71	-343			
Add Fawns by Sex		+225	+225			
TOTAL	2805	630	2175			
1972 Count	2805	757	2048	284	37:100	16:100
Loss by Hunt		-301	-272			
15% Natural Loss		- 77	-200			
Add Fawns by Sex		+160	+160			
TOTAL	2182	530	1652			
1973 TRACK COUNT	2302					

CHAPTER IV

CONCLUSIONS

1. Ft. Rucker soils are low in fertility and organic matter and contribute to low productivity of all vegetation and low nutritional quality of deer food plants.

2. The early fall dry period which retards forage growth and compounds low nutritive values coincides with fawning. Fawn survival may, then, be adversely affected by the period of fawning.

3. Water quality and availability do not present a deer management problem at Ft. Rucker.

4. Indications of range deterioration derived from the browse survey include: low total percent cover of browse species, low utilization of most of the available deer browse species, rarity of preferred browse plants.

5. Deer preference for browse species usually correlates positively with protein content.

6. The available deer browse plants are low in both protein and phosphorous.

7. Light levels reaching browse species is not a limiting factor to browse production at Ft. Rucker.

8. There is not enough mast produced for optimal utilization by all wildlife species present at Ft. Rucker each year.

9. Acorns generally do not meet minimal nutrient requirements for white-tailed deer.

10. A decrease in the deer herd will not eliminate pine damage from deer browsing until the deer range quality is improved.

11. Some compartments have less than 2 percent open area. Wildlife habitat could temporarily be improved by creating openings in these areas.

12. Indications that the Ft. Rucker deer herd is out of balance with the resources and is consequently malnourished include: decreasing average weights over the nine year study period, weights consistently below the Alabama average, poor condition based on internal examinations and tail fat index, high percent of spike bucks in the harvest, antler diameter and number of points below the criteria for a healthy herd in Alabama.

13. A sexual difference in natural mortality is suggested from differences in doe and buck conditions.

14. A decreased rate of fawn survival is evident.

15. A shift in deer densities to areas of low hunting pressure has occurred since 1968.

16. The population expanded and stabilized prior to 1971. The population declined in 1971 and 1972 due to decreased fawn survival.

17. Maximum annual harvest of deer can be obtained by keeping the population below the maximum carrying capacity of the range.

18. The deer of Ft. Rucker should be managed for early-age harvest.

19. A decrease in deer numbers to a level below the carrying capacity of the range combined with habitat improvement should improve deer herd quality and maximize yield of flesh per unit of forage.

20. Many methods of manipulating habitat to improve range carrying capacity are ephemeral. Without proper harvest, man's habitat improvements only hasten the natural cycle of overpopulation, range deterioration, and starvation.

CHAPTER V

NON-AXIOMATIC EXTENSIONS

Deer habitat quality at Ft. Rucker is most severely limited by inherent soil fertility and the abundance, variety, and quality of palatable forage as described in Chapter II. It is likely that range deterioration, caused by overpopulations of deer, has occurred. This is evidenced by low percent cover of high preference browse plants. However, the low utilization of the available browse species indicates that the quality of the deer foods is so low that deer die-offs will occur before any plant species are totally eliminated from the range.

It is logical to expect that no plants will be totally eliminated by deer since deer have occupied the North American continent since the middle Miocene (Taylor, 1956). For several million years deer and the environment have evolved together. Therefore it is likely that species of plants which were not able to withstand the impact of deer browsing disappeared long ago from the deer range. Gone, too, are those forms of the deer family that could not accommodate in some way to changes in the environment. In the long span of time, it probably matters very little if a deer population damages its range and goes into a prolonged decline. The ability of both the deer and the habitat to recover is there.

It has been observed that man likes to maintain optimum-sized populations of the things which provide him either esthetic enjoyment or creature comforts. Unfortunately man is seldom able to agree on

what constitutes an optimum population, how to arrive at it, or how to maintain it once achieved.

Leopold (1933) defined game management as "the art of making land produce sustained annual crops of wild game for recreational use." In Leopold's paper (1933), optimum yield is defined as the sustained, maximum number of animals that can be harvested annually. Unfortunately, it appears that either wildlife managers have failed to develop a full understanding and appreciation for wildlife population dynamics and yield relations, or existing legislation and putlic opinion have made the task of keeping populations from exceeding optimum carrying capacity impossible.

Literally hundreds of deer starve to death annually in over-populated areas of the United States and the lack of sufficient nutritious food in many other places has caused widespread malnutrition (Taylor, 1956). This is thought to be the case at Ft. Rucker where dietary deficiencies probably limit deer numbers as well as weights. Over-population has depleted preferred browse species and the resultant nutritional deficiencies appear to be the essential cause for drastic decreases in the reproductive capacity of the herd. Fawn mortality, due to small size at birth and failure of the does to lactate, seems to be the factor which is stabilizing or reducing population levels at Ft. Rucker. Thus, the Ft. Rucker deer herd is not density dependent, but rather is controlled by the productivity of the range. The productivity of the range is, in turn, negatively affected by high deer population levels. The outcome of the above circularity is that the deer herd becomes self-limiting, to some extent, after an overpopulation has developed.

A series of unusually good seasons, however, could cause this indirect population control mechanism to malfunction with a resultant final rise to an eruptive peak.

The principal management implication of the optimum-yield concept is that maximum annual production of young deer can be obtained by keeping population densities below the maximum range carrying capacity. If maximum annual harvest is the management goal, manipulation of the population to achieve maximum turnover rate should take precedent over manipulation of the population to achieve maximum size. This may better be explained in terms of energetics.

Energy requirements of deer vary according to age, sex, weight, and production status. The energy required by a 45 kg. lactating doe may be about the same as that required to maintain a 60 kg. buck in winter or that required by a growing 20 kg. fawn (Short, 1972). Thus, herds composed of different sex, age, or production classes may consume similar amounts of energy but represent totally different biomasses. Similar amounts of energy may produce different biomasses as a result of differing range conditions. Nutrient deficiencies, low digestibility, and high fiber content of deer foods reduce the conversion efficiency by deer. A doe on a high quality range will produce about 70 percent more viable young during an eight year lifespan than would her counterpart on poor range, if a conservative 30 percent greater fawn mortality on the depauperate site is assumed. Does from the two ranges would consume similar amounts of gross energy. Therefore, efficiency of utilization expressed as caloric intake per viable fawn is much superior on quality range.

Habitat quality at Ft. Rucker is limited both by low soil fertility and range deterioration due to overgrazing. Sufficient gross energy is available for deer, but seasonal deficiencies in protein and essential minerals make it virtually impossible to produce deer of excellent quality. Managing for late harvest or trophy animals should not be considered on such habitats (Short, 1972).

Management of the deer herd by regulating its sex-age configuration will affect the efficiency with which the gross energy present in the plant community is utilized. Where sport hunting is a management objective, deer herds should be managed for early-age harvest. This form of management maximizes the return in deer numbers and pounds of flesh per unit of forage consumed.

A decrease in the herd size at Ft. Rucker would be the first step toward managing the herd for optimum yield. If a density of one deer per 30 acres is assumed as the carrying capacity of the range, Ft. Rucker can support 1,775 deer. The present population, as discussed in Chapter III, is approximately 2,300 deer. If the fawn mortality remains high, which is likely to happen for several years unless habitat improvements are made, it will take approximately three consecutive hunting seasons with doe kills of about 300 and buck kills equaling doe kills to reduce the population to the carrying capacity of the range. If habitat improvements are made, it is likely that fawn survival will increase and more does will need to be harvested each year to decrease the herd to carrying capacity. A continued controlled harvest of does should also reduce fawn mortality. Once carrying capacity is reached and fawn mortality decreased, a harvest of approximately 1/4 to 1/3 of

the total population, evenly distributed between sexes, should maintain the population level. As the deer range recovers, the condition and size of animals will improve. It is estimated that it will take one complete forest cutting cycle to bring the deer back to the size that they were prior to the overpopulation (Leuth, 1969).

A combination of decreasing the deer herd and rebuilding the quality of the habitat would probably be the best action to take in improving deer herd quality.

Methods for increasing deer habitat quality include timber overstory and understory manipulation by cutting practices (Stransky & Halls, 1967, 1968; Shaw & Ripley, 1965; Schuster & Halls, 1963; Schuster, 1967; Cromer & Smith, 1968), manipulation of wildlife openings by altering the size and shape of cut areas (Harlow & Downing, 1969; Halls & Alcaniz, 1968), site preparation techniques (Beckwith, 1967), prescribed burning (Lay, 1957), and fertilization (Duncan & Hylton, 1968).

It must be remembered that manipulation of habitat by man is, at best, a temporary thing. If man improves habitat he should expect a corresponding rise in deer numbers and be ready to harvest the excess animals. Otherwise he will only hasten the natural cycle of overpopulation, range deterioration, and starvation.

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