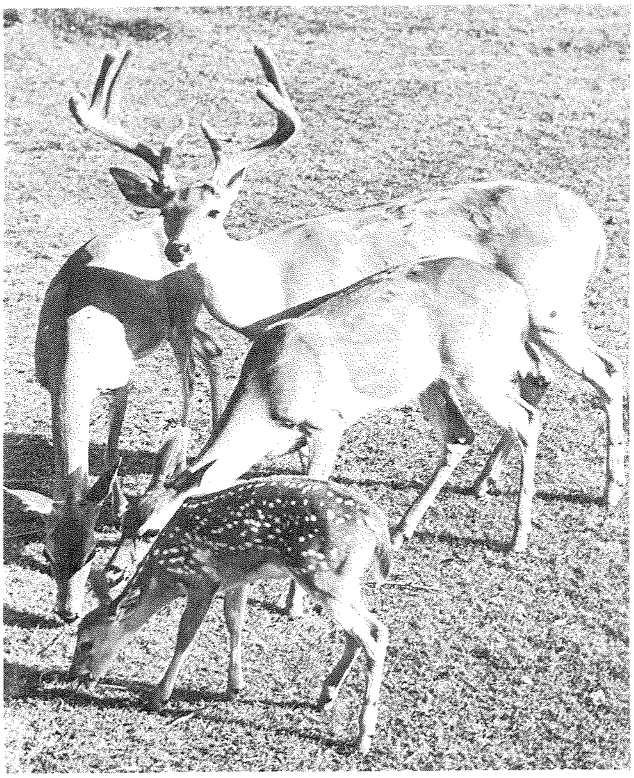

White-Tailed Deer in the Southern Forest Habitat

Proceedings of a Symposium

at

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Foreword

White-tailed deer were once nearly exterminated in the South. In the past several decades, however, improvements in game management and changes in land use patterns have enabled populations to recover. The deer today are more numerous than at any time since white men settled the country.

Deer are highly valued by the public. They are heavily hunted by sportsmen, admired by nature enthusiasts, and desired by some landowners as a possible source of additional income.

Yet to many persons the deer are less than a blessing. They sometimes severely damage farm crops and young trees. They are possible transmitters of disease. They often compete with other wild animals or livestock for food. They create difficulties in resource allocation and management. These problems become more complicated as human populations expand and as competition for land use intensifies.

The potential values of deer, however, outweigh the undesirable characteristics, but enlightened management is necessary if these values are to be achieved fully. The symposium was organized to consolidate known information and to offer a means of expressing new ideas and philosophy pertinent to management of white-tailed deer in southern forests. Persons from Federal agencies, State conservation departments, universities, and private industry were asked to contribute their knowledge and viewpoints. Speakers emphasized the background, characteristics, and management of deer and their habitat. Of special importance were papers concerning the outlook for deer as influenced by sociological, economic, and political factors.

It is believed that the information presented here represents the most complete compendium now available on the southern white-tailed deer.

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History of Deer and Their Habitat in the South

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The history of deer and their habitat in the South is separated into four periods: Precolonial, Exploitation, Recovery, and Today.

In the Precolonial Period deer populations and their habitat remained relatively stable over long periods of time even though deer were widely used for food, clothing, and tools by the Indians.

Exploitation through settlement and clearing of land, market hunting for meat and hides and hunting without restrictions throughout the year reduced deer populations to an alltime low in the South about 1920.

Recovery was initiated by the establishment of National Forest Preserves in the early 1900's. It progressed through the establishment and enforcement of hunting regulations, reversion of farmland to forests and Federal Aid to Wildlife Restoration restocking programs.

Currently, approximately 90 percent of the land area in the South is open to deer hunting, and the annual kill exceeds 300,000 deer.

ACKNOWLEDGMENT

I am indebted to the following persons for providing some of the information used in this paper: Charles Kelley, Alabama; Gene Rush, Arkansas; Gordon Spratt, Florida; Hubert Handy, Georgia; Fred Hardy, Kentucky; Bill Turcotte, Mississippi; Frank Barick, North Carolina; Frank Nelson, South Carolina; Roy Anderson, Tennessee; and Dick Cross, Virginia.

The white-tailed deer *(Odocoileus virginianus)* is the big game animal in the Southern United States.

Writings of early travelers through the South are replete with accounts of the abundance of deer (Du-Pratz 1774; Bartram 1792). The dependence of early settlers on the white-tailed deer for food and clothing is well known. During certain times the settlers depended heavily on the meat and skins of deer as items of trade. Through some of these records we are able to obtain information on the relative abundance of deer during the period of colonization of the South. For instance, Young (1956) reports that 2,601,152 pounds of deerskin from about 600,000 deer were shipped from Savannah (Georgia) from 1755 to 1773, and in 1 year, 1753, 30,000 deerskins were exported from the colony of North Carolina. Harlow and Jones (1965) report as follows: "The trade was lighter from St. Augustine (Florida), where in 1771 only 4,000 pounds of hides were traded, than from Pensacola (Florida) where during the same year the combined export from Pensacola and Mobile (Alabama) was 250,000 pounds of hides. The annual export from Charles Town (South Carolina) between 1739 and 1762 was from 131,000 pounds to 355,000 pounds and from Georgia between 1765 and 1773 was more than 200,000 pounds." George Barnard is reported to have shipped not less than 75,000 deerskins from near the present site of Waco, Texas, between 1844 and 1853, and at his death in 1883 was one of the wealthiest men in Texas, having gained his wealth from trade in deer and other animal skins (Strecker 1927).

Most of these records refer to the middle and late 18th century. I have not been able to establish the precise period during which a general decline in deer populations occurred throughout the South. It is assumed that the initial decline in numbers occurred first in the eastern seaboard States and progressed westward with colonization and subsequent exploitation. This pattern of decline is probably reflected by the dates when game laws were first established by the various States: Virginia, 1699; Maryland, 1730; North Carolina, 1738; South Carolina, 1755; Georgia, 1790; Mississippi, 1803; Alabama, 1822; Florida, 1828; Louisiana, 1857; Texas, 1860; Kentucky, 1861; Tennessee, 1870; and Arkansas, 1875. The South was obviously a land of plenty, insofar as deer were concerned, until the middle of the 19th century.

The chronology of evolution of deer and their habitat in the South can best be described in stages. For my discussion, I will utilize the following: Stage I—The Precolonial Period; Stage II—Exploitation; Stage III—Recovery; and Stage IV—Today.

THE PRECOLONIAL PERIOD

When we think of wildlife habitat in the South at the time of discovery and initial settlement by white men, we are prone to visualize a pristine wilderness. Obviously, most of the forested areas of the South were virgin wilderness, characterized by mature forests with relatively clean floors and little understory of value to deer. However, even at that early date in our history the Indians were practicing habitat management of a somewhat crude form by maintaining rather large openings in the forest by the use of fire (Prunty 1965). Deer habitat in this stage must have remained relatively stable over long periods of time subject only to the effects of natural (lightning) fires and those occasionally set by Indians, and other natural phenomena. In the absence of authentic records, I would guess that the three broad forest types would have rated as deer habitat in the following order: pine hardwoods, bottom-land hardwoods and longleaf pine lands. None of these habitat types should have been as productive as they are today.

The use of deer by the Indians for food, clothing, and tools has been well authenticated. From this we can

[1] This paper is a contribution of the Louisiana Cooperative Wildlife Research Unit; Louisiana State University, Louisiana Wild Life and Fisheries Commission, The Wildlife Management Institute and U. S. Bureau of Sport Fisheries and Wildlife Cooperating.

safely assume that deer were widespread and fairly abundant throughout the South during this period.

EXPLOITATION

The American Indian was apparently a much wiser conservationist, or game manager, than the white man who succeeded him. In general, the Indian took from the land only that which was needed to sustain him. There are exceptions, but the mere fact that the white man found such an abundance of natural resources when he arrived bears out this contention.

Exploitation of southern deer and their habitat must have started soon after the first settler set foot upon southern soil. The settlers immediately started to clear the forests so they could grow their crops, and unlike the Indians, sought wildlife as a medium of trade in addition to its use for food and clothing. The white-tailed deer was one of the most sought after species.

The unrestricted harvest of wildlife continued in the South until the mid 19th century. At this time the enactment of game laws became a part of the deer management picture in the South. But in spite of this, exploitation of the species continued. It appears that relatively unrestricted deer hunting continued in the South until about 1915-1920. In all cases restrictive laws were poorly enforced, or not at all.

According to the United States Census of Agriculture, there are approximately 332 million acres of land in the 12 States covered in this discussion. By 1850 there were 496,892 farms involving a total of 162,011,497 acres of land in agricultural production. By 1920 there were 2,481,101 farms operating 193,629,309 acres of land. The production of both softwood and hardwood lumber shows similar trends. Total lumber production in 1869 was 1,624,843,000 board feet; in 1920, it was 15,086,372,000 board feet (Steer 1948). At this time the agrarian culture of the South was approaching its peak, and it was characterized by high rural and low urban human populations with generally low financial status.

This unrelenting pressure from the white man had a telling effect on the white-tailed deer in the South. In many areas deer were completely exterminated by the practice of hunting with dogs all year long and killing all deer regardless of sex or age. By about 1920, the white-tail reached the alltime low point in its population (Barick 1951). It had been reduced to scattered remnant herds that were largely confined to the most remote and inaccessible habitat types—hardwood bottom-land swamps and mountainous terrain.

RECOVERY

In 1891 when the first forest reserves were established, the feeling of concern for forest resources in the country became evident. This feeling grew and resulted in the establishment of the U. S. Forest Service in 1905 and eventually to the establishment of the National Forest System. These National forests have played a key role in the recovery of southern deerherds. Some of the earliest National forests established in the South were: Ozark in north-central Arkansas in 1908; Ocala in north Florida in 1908 and the Pisgah in western North Carolina in 1916. National wildlife preserves were establish on a part of each of these areas. In the report of Leop *et al.* (1947) only two areas in the South are listed having problems with overpopulations of deer—t Ozark National Forest (Sylamore District) and t Pisgah. The establishment of the bulk of the southe National forests in the midthirties gave an additio boost to the marginal deer populations.

During the great depression of the late 1920's a 1930's, there is no evidence to indicate that substant recovery was made by southern deerherds. Howev some progress was made in restoration of habitat. mentioned previously, the bulk of the National fore of the South were established in the midthirties. In 19 the Civilian Conservation Corps was established and 1942, 2.5 billion trees had been planted on denud forest land; the gradual exodus of the human populati from farms to industrial jobs in cities had begun a farmland started the reversion back to forest land. B tween 1945 and 1953, 10 million acres of farmland the South reverted to forest (McGuire and Dickerm 1958).

The passage of the Federal Aid to Wildlife Restorati Act (more familiarly known as the Pittman-Roberts Act) in 1936 provided the key to the restoration of wil life throughout the United States. This act of Congre ushered in the era of wildlife management in this cou try. Some Southern States initiated deer restocki programs in the late 1930's utilizing Pittman-Roberts funds.

It was during this period that the remaining de populations in the South suffered several severe se backs. This Mississippi River flood of 1927 virtual wiped out the deer in Louisiana's Delta hardwo swamps: the fever tick eradication program whi started in Florida in 1937 and the overpopulation a subsequent die-off of deer on the Pisgah in North Car lina and the Sylamore in Arkansas set back the recove of deerherds in these States to a significant extent.

With the advent of World War II forces were aga exerted on deer and their habitat. To meet the deman of war in 1942, lumber production in the South climb to the then alltime high of 18,380,706,000 board fe exceeding the production of 1935 by almost 8 billi board feet (Steer 1948). Throughout the South lar tracts of land, most of which were suitable deer habit were acquired by the U. S. Department of Defense f military training purposes. Many of these areas we fenced and protected and ultimately harbored large de populations. A large segment of the hunting public w called into military service, but because of meat sho ages during the war years of 1941-1945 heavy deman were placed on game populations to supplement me rations. Approximately 54 million pounds of dress meat, principally deer, were taken from American fore in 1942 (Young 1956).

Although much of the foundation for recovery of de and their habitat in the South was laid between 19 and 1940, it was not until after the end of World War that real progress was made. With the return of m from military service, a work force became availab Federal Aid to Wildlife Restoration funds had bu up during the war years and adequate financing w available to the States, and finally trained personnel became available to the States as a result of the stepped-up program of training in many State colleges and universities. The demand for outdoor recreational opportunity was growing yearly. A general awareness of the need for a broad-base wildlife conservation effort became evident by the increase in the number of organized sportsmens groups and the reorganization of several State wildlife agencies.

By 1949 every State in the South had an active program of deer restoration with the exception of South Carolina whose trapping and transplanting program was initiated in 1951 (Barick 1951). Most of the forests had been cut over for several years and young second growth shrubby vegetation provided excellent browse conditions for deer. All States had initiated programs of acquiring land for the development of wildlife management areas. Between 1938 and 1967, 22,686 white-tailed deer were stocked in the 12 Southern States in areas where protection was provided and hunting was not allowed for a period of 5 years after stocking.

Originally there were six subspecies of the white-tailed deer in 12 Southern States covered in this report: *Odocoileus virginianus virginianus, O. v. macrourus, O. v. seminolus, O. v. mcilhennyi, O. v. osceola,* and *O. v. clavium.* During these restocking efforts, there was considerable mixing of the existing resident races of deer plus the introduction of at least two new races: *O. v. borealis* and *O. v. texanus* (table 1). The overall effects of this mixing is unknown, but at this time it is obvious that reproductive capacities are adequate for existing deer habitat.

The history of recovery of southern deerherds can best be treated by the data presented in table 1. The deer population increased from about 303,500 in the mid-forties to about 2,405,000 at the present time and the kill increased from about 60,133 in 1950 to 274,184 in 1967 in the 11 Southern States on which data are available.

Concerted efforts toward reestablishment of the South's deerherds were virtually completed by 1960. Kentucky was the only State with an active deer restocking program in 1967 when they restocked 458 animals. Deer hunting was once again a sport which could be enjoyed by the average person, and the number of deer hunters was increasing annually.

Table 1.—*History and status of deer restoration in the South*

State	Year restocking program started	Source of deer	Percent of State open to hunting prior to restocking	Percent of State open to hunting now	Before restocking		Now	
					Deer population	Deer kill	Deer population	Deer kill
Alabama	[1] 1945 [2] (1925)	Alabama Wisconsin N. Carolina	16	100	(1940) 15,000	(1950) 4,000	350,000	20,000
Arkansas	1945 (1940)	Arkansas Wisconsin	—10	99+	25,000	(1950) 4,112	250,000	21,750
Florida	1948 (1938)	Florida Wisconsin Texas	90?	90	33,000	(1950) 6,000	300,000	40,000
Georgia	1950 (1928)	Georgia Wisconsin Texas	10	90	(1940) 3,000	(1950) 8,000	150,000	20,000
Kentucky	1946	Kentucky Wisconsin	0	75	2,000	(1950) 0	65,000	8,000
Louisiana	1948 (1920's)	Louisiana Wisconsin Texas	30	95	67,000	(1947) 5,000	200,000	32,500
Mississippi	1944 (1937)	N. Carolina Mexico	30	95	2,500	(1941) 507	275,000	30,000
North Carolina	1944 (1937)	Wisconsin N. Carolina	—50	70	(1944) 50,000	(1950) 15,000	370,000	39,000
South Carolina	1951	S. Carolina	40	70	(1950) 80,000	(1950) 10,000	170,000	30,000
Tennessee	1947	Wisconsin Tennessee	0	75	(1946) 1,000	0	75,000	8,000
Virginia	1938	Wisconsin Pennsylvania	50	97	(1938) 25,000	(1951) 7,514	200,000	24,934
	Total		29	87	303,500	60,133	2,405,000	274,184

[1] Year when major effort was begun.
[2] Year when initial restocking started.

There were some problems developing, too. Deer hunting in the South had historically been "bucks only." Early proponents of deer restoration did an excellent job of selling the general public on protecting doe deer. I am sometimes prone to think that they did a much better job than was necessary.

As deer populations continued to increase, reports of timber reproduction and agricultural crop damage by deer increased. The constant threat of die-offs and domestic livestock-deer disease relationships prompted the States to organize the Southeastern Cooperative Deer Disease Study in 1947 to maintain surveillance over disease conditions in southern deerherds. The time had arrived when deerherd reductions across the South were essential in order to maintain the progress that had been made.

In the late 1950's most of the States started working toward either sex deer seasons. Much progress has been made, but all the problems have not been solved. Kentucky is the only Southern State that regularly permits either-sex deer hunting by archers and gun hunters alike. Several of the States (Arkansas, Kentucky, Louisiana, and Tennessee) allow lengthy either sex archery seasons. And all States in the South now have the authority to establish either-sex deer seasons vested in the respective State wildlife agencies and conduct restricted either-sex deer hunts annually. But this aspect of deer management has not as yet been accepted to the degree that will allow most State wildlife agencies the latitude necessary to properly manage southern deerherds.

Within the past 6 years another problem has developed. The highly fertile river bottom lands, some of the most productive deer habitat, are being cleared for agricultural crop production at an alarming rate. In Louisiana alone 896,308 acres were cleared between 1962 and 1967. Some of this land was supporting approximately 64 deer to the square mile. It appears that we must accept the fact that within the foreseeable future all of this highly fertile land will be placed in agricultural crop production, and deerherds in these areas will be reduced to remnants of their former abundance. Deer habitat in the South will be restricted primarily to the upland pine and pine-hardwoods areas, which cannot support nearly as many deer as the bottom-land hardwoods are now supporting.

TODAY

In the South today the white-tailed deer is hunted on approximately 90 percent of the total land area; 30 years ago only 30 percent of the land area was open to deer hunting, and some of this land supported no deer. The 12 Southern States covered in this report currently operate 317 management areas and refuges totaling 10,013,604 acres of land where the general public may hunt white-tailed deer on an annual basis. The limited deer stocking currently done in the South, with few exceptions, is not being done in the name of restoration. There are approximately 200,926,000 acres of forest land in the South, nearly all of which are suitable deer habitat. The annual kill of deer in the South undoubtedly exceeds 300,000 animals.

The unrestricted use of dogs for hunting deer and t abundance of free-ranging dogs in many areas of t South continue to be prime limiting factors on deer pc ulations. This is an area that deserves major attenti of responsible deer managers and game departme administrators.

Deer habitat and deer populations in the South a presently in good condition. I believe that continui public demand for good deer hunting will make it i perative that we continue to conduct our deer manag ment activities to the fullest extent of our abiliti Advances in deer management know-how are an abs lute necessity. We must all work toward that end.

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Population Dynamics of White-Tailed Deer

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Population dynamics is discussed in regard to changes in total number and population structure with reference to their importance to deerherd management. Some speculation regarding man's possible influence on genetic changes within the population is included.

Deer populations, like populations of any other species, undergo constant change and in this respect are dynamic. The terms stability and balance when used in reference to populations and conditions in nature actually mean a dynamic stability or dynamic balance. Fluctuations in total number and changes occurring in population structure which affect total number are of primary concern in deerherd management.

The rate at which a species could reproduce under ideal conditions and in the absence of mortality is referred to as the reproductive potential, and any species has the capacity to overpopulate its habitat in a relatively short time. In sexually reproducing forms the rapidity at which this could be accomplished depends upon the age of sexual maturity, the number of offspring which can be produced in a given unit of time, and the reproductive longevity of the species. Considering the reproductive potential of a single pair of white-tailed deer and following this through 10 generations gives some idea of the theoretical capacity of this organism to reproduce. The assumption is made that adult does would produce two young per year, yearling does would produce one young per year, juveniles (fawns) would not reproduce, and that no mortality would occur. A sex ratio of half males and half females is assumed. With the exception of the absence of mortality the above assumptions are conservative since it has been indicated by Severinghaus and Cheatum (1956) that under favorable conditions in New York some of the female fawns breed at 6 to 8 months of age and occasionally produce twins. Instances of does remaining productive for 10 years and longer are known. Successive increases shown in table 1 are similar to those developed by Leopold (1948) and can be obtained by mathematical equations (Kelker 1947; Eberhardt 1969). Allowing one deer per 40 acres, which would require good deer range, one section of land (640 acres) could be populated to near capacity in only 4 years and almost 12 sections in only 10 years.

Plotting this population growth curve shows a typical geometric progression (fig. 1). It becomes obvious immediately that the reproductive potential is largely theoretical and if attained at all in nature, would be maintained for only a short time. In a study of deer released in a 1,200-acre enclosure in Michigan O'Roke and Hamerstrom (1948) reported a population growth from four does and two bucks to 160 animals in 6 years. This rate of increase closely approaches the reproductive potential of the species. Other records of rapid population increase in large game mammals are numerous.

Table 1.—*Reproductive potential of a single pair of deer through 10 generations and the area which could be populated at one deer per 40 acres*

Year	Age class	Potential breeders	Potential number of young	Potential population	Acres needed at one deer per 40 acres
1	Adult	1M + 1F	2	4 = 4	160
2	Adult	1M + 1F	2	4	
	Yearling	0 0	0	0 = 6	240
	Juvenile	1M + 1F	0	2	
3	Adult	1M + 1F	2	4	
	Yearling	1M + 1F	1	3 = 9	360
	Juvenile	1M + 1F	0	2	
4	Adult	2M + 2F	4	8	
	Yearling	1M + 1F	1	3 = 14	560
	Juvenile	1M + 2F	0	3	
5	Adult	3M + 3F	6	12	
	Yearling	1M + 2F	2	5 = 22	880
	Juvenile	3M + 2F	0	5	
6	Adult	4M + 5F	10	19	
	Yearling	3M + 2F	2	7 = 34	1,360
	Juvenile	4M + 4F	0	8	
7	Adult	7M + 7F	14	28	
	Yearling	4M + 4F	4	12 = 52	2,080
	Juvenile	6M + 6F	0	12	
8	Adult	11M + 11F	22	44	
	Yearling	6M + 6F	6	18 = 80	3,200
	Juvenile	9M + 9F	0	18	
9	Adult	17M + 17F	34	68	
	Yearling	9M + 9F	9	27 = 123	4,920
	Juvenile	14M + 14F	0	28	
10	Adult	26M + 26F	52	104	
	Yearling	14M + 14F	14	42 = 189	7,560
	Juvenile	21M + 22F	0	43	

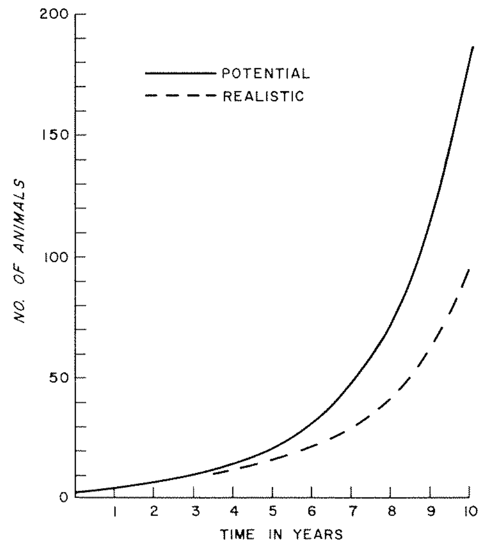

Figure 1.—*Potential population growth curve in white-tailed deer based on table 1 (solid line) and the probably growth curve under natural conditions (broken line) where the carrying capacity is approximately 100 animals.*

Comparing the curve for the potential increase with a hypothetical increase similar to that expected under natural conditions shows that the population tends to "level-off" as the carrying capacity of the habitat is reached (fig. 1). The difference between the theoretical and the realized population growth represents mortality and decreased natality.

Several factors within the total environment tend to bring populations down or prevent them from attaining unusually high levels. Prime among these are physical factors such as temperature, rainfall, and soil fertility which affect directly the available food supply. There are also several biological factors which tend to stabilize the population. Such factors as predation, disease, parasitism, movement out of the area, reduced fertility and natality, and competition for space, food, and cover are closely interrelated and tend to intensify as the population increases. The influence of these factors would vary in different localities or within the same locality at different times. Only through experience and familiarity with a given population can the wildlife biologist approach accuracy in evaluating the effect of these variables upon the population.

The term "leveling-off" does not imply that the number and composition of the population would remain fixed. The actual numbers would fluctuate around an average. Numbers would increase above the average during the period of birth when favorable conditions exist and decline below this average during more harsh periods normally corresponding to late winter or seasons of drought. During a series of favorable years the population is likely to increase well above the normal carrying capacity of the habitat with resultant overbrowsing. The habitat is severely damaged and a large portion of the population dies from starvation or from interactions between malnutrition and other decimating factors. The die-off normally reduces the population back to much lower levels than the original carrying capacity. Usually several years are required for the recovery of the habitat and the population. The removal or drastic reduction of normal mortality factors such as predation or parasitism, if not offset by increased removal by other means, may produce similar results.

The pattern of population growth and cycles indicate that a sizable portion of an established population is likely to be lost due to natural causes. But, if a portion of the population is removed prior to the decline phase of the cycle then the natural mortality is reduced in the approximate proportions of the segment removed. In a sense then, that portion of the population normally lost represents a "surplus." Efforts in wildlife management are directed toward harvesting this surplus and maintaining population levels at or near the carrying capacity of the range.

There are two portions of the population growth that seem especially important for the welfare of the deer-herd. The first is associated with the establishment level and the other is the point in the curve which approaches the carrying capacity of the habitat. When the population is low the actual increase in numbers is low and any factor which reduced natality or increases mortality will have the effect of holding the population at very low levels. In the example given in table 1 fawn loss the first year represents 50 percent of the populatio whereas loss of the same number of fawns during th 10th year would represent less than 2 percent of th population. In the first instance population growt would be greatly affected, but in the second the effe would be negligible. It is likely that populations fa to become established in many suitable areas becau of disturbance or reduction during the initial phase population growth. A second important period is th point at which the optimum carrying capacity is ap proached. At this level range conditions would be favo able and natality would be high. Thus, the large incr ment added to the population during the summer woul increase the numbers above safe levels for the wint range. A severe winter could result in high mortalit or an unusually mild winter causing little mortalit would compound the problem the following year.

It becomes obvious that habitat evaluation is a bas consideration for the wildlife biologist. Equally in portant is a knowledge of the deer population, includin its age composition and sex ratios. The importance this knowledge emphasizes the need for refinement methods and techniques for population analyses whic reflect the greatest accuracy with the least requiremer of time. Since certain of the data can be collected onl by close examination of the animals, it emphasizes th value of information gained from inspection of harveste animals over an extended period of time. Records this sort pertaining to deer populations in southern fore areas are noticeably scarce.

Table 1 can be used to show how the removal of di ferent age and sex classes will affect the population. Fo instance at year 9 there would theoretically be 26 male in the adult and yearling class. Removal of half these would reduce the total population to 110. Assumin each of the remaining bucks could service as many a four does, plus the fact that many of these killed woul have bred before being harvested, the population th following year would be reduced by only 13, giving total of 176. On the other hand, removal of 13 adu does in year 9 would result in a population of 150 th following year. The effect of female removal in othe age classes can be easily determined. The conclusio can be drawn that removal of buck deer, within limit of course, will not appreciably reduce the populatio Normally, dangers of overpopulation can be averte only by removal of does.

Table 1 also shows that the ratio of young deer (yea lings and fawns) to adults remains high as the populatio increases. But failure of an appreciable increment young to survive would result in more adults tha young. In actual management practice then, if a censu of a population reveals this high ratio of young to adult the assumption is made that the herd is increasing an that the population is within the carrying capacity the range. However, if the reverse proportions are ob served it indicates reduced natality or low fawn surviva which may mean overpopulation although it could b due to other factors. Data from other sources would b needed before an accurate assessment of the populatio in relation to its range could be made.

It may seem premature to talk of overpopulation her since many southern forest areas seem to be underpopu lated. But overpopulation can occur at low densities. If the range can support one deer per 50 acres and there are twice this many per acre, then the range is overpopulated. Maintenance of the population above the proper level is likely to damage the habitat and further reduce the carrying capacity. It has been demonstrated numerous times that under adequate protection deerherds will increase beyond range capacity in a relatively short time. Adequate protection requires cooperation of the people who own and use the land. Once this attitude is developed and deer populations are brought from scarcity to abundance there is often a reluctance by landholders to follow the advice of biologists and allow removal of antlerless deer. Thus, in many areas the population is held well above optimum levels.

Since food is a major factor in limiting deer populations, it is likely that in high populations some survival value would accrue for those animals which require less food to sustain life. Since energy requirements are related to body size it seems feasible that the genetically smaller animals would have a selective advantage over larger animals. This positive selection for smaller animals is further accentuated by hunting philosophies in which a premium is placed upon the larger deer. Theoretically then, there are two selective forces which favor survival of small animals. Such selection over a long period of time could result in reduction of the size of the deer within the population. Surface area, and consequently heat loss, is proportionally greater in smaller animals and one would expect such tendency for decrease in size to be offset by greater mortality of small animals in areas where winters are severe. In the South this offsetting selection would be of minor consequence. This concept offers additional sound reasoning for keeping populations at optimum levels and for a less-selective removal practice in established populations. Conversely, it indicates some value in making special effort to retain some larger animals for breeding purposes. Reduction in size would not necessarily be detrimental to the population. If hunters were willing to make the same economic investment to kill a small deer as compared to a large one, then a greater number of small deer might be desirable. However, present hunting philosophies do not follow this line of reasoning.

Change in size is difficult to detect and evaluate since it relates so closely to nutrition factors and age. Difference in size as a genetic trait is readily observed in other mammals, especially in domesticated forms where artificial selection has been practiced. It seems feasible that man's influence on deer populations could modify natural selective processes. Such genetic considerations in deerherd management may, in time, become quite important as the demand for more intensive land utilization increases.

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Foods and Feeding Habits of White-Tailed Deer

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Principal foods of white-tailed deer are browse, fruits, succulent herbage, mushrooms, and agricultural crops. Deer diet is notable for great variety. Browse accounts for less than half. Preference varies by season and among species as does quality. The best insurance for proper deer nutrition on forest range is maximum habitat variety.

Deer diet is one of the oldest subjects for wildlife investigations and it remains an essential part of deer management in southern forests.

FOODS

Browse

Leaves and twigs of woody plants constitute browse, which is generally considered a major component of deer diet. Field observations on a deer range reveal more sign of deer use of browse than anything else. Browse is the one component of the food supply which is available in some form year-around. But leafless twigs are rarely used in the South. Deer are not especially well equipped to digest the high fiber content of browse. Food habits studies often reveal only minor utilization of browse.

Herbage

Nonwoody plants include many deer foods. Most broadleafed herbaceous species are likely to be utilized. If deer have access to openings in early stages of plant succession, they are sure to find many attractive herbs.

Grasses and sedges are taken in limited amounts. When early spring growth appears, some grasses (especially those with winter rosettes) are taken. On ranges where other foods are scarce, grasses may be used year around. Bracken and other species of fern are taken by deer.

Dried leaves, both woody and herbaceous species, are used. The extent of use and its significance are not clear.

Fruits

Most fruits growing in eastern Texas are eaten by deer. As shown in table 1 seed remains of 37 species or genera were found in 3,195 deer pellet samples. August to January was the period of heaviest use although some seed remains were found every month. Acorns *(Quercus)* were recorded for every month but April. Three species were found every month of the year: yaupon *(Ilex vomitoria)*, hawthorn *(Crataegus)* and partridgeberry *(Mitchella repens)*. Some species are known to be used but the seed were not readily found in droppings, due to tiny size or high digestibility.

Wild persimmon. Fruits of many forest species are important to the white-tailed deer.

The plants which produce fruits for deer usually pr vide browse also.

Mushrooms and Fungi

Most mushrooms and other fungi are relished ŀ deer. Bracket fungi have been found in stomachs in add tion to the more common fleshy mushrooms. This is oı food item that is difficult to appraise by field observ tion, as no sign remains when one is consumed. Tŀ supply also comes and goes in a matter of hours or day

Agricultural Crops

Many crops attract heavy deer feeding: peas, melon soybeans, corn—to name a few. Agricultural crops aı especially important after acorns are consumed. Damaᶃ may reach the point that certain crops cannot be pı duced in the presence of deer populations.

Fertilization makes crops especially attractive. Wint greens such as oats, vetch, rye grass, and clovers a attract heavy deer pressure.

Probably heavy fertilization of evergreens such ; Japanese honeysuckle *(Lonicera japonica)* would maŀ them equally attractive. Pine *(Pinus* sp.) seedlings froı fertilized nursery-beds may be browsed by deer whe planted on a range, with little food present. Yet natur pines are not taken under moderate stocking.

Water

Deer in the South do not require or use surface wat at all times. Apparently much of their requirement supplied by the vegetation they eat. Most deer fooc are 50 to 90 percent water.

[1] A contribution of Federal Aid in Wildlife Restoration Projects.

Table 1.—*Frequency of fruit remains in 3,195 east Texas deer pellet groups, 1956-68*

Name	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Ampelopsis arborea							3	1	2	1	3		10
Berschemia scandens							1			2	2	3	8
Callicarpa americana	9	1	1				37	93	122	106	71	33	473
Carya sp.										1			1
Celtis occidentalis	1	1							1				3
Chionanthus virginicus					1	1	16	12	7	6	1		44
Cornus florida	11	5							1	4	27	21	69
Crataegus sp.	41	21	6	8	19	10	9	39	40	42	10	14	259
Gleditsia sp.	1	4							8	17	3		33
Hypericum sp.												2	2
Ilex coriacea												1	1
I. decidua	6	9				7	5	2				2	31
I. opaca	3	15	1		1			1				1	22
I. vomitoria	58	39	13	5	16	14	8	10	5	10	42	36	256
Lonicera japonica	1								1				2
Mitchella repens	7	20	3	5	1	10	17	25	17	23	12	10	150
Myrica cerifera	18	5						1		9			33
Nyssa sylvatica	30	2	1			2		4	7	22	26	40	134
Quercus sp.	70	60	3		1	1	1	5	43	100	67	38	389
Prunus mexicanus						9							9
Prunus sp.								1					1
Rhus sp.	22	10	2				3	5	15	17	18	17	109
Rubus sp.					24	43	11	4	1				83
Sambucus canadensis							2	7	3				12
Smilax glauca	1												1
S. laurifolia			1				1						2
S. rotundifolia	1	5					2	1		1			10
S. walteri					1								1
Smilax sp.								3	3	3	2	3	18
Styrax americana										1	2		3
Symphoricarpos orbiculatus	4												4
Symplocos tinctoria									1	12	5	2	20
Toxicodendron radicans									2	5	2		9
Vaccinium arboreum											1		1
Vaccinium sp.	1				2	1							4
Viburnum molle								1					1
Vitis sp.							3	2	3				8
Totals	289	197	31	18	66	98	119	217	282	382	294	223	2,216
Number examined	354	493	218	198	213	262	247	291	220	281	223	195	3,195
Identifications per 100 examined	81	40	14	9	31	38	48	74	128	136	132	114	69

FACTORS AFFECTING DEER FEEDING HABITS

Animal

Diet is limited to what is available within the travel range of deer. An individual deer may be observed regularly in a key spot of habitat—such as a honeysuckle thicket—that may not exceed 1 acre.

Enclosed deer may spend a lifetime on tracts of less than 100 acres, but there is some evidence that confined deer are not as well nourished by a given habitat as unconfined deer. A possible reason for this would be the better use of uncommon food items a deer may find in a larger territory.

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

Needs of the deer vary with season and sex, and selectivity doubtless represents search for nutrients as required by lactation, growth, reproduction, and antler development. Selectivity of the animal may result in a diet with 66 percent more protein than hand-collected material of the same species, according to Wilson (1969).

The most critical diet requirement, considering the numerous authorities, is for 13 or 14 percent of protein and 0.40 percent phosphorus (Murphy and Coates 1966). Also, the fiber level should be modest to assure adequate digestibility.

Daily feeding routines are not especially notable. When undisturbed deer generally have two feeding periods—

early and late daytime. With disturbance they feed at night or when they can. Corn, for instance, when placed in front of a hunting blind is generally taken when the blind is empty.

The reach of deer limits feeding to the zone up to 4.5 feet high. When necessary, feeding may be accompanied by standing on the hind legs and reaching higher. This occurs in periods of scarcity and favors the stronger and taller individuals.

Environmental—Season

Seasonal changes in the deerfood supply are a major aspect. The composition of foods changes with the stage of growth. Many food items ripen or develop at a specific season. Others are taken only at certain seasons due to changes in available foods. Evergreens have a special value in winter.

The major support for deer on a range may be one or two good evergreens such as yaupon *(I. vomitoria)* or Japanese honeysuckle. Seasonal availability determines use of such desirable foods as fruits. Some fruits dry in place and are found by deer long after the period of fresh fruit availability. Others may be scratched out of drifts or used when they germinate—as acorns.

Environmental—Weather

The mild southern climate exerts little direct influence on deer feeding. Rarely does snow or ice cover the food supply and then for short periods. Bunching in "deer-yards" does not occur. Summer heat seems to cause more stress than winter cold. "Die-offs" occur more often in late summer. This is the period of declining forage quality and increasing strain of lactation and growth on does and fawns (Short *et al.* 1969; Goodrum and Reid 1962).

Environmental—Topography

The southern terrain does not limit deer access and little consideration for topography seems to be required. Deer do use certain trails, runs, and feeding spots more than others for obscure reasons.

Food Availability

Food supply is the major determinant of deer range carrying capacity. Much effort has been devoted to measuring the browse supply as an index to how many deer can be supported. Often the results indicate more deer could be grown if limiting factors, such as excessive hunting, were not operating.

Methods of appraising the food supply sometimes need refinement. Too often species or plant parts are included which are not nutritionally adequate. Also, summer surveys need careful interpretation as to what would be available at other seasons.

It is known that a 100 pound deer needs about 2.5 pounds of dry forage per day (Davenport 1939, Nichol 1938; Smith 1950). To maintain a herd of one deer to 10 acres, each acre would contribute 91 pounds of dry weight of acceptable food (2.5 x 365/10).

Browse utilization should not be more than about half for the welfare of the plant. If the choice species are taken at a 55 percent rate, the medium choice specie will be taken at a 30 percent rate, and the low choic species at a 5 percent rate—in Texas experience. Thi means that not more than a third of the current growt on all browse plants should be considered available t deer. A range needs to have available, according t these estimates, 273 pounds (dry basis) per acre to carr a deer to 10 acres.

In north Georgia, Ripley and McClure (1963) foun an average of 36 pounds per acre of browse forage wit only 16 pounds of that desirable species. They estimate it would take 52 acres of National forest or 33 acres o private land to carry one white-tail. This was base on 2.5 pounds consumption for 100 days at a level of 4 percent utilization. Two questions arise: is this a satisfactory deer density and what do deer eat the other 26 days each year?

On some ranges winter browse is almost nonexistent Dunkeson (1955) reported this for the Ozarks where only the unpalatable pine and cedar *(Juniper)* are generally available.

In Ozark forests studied by Segelquist and Greer (1968), mast was five to 10 times more abundant than winter browse—98 pounds of acorns to 9.2 to 19.9 pounds of browse.

A study of browse utilization by penned deer in a 58 acre enclosure at Kirbyville revealed less than half of the diet was supplied by browse (table 2).

Table 2.—*Estimated contribution of browse to deer die in a 58-acre enclosure at Kirbyville (air-dry weights)*

Year	Number deer	Predicted requirement in pounds	Pounds browse utilized	Percent of diet supplied by browse
1954	2	1,620	468	29
1955	3	2,428	1,005	41
1956	4	3,600	1,896	53
1957	4-6	4,634	1,924	41
1958	5-6	5,364	1,839	34
1959	4	4,320	1,738	46
1960	4	4,500	1,371	30

Fruits may be more abundant than is generally recognized. Yields of some cultivated crops range into the tons per acre.

The current study of deer in two enclosures at the Stephen F. Austin Experimental Forest, Nacogdoches has revealed something of the productivity of fruit in southern pine-hardwood forest habitat. About 34 fruiting, woody species are present. The average fruiting population is 138 plants per acre in the pure pine stand and 165 in the pine-hardwood stand. Pines are not counted. The most common species is American beautyberry *(Callicarpa americana)* and estimates of its fruit yield have ranged to about 60 pounds per acre. The yield per plant has been about 0.25 pounds for beautyberry and 0.95 to 3.3 for dogwood *(Cornus florida)*. Yields of 20 species are shown in table 3, based on counts of fruit on 658 plants.

Table 3.—*Summary of whole-tree fruit counts in eastern Texas in pounds per tree* [1]

Species	Year or years	Number	Diameter breast high	Pounds per tree
American beautyberry				
(Callicarpa americana)	?	42	[2] 0.47	0.24
	1963	100		.19
	1964	100		.30
	1966	58		.28
White fringetree				
(Chionanthus virginicus)	1958	41	[2] 1.75	1.1
	1963-67	47	[2] 1.66	.81
Flowering dogwood				
(Cornus florida)	1958	26	4.0	3.3
	1966	35	[2] 3.72	.95
	1967	38	[2] 3.17	2.35
Blueberry hawthorn				
(Crataegus brachyacantha)	1958	10	3.0	2.4
Parsley hawthorn				
(C. marshalli)	1958	10	2.04	1.24
Common persimmon				
(Diospyros virginiana)	1959	1	4.1	13.4
American beech				
(Fagus grandifolia)	1959	1	15.0	11.6
Possumhaw				
(Ilex decidua)	1958	8	1.8	2.2
Gallberry				
(I. coriacea)	1958	5	[2] .7	.18
Yaupon				
(I. vomitoria)	1959	5	[2] 1.7	2.18
Blackgum				
(Nyssa sylvatica)	1959	1	11.9	5.77
Red bay persea				
(Persea borbonia)	1959	6	2.56	.93
Black cherry				
(Prunus serotina)	1959	1	3.05	1.73
Flatwoods plum				
(Prunus umbellata)	1958	8	3.1	1.18
Chinese tallowtree				
(Sapium sabiferum)	1960	3	4.88	5.75
Common sweetleaf				
(Symplocos tinctoria)	1958	38	2.4	.64
Farkleberry				
(Vaccinium arboreum)	1962	7	2.29	1.05
Kentucky viburnum				
(Viburnum molle)	1959	51	[2] .87	.08
Rusty blackhaw viburnum				
(V. rufidulum)	1967	15	[2] 2.36	.52
Muscadine				
(Vitis rotundifolia)	1958	1	2.4	53.8
		658		

[1] All trees were randomly selected among those having some fruit and were located in a fully stocked pine forest, except the single-tree samples.

[2] Diameter was measured 6 inches high.

Browse availability is important because it lends itself to measurements, is present year-around, and serves as an indicator of the degree of pressure. Caution should be used in converting pounds of forage present into deer carrying capacity. Unmeasured variables such as nutritional quality, seasonal conditions, preference of deer, and short-term foods like mushrooms—all complicate the process.

Food Quality

Food quality is more limited than quantity. Phosphorus and nitrogen or protein are generally inadequate except in spring. Table 4 gives estimates of seasonal composition of browse by three categories of palatability (Lay 1957).

Table 4.—*Seasonal variation in protein and phosphoric acid in browse forage* [1]

Season	Number species	Protein	Phosphorus
Spring	10	14.5	0.18
Summer	22	9.5	.08
Fall	10	8.2	.08
Winter	25	7.2	.08

[1] Two-inch tips, corrected to ovendry matter base (Lay 1957).

Crude protein dropped from about 15 percent in spring to 7 in winter, phosphorus dropped from 0.18 to 0.08. These may be compared to the 13 percent protein and the 0.40 phosphorus needed. Seasonal differences are great and most species are best at only one time during the year.

Special recognition should be given evergreens. These may approach adequate levels for protein even in winter. *Smilax smalli* has 15 percent protein and 0.12 phosphorus (Lay 1957).

Some good densities of deer do occur. Several methods are used to offset the scarcity of N and P. Deer feed with care, often taking only a tip here and a leaf there. They make heavy use of such high quality items as mushrooms which in winter in east Texas may average 23 percent protein and 0.55 percent phosphorus (Miller and Halls 1969). Succulent greenstuff, however, is the common source of P and N.

Fruits, including acorns, may be high in fats and digestible carbohydrates. Acorns may have 30 percent fat and 50 to 80 percent nitrogen-free extract (Fraps 1919; Caillouet 1960; Goodrum 1959). Fat content of some other fruits are: whole dogwood 17 percent, dogwood flesh without seed 34 percent, whole arrowwood fruit *(Viburnum dentatum)* 26 percent, yaupon 13 percent, and American beautyberry 11.5 percent. Parsley haw *(Crataegus viridis)* and dogwood each contain more than 1.5 percent calcium (Hastings 1966).

The fiber shown for fruit is largely in the seed which is passed without digestion. The digestible part is low in fiber and this enhances its contribution to the diet.

The great contribution of fruit to the diet is energy. Any hunter knows deer fatten soon after acorns start falling, if they have not already fattened on late summer crops of blueberry hawthorn *(C. brachyacantha)* and/or American beautyberry. These enable the building of reserves for the rut and for winter.

Food Palatability

Some ranges, such as one with a long history of high deer and/or livestock stocking, may have few first-choice foods present. Second and third-choice foods may be taken with seeming relish; but this does not denote preference. Observations are more significant on lightly stocked ranges with no livestock present and with a previous history of little or no stocking.

The role of the digestive fauna must be considered. Deer need time to adapt to new foods—even to corn. They must have or acquire the proper kind of digestive fauna to break down a given food with a net gain in energy.

Some workers (Longhurst *et al.* 1968) have shown relationships between palatability and evolutionary development of the plant species. Some plants contain protective substances which cause deer to avoid eating them.

Deer may be forced to eat pine but this does not denote palatability or adequacy. It should be considered an alarm that deer are ill fed and in a precarious position.

There is a sequence of utilization, even among the third-choice species. Pine browsing, for instance, follows heavy use of wax myrtle *(Myrica cerifera)*. Such species have special value as indicators of pressure on the food supply.

To add to the complex of palatability, individual animals differ significantly.

Composition tests may not show why deer prefer one species over another. I suspect choice usually is guided by nutritional requirements, and that deer recognize food quality better than we. The avoidance of high fiber content may be as necessary as the attainment of required N and P.

Food Competition

Deer die with stomachs full of the wrong things. The deer manager can anticipate starvation by observing the competition for food. The herd should be reduced before such die offs occur. Often this happens in unspectacular loss of fawns and does in late summer.

Close observation and imagination is required to grasp the true degree of food competition among deer. On ranges where the fawn survival is less than 50 percent, serious competition is indicated. Carcasses of dead deer are not often found because they decompose or are consumed rapidly. Also, visibility in dense cover may be only a few feet.

Livestock eat many foods taken by deer. Cattle reduce the carrying capacity for deer in southern forests by eating deerfoods and by suppressing their reproduction. Many browse species, especially evergreens, are superior to forest grasses and they attract cattle as much as deer. Some browse species are taken by cattle but not by deer. Flowering magnolia *(Magnolia grandiflora)* and American holly *(I. opaca)* are examples.

SUMMARY—THE IMPORTANCE OF VARIETY

Deer in southern forests normally are searching for foods which will improve their diet. Rarely do they find a time and place where they can grow and fatten on a abundant supply of foods with adequate protein, pho phorus, and energy.

The use of many kinds of fruits, forbs, mushroon and other succulents in addition to many species browse demonstrate the importance of variety (La 1967). This is necessary because most foods have certai times when they are most nearly adequate.

The best insurance for proper deer nutrition on fore range is maximum habitat variety.

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Physiology and Nutrition of Deer in Southern Upland Forests

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Upland forests in the South generally have infertile soils and produce roughages that are seasonally deficient in net energy, protein, and phosphorus for deer. To increase the number and size of deer, palatable and nutritious foodstuffs must be produced at seasons when naturally occurring foods are nutritionally inadequate.

White-tailed deer *(Odocoileus virginianus* L.) on the extensive upland habitats of the Southern United States are often small and occur at relatively low densities. This situation is caused largely by low soil fertility, which seriously limits the production of nutritious forage. This paper reviews findings about seasonal nutritive requirements of deer and the seasonal nutritive quality of forest foodstuffs, which are sometimes deficient in net energy, protein, and phosphorus.

ENERGY

Energy intake of deer varies with age, sex, and reproductive condition. In a recent study (Short *et al.* 1969), *ad libitum* consumption of a nutritious ration by yearling bucks was high during spring and early summer (table 1). Intake diminished in midsummer, apparently because of climatic stress. Food intake increased in late summer or early autumn, when heat and humidity moderated. It decreased during rut and remained low throughout the winter, when nutrient deficiencies in forage normally exist.

[1] The author is on the staff of the Wildlife Habitat and Silviculture Laboratory, which is maintained by the Southern Forest Experiment Station in cooperation with Stephen F. Austin State University, Nacogdoches, Texas.

Rates of food consumption of yearling females ha a similar but less variable pattern (Short *et al.* 1969 Does in late gestation consumed more food than no pregnant does. During and immediately after lactatio does with fawns might ingest one-third more food tha those without fawns.

Table 2 shows the approximate nutritive content several east Texas foodstuffs. Energy contents of foo stuffs (kcal/g.) were calculated from proximal analys and Tyler's (1964) conversion factors for protein, fa and carbohydrates. Caloric values for different types foodstuffs are similar to those cited by Golley (1961 Acorns have relatively high gross energy (5.4 kcal/g. loblolly pine browse has intermediate values (4.4 to 4. kcal/g.), and mixed browse, mixed grasses, and mixe forbs have low energy levels (3.9 to 4.3 kcal/g.). Acorn have a higher gross energy than do most fleshy frui and legume seeds, and all have more ether extract (an therefore more gross energy) than do grass seeds (Kin and McClure 1944). Fleshy fruits and berries are moderate energy value (Wainio 1941).

Gross-energy intake of yearling bucks on an adequa ration was 5,000 to 6,000 kcal/day from April to Octobe and 3,500 to 4,000 kcal/day during late autumn an winter (table 1). Consumption of only 1 to 2 kg. (over dry weight) of nutritionally adequate foodstuffs per da would satisfy these energy requirements.

The digestibility of a foodstuff determines the amoun of the gross energy that is available to animals. Dry matter digestibilities of the foods in table 2 were est mated from their fiber components. Though these value

Table 1.—*Weight gains and average rates of nutrient ingestion for deer on rations of constant and varying nutrient value*[1]

Month	Age	Control rations				Experimental rations			
		Body weight	Estimated daily intake of five bucks			Body weight	Estimated daily intake of five bucks		
			Energy	Nitrogen	Phosphorus		Energy	Nitrogen	Phosphorus
	Mo.	*Kg.*	*Kcal.*	*Grams*	*Grams*	*Kg.*	*Kcal.*	*Grams*	*Grams*
Feb.	8	32.9	3,400	19	3.5	27.6	3,100	10	0.8
Mar.	9	34.8	3,700	21	3.8	28.4	3,100	12	1.1
Apr.	10	39.4	5,000	28	5.2	32.7	4,200	26	2.4
May	11	45.2	5,300	30	5.5	38.1	4,500	26	2.4
June	12	50.7	5,400	30	5.6	42.6	5,200	23	2.2
July	13	56.0	5,300	29	5.4	48.0	5,500	25	2.3
Aug.	14	59.0	5,000	28	5.2	52.3	5,200	22	2.2
Sept.	15	62.3	6,000	33	6.1	53.2	5,000	16	1.9
Oct.	16	64.2	5,400	30	5.5	52.4	5,000	16	1.8
Nov.	17	63.1	3,700	21	3.8	49.4	3,300	11	1.2
Dec.	18	58.9	3,900	22	4.0	47.7	3,600	11	1.2
Total 11 months			1.58×10^6	8.9 kg.	1.6 kg.		1.45×10^6	6.0 kg.	.6 kg.

[1] Data from Short *et al.* 1969.

Table 2.—*Nutrient content and predicted dry-matter digestibility of several foods sampled from southern upland forests at different seasons of the year*

Forage	Estimated gross energy	Phosphorus	Crude protein	Cell-wall content	ADF	Lignin	Predicted dry-matter digestibility [1]
	Kcal./g.	*Percent dry weight*				*Pct. ADF*	*Percent*
Woody twigs with leaves, when present (terminal 2 inches)							
May	4.3	0.3	16	32	27	37	61
July	4.3	.1	10	34	27	44	58
Sept.	4.3	.1	10	37	31	36	58
Nov.	4.1	.1	6	32	29	56	57
Feb.	4.2	.1	6	57	46	40	41
Current twigs of woody plants (terminal 4 inch average summer-winter)	...	...	4-6	70	53	27	41
Green leaves of browse plants	...	...	8-14	32	24	25-29	64-67
Dead fallen leaves	4.1	.4	5	49	36	65	39
Mixed forbs (terminal 2 inches)							
May	4.2	.3	15	34	29	22	66
July	4.3	.2	11	37	32	25	63
Sept.	4.2	.2	9	41	35	22	62
Nov.	4.2	.1	8	43	37	37	53
Mixed grasses (terminal 2 inches)							
May	4.2	.2	13	67	38	10	65
July	4.1	.1	9	67	40	12	61
Sept.	4.2	.2	12	68	39	13	59
Nov.	4.0	.1	7	71	44	21	46
Feb. (includes fertilized winter grasses)	3.9	.2	15	57	39	13	63
Loblolly pine (terminal 2-inch twigs with needles)							
May	4.4	.2	9	45	36	37	52
July	4.4	.1	7	45	39	42	50
Sept.	4.4	.1	7	47	40	39	49
Nov.	4.5	.1	8	45	39	50	47
Feb.	4.6	.1	8	41	37	40	54
Acorns (whole but without cups)	5.4	.1	6	28	22	50	61

[1] From equations for estimating digestibility of dry matter (Van Soest 1965).

may not accurately depict the usefulness of these forages for deer (Short, H. L., unpublished data), they indicate the relative usefulness of different foods and the effect of seasonal changes on digestibility.

Woody twigs have a relatively high lignin content. Composite samples of the terminal 2 inches of twigs with attached leaves may be 57 to 61 percent digestible. Digestibility diminishes to about 41 percent after leaf drop. Green leaves of woody plants are 64 to 67 percent digestible, while dead leaves, after nutrients have been leached, are only 39 percent digestible because of a high lignin content.

The terminal 2 inches of mixed forbs have a higher cell-wall content (CWC) and acid-detergent-fiber (ADF) content but a smaller lignin content than browse. Thus, forbs are predicted to be slightly more digestible than browse. The terminal 2 inches of mixed grasses characteristically have high CWC and low lignin content. Dead grasses have low potential digestibility, but fertilized cool-season grasses are as digestible in winter as mixed warm-season grasses are in summer. Predicted digestibility of the grass samples in table 2 is less than actual digestibilities listed for some orchard grass, brome grass, and timothy samples cited by Van Soest (1963). Pine browse samples contain intermediate CWC levels, relatively high lignin levels, and more ADF than other browses. Pine samples are about 50 percent digestible throughout the year.

Digestibility percentages may be almost 20 points lower in autumn and winter than in spring. The net energy values of most plant tissues, therefore, are far lower in autumn and winter, even though similar caloric contents are present throughout the year. After the growing season has terminated, high levels of fiber components limit the value of foods such as woody twigs and dried leaves. Energy deficiencies exist for deer whenever the net energy derived from foods fails to fulfill maintenance or production requirements. Because of their relatively high metabolic requirements, lactating does and weaned fawns are particularly vulnerable to low-energy diets.

PROTEIN

Protein is essential for body maintenance and production. Yearling bucks fed a control ration of about 15 percent protein (N × 6.25) consumed 8.9 kg. N from February through December (table 1). They consumed about 30 g. N per day from April through October and increased body weight at least 5 percent per month from February through September.

Bucks fed diets formulated to resemble natural forages which are seasonally available in upland forests consumed only 6 kg. N from February through December. During spring (dietary protein about 17 percent) and early summer (dietary protein about 12 percent), they consumed somewhat less nitrogen per day than did control deer. Body weight increased at least 5 percent per month only from April through August. Gain essentially ceased in late summer (dietary protein less than 9 percent). During autumn and winter (dietary protein about 8 percent) these bucks lost more weight than did control-fed deer. Deer fed the control ration consumed 48 percent more protein and gained nearly 30 percent more in body weight than did deer on the experimental diets (table 1).

Deer fed low-protein diets (7 percent) throughout the year were physically stunted, and does fed diets of 7 to 11 percent protein produced fewer fawns than those on an adequate diet (Murphy and Coates 1966).

Protein deficiencies in vegetation restrict the growth and development of deer. Deer killed during autumn on upland forests in Louisiana weighed only 68 percent as much as captive deer fed an adequate ration (Short *et al.* 1969). Protein deficiencies also restrict populations in uplands. Inadequate protein during lactation probably reduces fawn survival and hinders the recovery of lactating does prior to breeding. Low protein levels also probably adversely affect the growth and survival of newly weaned young.

The predominant red and yellow podzolic soils of upland habitats tend to have high aluminum and iron oxide contents, a low reserve of organic matter and many soil nutrients, and a low exchange capacity. These highly leached soils are moderately to strongly acid and support forest vegetation high in carbon and low in nitrogen. Such environments support relatively low densities of herbivores (Albrecht 1957). Soil fertility varies by site, and leaves from plants growing on nitrogen-rich soils contain more nitrogen than those on deficient soils. Plant species themselves vary in nitrogen requirements. Red, white, and chestnut oak and red maple grow on soils low in nitrogen, while such species as white ash, yellow-poplar, and basswood need soils with a high nitrogen content (Kramer and Kozlowski 1960).

Plant parts and plant species vary as sources of nitrogen. Leaves are better sources than twigs (Gessel 1962), and hardwood leaves are better than coniferous needles (Kramer and Kozlowski 1960). Some plants, such as legumes, can fix atmospheric nitrogen, and others are particularly efficient in utilizing the available soil nitrogen.

Stand conditions affect the total nitrogen available to deer. In a model of an old-field community that succeeded to pines (Switzer *et al.* 1968), the total nitrogen in the standing herbaceous cover that was physically available or contained in plants palatable to deer progressively diminished. When the pines were 5 years of age the total nitrogen in the ecosystem was about the same as it had been 5 years before, but only about 60 percent was in vegetation potentially useful to deer. At age ' the pine canopy had closed and, even though total nitrogen in the ecosystem had increased, little or none was available to deer. Little forage nitrogen will be available to deer until the canopy opens and forage again develops near the ground (Switzer *et al.* 1968).

When deer-forage species do invade the plantation their contribution to the nitrogen requirements of deer may be small. The total annual production of browse and herbage in a Louisiana plantation of 105 to 13 square feet of basal area was about 90 to 135 kg./acre (Blair 1967). Many browses and herbages contained no more than 1 to 1.5 percent N (9 percent or less protein after growth ceased (table 2). Thus, in this plantation only up to 2 kg./acre of nitrogen were potentially available to deer. Stands of shortleaf and loblolly pines and mixed hardwoods in east Texas produced approximately 195, 330 to 385, and 725 kg./acre at basal areas of 96 76, and 26 square feet (Schuster and Halls 1963). The most open stands probably provided no more than 11 kg of forage nitrogen per acre.

Plant tissue has a high nitrogen content only when growth is rapid. At this time, nitrogen may make up more than 3 percent of the dry matter in new growth After tissues mature, nitrogen content is diluted by the rapid accumulation of carbohydrates. Some translocation and leaching occur from leaf tissues as early as July (Kramer and Kozlowski 1960). Thus, the nitrogen content of the terminal portion of many forest forages is often less than 1.5 percent in autumn and winter (table 2). Furthermore, much of the nitrogen in poorly digested fibrous tissues in stems, twigs, and dead leaves is not metabolically available to deer.

Foods which contain adequate levels of crude protein at seasons other than spring are legume, pine, and grass seeds (36, 26, and 12 percent, respectively) (King and McClure 1944), mushrooms (up to 30 percent) (Miller and Halls 1969), and leaves of some evergreen broadleaved species. These highly nutritious foods are often scarce in the forest.

PHOSPHORUS

Phosphorus is needed for metabolism in herbivores and is a major constituent of bones, antlers, and soft tissues. Phosphorus deficiencies in female herbivores affect estrus and therefore influence productivity (Maynard and Loosli 1962). Does require relatively high levels of phosphorus during gestation for normal development of the fetus, and they secrete extensive quantities in milk

Phosphorus levels necessary for deer have been estimated at 0.25 to 0.30 percent for maintenance and 0.50 percent for optimum growth (Magruder *et al.* 1967)

Apparently adequate growth and development of deer occurred with diets that provided either 0.25 or 0.44 percent phosphorus (Short *et al.* 1969). Yearling bucks fed the control ration (0.44 percent P) ingested over 5 g. P/day during the rapid growth period of spring and summer, and about 3.5 to 4.0 g./day during the other months of the year (table 1). Young bucks on the experimental diets of varying composition (0.25 to 0.18 percent P) ingested slightly more than 2.2 g. P/day during the rapid growth period of spring and early summer. Phosphorus intake was less than 1.2 g./day during autumn and winter, when phosphorus levels in the diet were only 0.16 to 0.11 percent. Preliminary evidence suggests that the plasma phosphorus levels of experimental deer dropped in autumn and winter and that the levels were lower than those measured in control deer (Matthews 1968). These data suggest inadequate bone nutrition (Maynard and Loosli 1962), which could result in diminished skeletal size. Control bucks ingested 167 percent more phosphorus during an 11-month period, were larger (table 1), and had more antler points (Short *et al.* 1969) than did those on experimental rations. Production capabilities of wild deer should be very limited on foodstuffs with less than 0.16 percent phosphorus.

The same soil characteristics which frequently limit protein in forages grown in upland forests cause phosphorus deficiencies in many plant tissues at seasons other than spring and early summer. Phosphorus is closely associated with plant metabolism and accumulates in actively growing tissues such as buds and newly developing leaves. Phosphorus content declines in older, senescent leaves because phosphorus is translocated back into twigs. Phosphorus deficiencies after spring have been reported in common browse tissues by Blair and Halls (1968) and Halls *et al.* (1957), and in range forage by many authors. Only occasional herbaceous species contain adequate phosphorus during autumn and winter (Causey 1964). The phosphorus content of several mushrooms was 0.20 to 0.58 percent, legume and pine seeds nearly 0.60 percent, and grass seeds and several fruits about 0.25 percent, while acorns were clearly deficient with only 0.10 percent (King and McClure 1944).

FOREST MANAGEMENT AND DEER NUTRITION

The population and physical size of deer on upland habitats in the South are limited by malnutrition. Even when they are abundant, forages grown on poor soils often have high carbon and fiber contents and seasonally inadequate levels of net energy, protein, and essential minerals. Some studies indicate that deer partly compensate for poor roughage quality by utilizing a large variety of supplemental foods, including fleshy fruits, seeds, nuts, fleshy fungi, and succulents.

In many instances, manipulation of the canopy on upland sites may simply increase the supply of roughages which are seasonally deficient in important nutrients. Habitat managers should consider alternatives to provide nutritious foods if large numbers of quality deer are to be produced on upland habitats. Supplements might be provided directly to forest deer. A better approach might be to fertilize areas within the forest and seed plant species selected for palatability and high nutritional quality during seasons when many unmanaged deer foods are deficient in essential nutrients.

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Seasonal Changes in Movements of White-Tailed Deer

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Locations of 36 white-tailed deer tagged as fawns in a 2,322-acre enclosure at Radford Army Ammunition Plant were recorded almost every month for the first 2½ years of their lives. Striking changes in movement occurred during hunts when more than two-thirds moved outside their normal ranges. Almost 40 percent of the yearling bucks moved outside their normal ranges during the rut, but none as far as ¾-mile from the center of activity. At 2½ years of age, however, 60 percent of the bucks moved outside their normal ranges, 30 percent moving more than ¾-mile. Does did not move outside their ranges during the rut. Another period of increased movement was the summer, especially June. The one observed permanent change in range took place during this time. Many deer extended their ranges in summer but continued to use most of their original ranges. These results are compared with other movements reported in the literature.

Most studies have shown the white-tailed deer *(Odocoileus virginianus)* to be a relatively sedentary animal during most of its life. However, under some circumstances it will extend or shift its home range, disperse, or even migrate. Long movements are documented in the Northern States due to work by Shiras (1935), Bartlett (1938), Dahlberg and Guettinger (1956), and Carlsen and Farmes (1957). Only a few movement records are available from the milder climates (Progulske and Baskett 1958; Thomas *et al.* 1964; Michael 1965; Leuth 1966). In addition, almost every State has instances of deer having spread from small nucleus herds to occupy adjacent and sometimes distant ranges. We should keep in mind that we are dealing with a potentially mobile species that has shown the ability to seek solitude, cover, and better food in rather distant places, and to escape from floods, fire, deep snow accumulations, predators, and hunters if necessary. It seems that the majority of the deer in the South do not move very far during their lifetimes, since they may be responsible for the spread of the species into unoccupied habitat. Sanderson (1966, p. 231), discussing another problem associated with mammal movement studies, very aptly stated, "Emphasis will have to be shifted from the movements themselves to the reasons for the movements."

We have begun a study to determine the reasons for long, irregular deer movements and will attempt to interpret our findings for the information of others. This will be followed by a discussion of the significance of these movements as they relate to similar published and unpublished reports. Our work was done in a 2,322-acre area enclosed by an 8-foot high chain-link fence at the Radford Army Ammunition Plant, Dublin, Virginia. The enclosure contained 200 to 450 deer during the study period from 1965 through 1968. During these 4 years, 177 fawns were captured and marked for long-range visual identification. Primarily, we will discuss the irregular movements observed for 36 of the 60 fawns marked in 1966, with occasional reference to interesting movements of other individuals in the area. Our discussion emphasizes irregular movements because they seem more likely to result in dispersal or changes in range. Irregular movements are those generally ½-mile or more from the center of home range activity. We are deeply indebted to personnel of the Radford Army Ammunition Plant for their cooperation and assistance in this study. Special thanks are due Lt. Col. John W. Sevareid and Lt. Col. Dewey G. Weeks.

METHODS

The fawns captured in 1966 were born between May 26 and June 13 and were captured at 1 to 12 days of age. Each fawn was uniquely marked with 2½-inch long streamers of ½-inch wide plastic tape affixed to the lower edge of each ear by means of aluminum "Perfect"[2] ear tags (Salt Lake Stamp Co., 380 W. Second South, Salt Lake City, Utah). Observations were made almost every month to identify individuals and to study their movements and behavior. The habitat, which is mostly rolling, open grassland, has scattered clumps of hard-

[1] Cooperatively supported by the Bureau of Sport Fisheries and Wildlife, Virginia Polytechnic Institute, Virginia Commission of Game and Inland Fisheries, and Wildlife Management Institute.

[2] Reference to trade names does not imply endorsement of commercial products by the Federal Government.

woods and cedar, and several young pine plantations. Because nearly 90 percent of the area is visible from a network of paved roads, 1,447 observations of the 36 deer under study were made during the 32-month period. The least number of sightings for any of the deer markeo in 1966 and discussed here was 19, the most was 108, and the mean was 43.

To define some point from which to measure plotted movements for each deer, we established a center of activity based on all observation points recorded during its first year of life. This center point was the intersection of a north-south and an east-west line, each line equally dividing the observation points. With only two exceptions, this point proved to be within or very near each deer's annual home range as ascertained in subsequent years.

RESULTS

Hunting Season Movements

All observations during November 1966 were on hunt days. Up to 80 archery hunters per day were allowed in the area, and virtually every clump of trees was occupied by one or more hunters. Deer soon learned to stay in the large openings, and even here they wer sometimes stalked by impatient archers. Harassmer of the deer was probably as intense as with any othe type of hunting except dog hunting, and a great de of movement was noted for all sex and age classes (fig 1 and 2). Even so, most deer were seen near their cente of activity on hunt days and no change in home rang resulted.

Movements to Seek Food and Cover

Two sources of unusual food were provided during th study. A 22-acre stand of hardwoods clearcut in earl summer of 1968 seemed attractive to deer during earl fall and winter; 27 being seen there at one time. How ever, no significant long-range movement of tagged dee to reach it was noted. A 20-acre planting of new gras in early fall, 1968, proved extremely attractive to dee 133 were seen feeding there at one time. Neverthele no marked deer were observed to move a great distanc to reach this planting.

We have too few winter observations to draw co clusions about long-range movements during this se son. Several deer made relatively long movement during the winter, but no change in range resulte

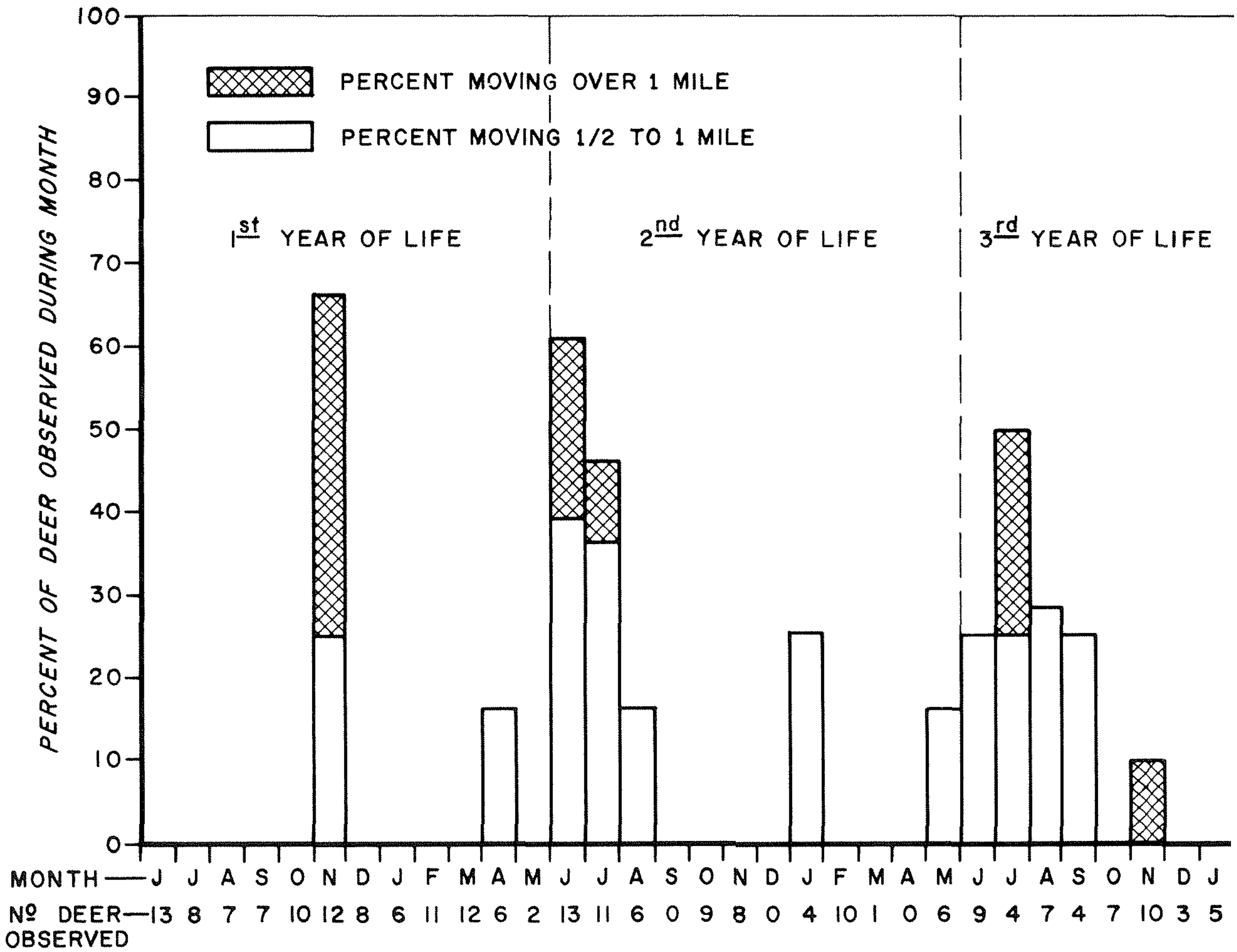

Figure 1.—*Percent of female deer moving ½ to 1 mile and over 1 mile from center of activity, Radford Army Ammunition Plant, Virginia.*

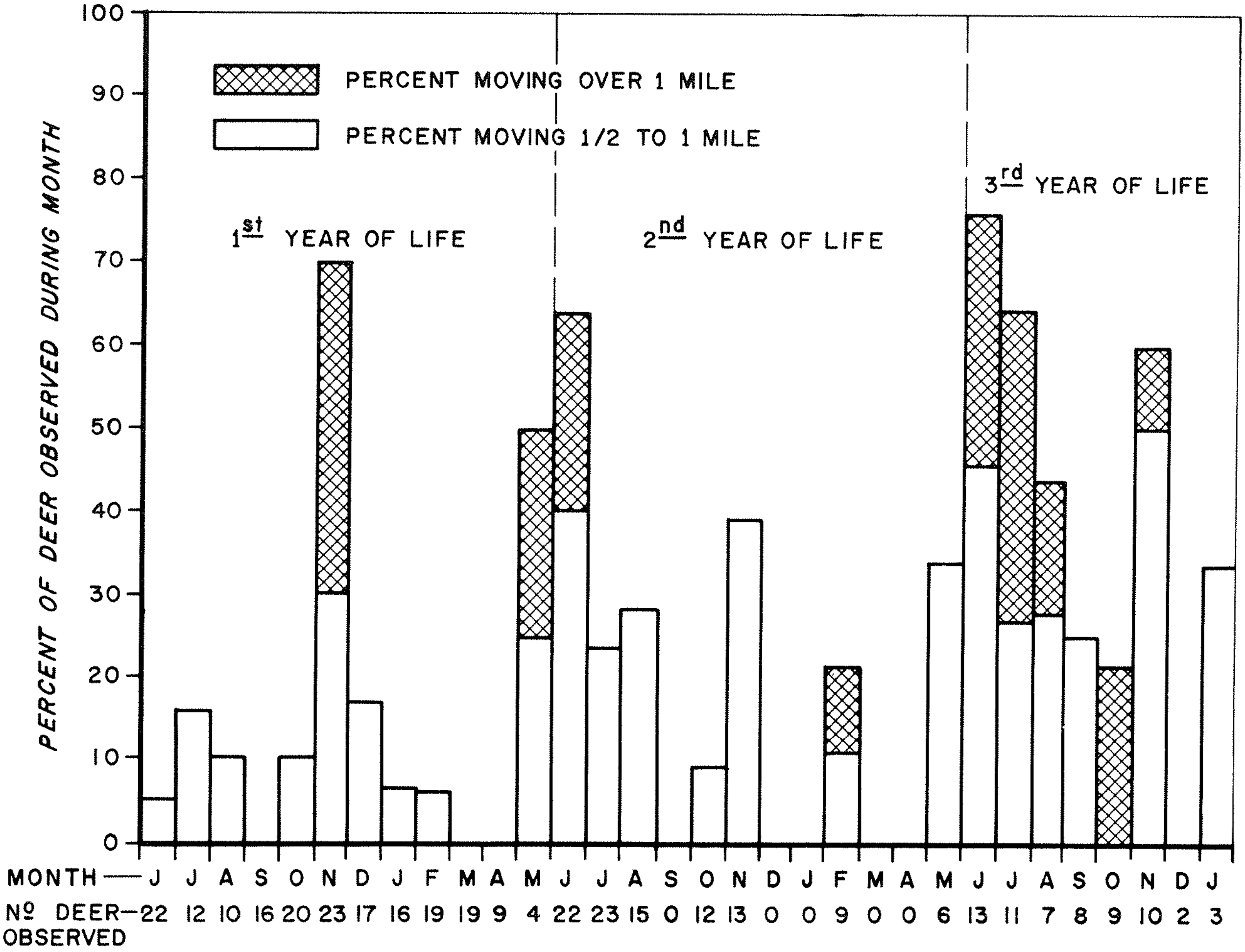

Figure 2.—*Percent of male deer moving ½ to 1 mile and over 1 mile from center of activity, Radford Army Ammunition Plant, Virginia.*

However, no long movement to reach food or cover was expected, because most home ranges appear to offer plenty of each.

Breeding Season Movements

It is noteworthy that none of the eight does observed in November—their normal breeding month— was seen more than ½ mile from the center of activity in 1967, and only one of 10 more than ½ mile in 1968 (fig. 1).

Many bucks were seen outside their home range during the rut, but usually they were not actually chasing does, and several were alone or with other bucks. A different behavior due to age seemed apparent during the actual rut, as a higher percentage of the bucks moved longer distances during November 1968 than during November 1967 (fig. 2). Too few 3½ year old bucks were observed to indicate whether this greater movement with increased age applies to older age classes.

No permanent change in range resulted from rutting movements; however, one 3½ year old buck was observed three times during a 2-week period more than 1 mile from his normal range. This buck was seen in the same area during the rut as a 2½ year old but returned to his original range for the remainder of the year.

Summer Movements

Only one of the 13 does ventured more than ½ mile from her center of activity during the first year (note April 1967 in fig. 1). However, a marked increase in movement was noted during June 1967 when 39 percent of the 1-year-old does moved ½ to 1 mile and another 23 percent moved more than 1 mile. This increased activity continued through July and apparently subsided in August. Movements beyond ½ mile were noted again during the summer of 1968 when the does, now 2 years of age, again frequently moved more than ½ mile from their center of activity. Seven does tagged in 1965 exhibited a similar pattern of increased movement during the summer at ages 1 and 2, but failed to show any increase in movement at age 3.

Long summertime movements of bucks at 1 and 2 years old were similar to those of does, but they began these movements earlier. There was also a tendency for summer movements of bucks to increase with age (note the higher percentage and longer duration of buck movements at age 2, fig. 2).

One seemingly permanent change in home range that could be regarded as a dispersal took place. One male marked in 1966 moved from his home range of the first year to a new one more than a mile distant sometime between April 5 and June 2, 1967, and has never been seen since within the original home range. Two other males shifted their home ranges in June 1968, but still use a small part of their original ranges. If the deer had not been enclosed within a fence, perhaps more of them would have moved greater distances and found more favorable habitat. This supposition is based as much on behavior of the animals as on distance moved. In many of the cases in which yearlings were observed outside their normal range during June and July, they were alone and obviously "on the move." This behavior was evidenced by rapid walking or running, which resulted in their being seen several times in the same hour in distant portions of the enclosure. Such behavior was commonly observed during the early June fawning time and may have been triggered by their mothers' antagonism toward them during this period.

DISCUSSION

Escape from Hunting

Deer do not seem reluctant to make whatever movements are necessary to escape a markedly unpleasant situation. Schoonmaker (1938, p. 504) said, " . . . when persistently hunted the animal is apt to go beyond the limits of the home range. Also, when wounded and tracked by hunters and when trailed by dogs the deer may leave its territory, but barring death or accident it usually returns." Progulske and Baskett (1958) reported a deer being chased 3¼ miles in ½ hour by dogs. Tester and Heezen (1965) also reported a deer that moved 1 mile outside its home range during a drive census. During the same drive, however, another telemetered deer stayed within its home range.

Urbston (personal communication), working at the Savannah River Project, Atomic Energy Commission in South Carolina, reported that a buck tagged as a fawn May 15, 1967, was killed by hunters 14.5 miles distant in November 1968. Dog hunts were conducted near the capture site in 1967 and again in 1968, only 3 weeks before the date of the kill and may have contributed to this movement. However, hunting did not fully account for the movement, since pressure was higher where the buck was killed than in his original home range.

Marchinton (personal communication), working in the same locality as Urbston, chased a telemetered buck with dogs several miles outside his normal range on several occasions and found that the deer returned home within a few hours. However, on one occasion, the chase was continued with fresh dog packs, and the buck moved over 7 miles from his normal range. Instead of returning immediately, he worked his way back very slowly, taking 2 weeks to return. Then he stayed only 1 or 2 days before resuming his movements, becoming for a while a wanderer. This wandering behavior coincided with the rut and may have been due to breeding activity. Nevertheless, the buck has not yet returned home, but has taken up residence in an area of higher deer pop lation 3 miles from his original range. Most of the mov ment of Marchinton's deer was on its own and not wh being chased, but was undoubtedly triggered by t initial chase.

Our Radford deer readily reacted to hunters by movi considerable distances within the enclosure. More th two-thirds of the deer we studied moved outside th normal ranges during hunts, many of them going as f as the enclosure fence would allow.

The fact that movements take place during hunti makes us wonder how well hunter returns of tagg animals represent normal dispersals and migrations, a how much of this movement is of a temporary natu taking place only during hunt days. We have not prov that permanent changes in range occur as a result hunting, but we do know that hunter returns of tagg deer do not necessarily indicate the normal range of t animals.

Migrations to Reach Better Food or Cover

Studies of deer migrations in Northern States ha shown that deer move many miles to escape deep sno or to obtain better food and cover. Severinghaus an Cheatum (1956, p. 158) said, " . . . it appears that migr tion movements are minor or nonexistent in deer rang where seasonal contrasts in weather are not great. Whe contrasts are marked, in mountainous regions, and acro the Northern United States and Canada, seasonal migr tions of white-tails are common and sometimes pr nounced."

Severinghaus and Cheatum (1956) cite studies whi indicate that in severe winter weather, cover may more important than food. They also said (p. 158), "T spring movement back to summer range appears to a release from a restricted food supply during which t animals move out to the newly available spring forage

Ruff (1938, p. 29), in discussing the mild winter 1937-1938 in the high mountains of North Carolina, sai "As the weather remained unusually mild and the grou free of snow, a large number of animals remained these areas all winter, not moving into lower count until the last of March or early April, when early gre growth was available as food. Thereafter, as the grow advanced into higher altitudes, the deer again follow it upward." The senior author noted a similar altitudin movement in the North Carolina mountains during 196 An adult doe was captured and equipped with a rad transmitter in January 1968 near a food plot where s had previously been captured more than a year befo During a week of radio tracking, she remained with ½ mile of this location (elevation 2,200 to 2,800 fee The transmitter ceased functioning after about 10 day but the doe, her tagged fawn, a tagged yearling buc and several untagged deer were seen repeatedly for t next 2 months in or near the same food plot. About t first of April she and the other deer were seen movi downstream from this plot. A few days later the enti group was seen over 6 miles downstream in a broad fl valley at least 1,000 feet lower in elevation than h original location. The date of this movement coincid with spring green-up at lower elevation. Several wee later this doe was seen again in the mountains where she was originally tagged.

Progulske and Baskett (1958) and Michael (1965) reported short migrations not connected with mountainous terrain. Ellisor (1969) noticed that marked deer moved across an intermittent stream during winter to reach a patch of oats. He also noted that a heavy stocking of cattle caused 13 marked deer to move an average of more than 1 mile to a moderately stocked range, but it is not known if this was caused by disturbance or by a change in habitat. Dahlberg and Guettinger (1956, p. 59) said, "It is an established fact in Wisconsin that nothing will move deer like a logging operation. Where these operations are begun before heavy snowfall and conducted in suitable cover, they inevitably attract deer that apparently have previously wintered elsewhere. Artificial feeding, when begun early in the winter before deep snows, seems to have a similar effect."

At Radford, we observed only one buck more than 1 mile from his normal range during the winter, and he subsequently returned home. No portion of the enclosure affords better food or cover than any other, so little winter movement was expected. The clearcutting and new grass plot were attractive to deer, but no marked deer moved to them during summer and fall. Choice foods were exhausted before the colder periods of winter. Our actual count of 133 deer feeding on a small grass plot indicates that deer will move to a choice food supply. Movement of this type may be more common than is generally recognized.

Breeding Season Movements

Schoonmaker (1938, p. 504) said, "A buck in quest of a mate may travel far during the rutting season . . . . " Marchinton (1968) noted two unmarked bucks during the rut in an area where they had never been seen before. He also noted that one marked animal moved a mile outside his range during the same period. Marchinton (personal communication) also reported a buck near Athens, Georgia, that moved 2 to 3 miles outside his normal range during the rut. Ellisor (1969) reported a buck that moved 2.6 miles between observations during the breeding season in brush habitat in south Texas. However, no permanent changes in range as a result of rutting activity have been reported. Farther north, it may be difficult to separate these activities from normal migrations. Most States set hunting seasons to coincide with the rut; therefore, movements to escape hunters may confound rutting movements and migrations. We suspect that when a great deal of movement takes place during the rut, a few individuals are apt not to return home. We are therefore suggesting that the rutting period may be another time of dispersal. Our data suggest that bucks are more apt to move during rutting than does.

Summer Movements

Severinghaus and Cheatum (1956, p. 119) said, "The summer season for deer is a quiet, lazy time. The bucks are being careful of the ultrasensitive growing antlers, and the does are tending their young." We have not found this to be true. More than two-thirds of the 1- and 2-year-old deer in our study made relatively long movements during summer, especially during the peak of the fawning season in June. Track count data presented by Downing *et al.* (1966) indicate that significantly more movement was recorded in June than in August, but June track counts were less than October, a breeding month in south Georgia. Marchinton (personal communication) reports that a buck that was radio-tracked for 7 months at Eglin AFB in Florida took a 1- or 2-day excursion more than 2 miles from his normal range during summer.

In discussing movements of mule deer *(O. hemionus)*, Leopold *et al.* (1951, p. 48) said, "During the summer the does rear their fawns; the yearlings being temporarily dispossessed, tend to disperse and wander . . . . " Miller (1966), in a study of black-tailed deer, a subspecies of mule deer, noted more extensive movements during May and early June, which he called a prefawning shift.

If the normal pattern of June movement is everywhere as extensive as noted at Radford, why has this not been noted more frequently from the recent rash of telemetry studies? We can offer only one explanation—few of these movements result in a permanent change of range, and since deer usually move extensively for only a short period of time, the movement may go undetected.

CONCLUSIONS AND RECOMMENDATIONS

In spite of numerous studies showing that deer movements are confined within a small area, there is ample proof that under some conditions permanent changes in range take place. Our study has shown that irregular movements may be expected during three periods of the year: (1) Hunting seemed to cause extensive movements of all age classes. (2) Mature bucks moved considerable distances during the rut. These movements were not known to be permanent. (3) Summer movements involved yearling and 2-year-old deer and were most prevalent during fawning season. Our limited data and the limited size and diversity of the study area failed to show any winter movement that could be considered a migration.

Future movement studies should be conducted during hunts, the rut, and during the peak of fawning. Researchers should look for factors that trigger long movements. An attempt should be made to correlate habitat and disturbance conditions of old and new locations with the adoption or rejection of the new environment. We know of many locations in the southeast where deer are spreading into adjoining good deer range rather rapidly, while other areas that look as good remain unoccupied.

Is there a disturbance factor such as free-ranging dogs that needs control during these periods of greatest movement? Is hunting pressure too high on the "outside" of herd nucleus areas because of overly restrictive regulations inside? In other words, could hunting or other disturbances be utilized to drive deer into unoccupied habitat rather than out of it? Could particularly choice food patches or browse cuttings be used to draw deer into unoccupied territory? Through the use of proper stresses and enticements, might it be possible to create widespread annual migrations where none had occurred before? We hope that these questions will stimulate your thinking and possibly some additional research on this subject.

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Deer Predation in North Carolina and Other Southeastern States

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A questionnaire survey of wildlife management areas in the southeastern United States indicates that predation by free-running dogs and bobcats accounts for 6 and 2 percents, respectively, of the annual drain of deer thereon. This compares with 63 percent through legal gun harvest and 20 percent through illegal hunting.

STUDY OBJECTIVES

The primary objectives of this study were to identify the principal predators of deer in the southeastern United States and to determine their impact on deerherds and deer management. In doing this we have attempted to also identify other forms of deer mortality and assign numercial values to each, in relation to total population and annual drain.

STUDY PROCEDURE

In conducting a study such as this, two general approaches might be considered. One would be to study intensively a single or small number of areas over a long period of years. Another method would be to study less intensively a larger number of areas over a shorter period of time. Since we were assigned this subject only a few months ago, we chose the latter course.

The individual study units were manned wildlife management areas rather than counties or States since it was felt that personnel on such areas could provide the most nearly accurate information due to their close personal observation of limited land areas. While predation is usually "controlled" on such areas, the magnitude of loss in spite of control, as well as extent of control exerted, provide valuable insight into the magnitude of the predation problem in localities not subject to intensive protection.

To secure information on these areas, a questionnaire was devised for completion by resident wildlife area managers throughout the southeast. The questionnaire was filled out by all area managers in North Carolina that have any responsibility for deer management—28 in all. Each man was sent a copy of the questionnaire and instructed to study it but *not* fill it out. They were filled out in the course of a series of meetings attended by the author so as to insure clear understanding of the meaning and intent of each question.

Five copies of the questionnaire were sent to the director of each southeastern State with the request that they be completed by managers of five representative areas. Completed questionnaires were returned by 10 States (Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, Oklahoma, South Carolina, Tennessee). Some States enclosed supplementary information with their replies and one State (Virginia) sent relevant information in place of the completed questionnaires.

Thus, the study is a compendium of replies to a questionnaire completed by resident managers of wildlife areas, and an evaluation of these replies.

It is obvious, of course, that our evaluation of data from other States is more tenuous than that of North Carolina data. Thus, our report is based primarily on North Carolina data, with somewhat gross checks for corroboration and comparison in other States.

STUDY UNITS

Manned wildlife management areas in North Carolina range from 6,000 acres to over 86,000 acres in size. The larger ones have several managers assigned and the average assignment per manager is about 15,000 acres. However, some are assigned as few as 6,000 acres while others have over 28,000 acres.

Managed hunts are conducted on all but one of the North Carolina areas included in this study. The deer harvested are brought through check stations. Resident area managers spend a substantial portion of their time through the year patrolling for illegal hunting and they are authorized by law to kill dogs running deer as well as to control other predators.

A limited amount of food planting and browse cutting is done but in most cases this provides only a very minor portion of the total food supply. In most cases basic productivity of the land is lower than that of surrounding privately-owned land. Deer populations are considered to be at or above an estimated capacity of one per 50 acres since annual harvest averages less than 200 acres per kill.

Wildlife management areas in States other than North Carolina included in this study are similar in some respects and different in others. Some areas are much larger and some are much smaller. Some do not have resident managers and some have professionally trained biologists as managers. Most provide public hunting but some are recently established areas that have not yet been hunted and at least one is a refuge area closed to all hunting.

QUALITY OF DATA

While this does not pretend to be a "scientific" study in which basic data are compiled by trained biologists, it does, in our opinion, contain the best information available within the specified limitations of time. The North Carolina data may be characterized as having four degrees of reliability:

1. Numbers of deer killed and checked out on managed hunts may be considered to be as near accurate as field data can be.

2. Mortalities classed as "known" or "observed" are, in about one-third of the North Carolina data, based on records kept by the area manager. In other cases it was purely memory, or a combination of some records, and memory.
3. "Estimates" of mortality were based on the assumption that it would be impossible to observe all mortalities and therefore "estimated" mortalities are greater than "known" mortalities. It was also assumed that values for "estimated" mortality more closely approximated actual mortality than did values for "known" mortality.
4. "Estimates of potential mortality" might also be called "educated guesses" and would, of course, have the lowest level of reliability.

Examination of replies showed some "estimates" as being extremely low and others as extremely high. However, there was throughout a fairly close grouping about the means. There might have been some reluctance to divulge information on extent of dog control in spite of legal authority for same but we believe this was, to a substantial extent, overcome by assuring anonymity.

ANALYSIS OF DATA

North Carolina data indicate that predation of deer reaches significant levels only in the western mountain section of the State. It also appears that predation is least significant in the Eastern Coastal Plain section which is characterized by vast wetland areas. Accordingly, the data are grouped so as to derive average values for 23 mountain areas, three Coastal Plain areas and two mid-State Piedmont areas. While no attempt was made to similarly regionalize the data from other southeastern States, it was obvious that the predation problem is considered to be much more serious on some area than others.

The questionnaire specified that all data be in refer ence to one single calendar year—January 1 throug December 31, 1968—so that averages derived could b considered as *annual* values. Also, since much of th study is concerned with western North Carolina area where dog predation is a significant problem, and sinc these areas average about 15,000 acres in size, averag figures in regard to them may be considered as annua values for 15,000-acre units.

Data in regard to individual area size and numbers o dogs controlled were omitted from tabulations to assur anonymity and to preclude controversy irrelevant t the purpose of this study.

Respondents were asked to indicate whether their re plies in regard to dog predation were based on records memory, or both so as to provide insight in regard t reliability. Of 23 western North Carolina area managers nine indicated that their replies were based on records seven on memory, and seven on some of each. In com paring the number of dogs reported controlled by thos in each group, both the range in values and averag values were quite similar. The observed number o deer killed by dogs, however, varied substantially. Thos basing replies on records averaged 0.7 observed dee killed per year per 15,000 acres while those basing replie on memory averaged 1.6 and those basing replies on bot records and memory averaged 2.9. In spite of thi divergence, the average of estimated deer kill per are was almost identical—11, 9, and 10, respectively. Whil these observations may not be a reflection of reliability they do indicate a considerable consistency and the prob ability that this element of consistency characterize all estimates.

Protective coloration and meager body scent protect this fawn from predators.

In the case of both dog predation and bobcat predation, questions were asked in regard to control so as to verify the presence of these predators on the areas. Similarly, a question called for the number of poachers apprehended to determine the level of concern with illegal hunting and illegal kills.

In computation of total drain and total population, values for *estimated* losses rather than *known* losses were used. This approach was used because *known* losses are obviously minimal and it is obvious that many unobserved losses occur. Hence we assumed that *estimated* losses would more nearly approximate the actual. The term "total drain" is defined as all removals of deer from the population, whether by death or live transfers.

Total deer populations were computed in the same manner on each area, in accordance with an obviously arbitrary procedure. It was assumed that the populations were stable on all areas, i. e., that reproduction added 25 percent to the spring population and that annual drain removed this number by the following spring.

Since these computations were based on the assumption of a 25 percent increase through reproduction, the "total population" was considered to be five times the annual reproduction which was considered to be the same as the annual drain. Hence "total population" was computed as five times the annual drain.

While these assumptions are rather gross, they are nevertheless reasonable and well within the "ball park." Since there was no evidence of starvation or disease during the survey year, no allowance was made for it. Also there was no attempt to include consideration of prenatal mortality or immediately postnatal mortality.

PREDATION BY DOGS

There are some skeptics who question the ability of dogs to kill deer. Some claim that they are capable of killing only fawns or pregnant does or deer that have been wounded by hunters or incapacitated by disease or parasites. While there may be reason, in some cases, to question reports even of "known" kills by dogs, we have too many reliable reports of observed kills of healthy deer to discount dogs as predators. In addition, many deaths by car, train, fence, drowning and cold water shock may be attributed to chasing by dogs.

Most dog kills occur in the mountain region of North Carolina where swamps and lakes are not available as means of escape (table 1). However, each year we receive reliable reports of a few deer being run down and killed by dogs on eastern wetland wildlife management area hunts where the use of dogs is allowed. (Use of dogs in hunting deer is not allowed in the central and western parts of North Carolina.)

None of the several hundred dogs controlled on western North Carolina areas were accompanied by their owners but 62 percent of them showed signs of being owned and even the "strays" showed signs of domesticity. In questioning area managers about this point we attempted to determine whether any of the "strays" could be considered as true wild dogs that had been born and reared in the wild and had developed into a special breed completely independent of civilization. None of the area managers could certify to this development. On the contrary, most "strays" were described as appearing to be recently separated from human ownership.

Table 1.—*Deer losses in 1968 on manned wildlife management areas in western, central, and eastern parts of North Carolina (values are averages per area)*

Item	23 areas in western part; avg. size 15,413 acres	2 areas in central part; avg. size 12,518 acres	3 areas in eastern part; avg. size 38,933 acres
		NUMBER	
Dogs			
Observed kill	1.6	2	2
Sex of deer killed [1]	.4-.7-.4		
Estimated kills	10	7	6
Potential kills	37	10	7
Bobcats			
Observed	.4	0	1
Estimated	6.2	1	2
Illegal kills on hunts			
Known or observed	3.4	5	6
Estimated	14.0	10	13
Other illegal kills			
Known	2.0	2	2
Estimated	8.0	4	21
Potential illegal kills			
On hunts	87.0	110	183
Other	174.0	220	333
Legal kills lost			
Known	3.2	1	5
Estimated	9.1	5	11
Other mortalities [2]			
Observed	4.5		
Estimated	12.0	14	31
Legal kills and collections			
Archery hunt	2.6	30	4
Buck hunt	33.0	48	61
Either-sex hunt	39.0	47	53
Other collections	.9	0	0
Total	77.0	125	118
Total drain			
Known	91	139	155
Estimated	136	161	220
Computed deer population based on known drain			
Fall population	457	695	777
Acres per deer	58	60	60
Computed population based on estimated drain			
Fall population	682	805	1,095
Acres per deer	30	38	47
Annual drain composition (based on estimated drain)		PERCENT	
Checked out legal kills	52	60	57
Lost legal kills	6.6	4	8
Illegal kills on hunts	9.6	3.5	9
Other illegal kills	6.7	3.5	9
Killed by dogs	9.5	7.0	4
Killed by other predators	5.1	.5	3
Miscellaneous kills	9.7	22	10

[1] Figures in column are numbers of adult bucks, adult does, and fawns.
[2] Includes fences, cars, disease, cliffs, trains, study collections, drownings and cold water shock and predation by bear and fox.

Dog ownership was even more evident on eastern areas where most dog control activity occurred during the hunting season. (Use of dogs is allowed in deer hunting in this section.) Only about 5 percent of the dogs were strays and 89 percent of the dogs were picked up during the hunting season. Thus, dog predation is not a year-round threat in eastern swamplands. In strong contrast, however, dog activity, as evidenced by season of control, was practically uniform throughout the year on western areas (table 2).

Table 2.—*Percent of stray dogs controlled, by season of year, on North Carolina wildlife management areas where dogs are or are not allowed in deer hunting*

Season	Dogs allowed	Dogs not allowed
	--- *Percent* ---	
Spring	5	25
Summer	6	17
Fall	53	32
Winter	36	26
	100	100

On eastern areas most dogs controlled were deerhounds (85 percent) with the remainder about equally divided between beagles, bird dogs and "mixed" breeds. On western areas 54 percent were mixed breeds and 28 percent were hounds. Most of the remainder were beagles, shepherds, and collies. Eighty-three percent were in the act of chasing deer when they were controlled and 9 percent had actually cornered their quarry and were in the act of killing or feeding on them. In most of these cases the deer were saved and only 37 "known" deer kills were listed. They included 10 fawns, 17 does, and 10 bucks. The number of "known" dog kills per area varied from zero to nine and averaged 1.6 on western areas.

On intensively protected wildlife management areas in western North Carolina, the average annual loss of deer to dogs per 15,000 acres is 1.6 known, 10 estimated, and 37 potential (without dog control). The reliability of the figure for potential kill is of course a matter of opinion. I will only observe that, while predation is pretty much an around-the-clock process, the area manager's various duties—not to mention his need for a night's sleep—keep him from hearing more than a fraction of the dog races.

To further explore the impact of this level of predation, let us consider two hypothetical examples. Consider first a 15,000-acre area with a deer population of one per 50 acres or a total population of 300 deer and, at a 25 percent reproduction rate, an annual increment of 75 deer per year. In this case a dog predation rate of 37 deer per year would remove 50 percent of the annual increment. Next consider another 15,000-acre area, less remotely located, closer to human habitation, more heavily infested with free-running dogs, that has been stocked with 50 deer. It is immediately obvious that unless dog control is initiated prior to stocking, the deerherd will have little, if any, chance to exist, much less multiply and expand.

It is also obvious that under such circumstances, control of free-running dogs is the most important single function of the wildlife area manager. These considerations also underline the importance of his being headquartered *on* the area rather than in town several mile away. And it also demonstrates the importance of havin legal authority to exercise control.

One further aspect of dog predation should be con sidered, namely that of ownership, for herein lies th crux of the problem. If dogs were wild animals rathe than personal property it would be a relatively eas matter to bring them under control. But the fact tha dogs are personal property precludes some very effectiv control procedures. And the fact that they are mas produced by people on a "sustained yield" basis, an not only allowed but actually encouraged to roam un controlled, magnifies tremendously the problem of dee restoration.

However, these circumstances also identify the solutio to the problem, i. e., cooperation of dog owners by keep ing their dogs confined. Thus, the best tools for contro of this problem include magazine and newspaper articles radio and personal communication. Also helpful is cour prosecution of people who allow their dogs to run dee where prohibited by law. Since actual control of dog by wildlife protectors is limited to designated wildlif management areas, establishment of deerherds by over flow into the surrounding areas is virtually impossibl if the local people are not sufficiently concerned t control their dogs.

While most of this section on Predation by Dogs i based on data from western North Carolina wildlif management areas, data from other States indicate tha the problem is not peculiar to North Carolina. Replie to questionnaires indicate that this is also a seriou problem in parts of Georgia, Virginia, Tennessee, Oklahoma, South Carolina, and Mississippi.

PREDATION BY BOBCATS

Bobcats are the third most important predator—afte man and dogs—on deer in the southeast (table 3). Thirtee "known" kills were reported for 1968 by North Carolina wildlife area managers and 151 "estimated" kills. Reports from 10 of the 11 States responding to our questionnaire indicated an "estimated" 201 deer kills on 51 area aggregating 2,906,985 acres. This indicates that th bobcat has been able to survive in good numbers i remote localities throughout the southeast. It woul appear that most "wild areas" of 10,000 acres or mor have at least a few bobcats.

While some may question the ability of a 25-poun bobcat to kill a deer several times its own weight, ther has been a sufficient amount of testimony to this effec from our own personnel to convince us that this doe take place. Furthermore, review of the survey figure indicates that this has the potential of being a mor serious problem than commonly suspected. Whil "known" bobcat kills of deer averaged only 0.4 pe 15,000-acre area in western North Carolina, and thi figure is only one-fourth the value derived for "known dog kills, many of the dog kills were the result of race intercepted by the area manager. In contrast, cat kill are silent and usually in more remote localities tha dog kills, and furthermore cats usually cover their kill thus making them even less likely to be discovered b man. Thus, it is not at all inconceivable that cat kill

Table 3.—*Annual drain of deer on wildlife management areas in southeastern United States (as estimated by area managers)*

State	No. of areas	Total acreage	Hunter kills: Retrieved legal	Unretrieved legal	Illegal	Predator kills: Dogs	Bobcats	Wolves	Panthers	Coyotes	Bears	Miscellaneous kills: Cars	Fences	Trains	Cliffs	Ticks	Drownings	Disease	Shock	Study collection	Unknown
Arkansas	8	562,340	448		238	13	45	32				109	1					1			
Florida	5	542,060	1,239		152	16	8		3			221	4								
Georgia	7	152,000	632		104	82	10					2	2		1						1
Kentucky	5	183,300	642		464	30						44	2								5
Louisiana	4	128,000	895		38	12	25						1							1	7
Mississippi	4	481,000	537		197	47	3					43	35								
Missouri	6	45,285	178		17	3	2					12									3
North Carolina	28	499,330	2,366	253	638	271	151				9	112	1	25	14		11	6	5	1	
Oklahoma	3	226,000	665		586	285	65			35		94	4	8	4	15					16
South Carolina	4	218,000	836		93	54	33					28	1					2			
Tennessee	5	267,000	930		302	72	10					59	6		4			1			
Totals	79	3,304,315	9,368	253	2,829	885	352	32	3	35	9	724	57	33	23	15	11	10	5	2	32
Percentages			63	2	20	6	2		0.5			5				1.3					

Grand total of deer drain, all causes—14,678.

could approximate and even exceed dog kills on areas where the cat population is not kept under control.

The potential kill by bobcats may be further explored by considering that on those areas where cat control has been exercised the annual take of bobcats has ranged from one to 15, for an average of 4.5 per 15,000-acre area. On a few areas trapping has netted an average annual catch of six to 10 cats per year. Thus, if annual reproduction of cats averages about 25 percent, the normal November population could average about 40 cats. The average of western North Carolina area managers' estimates of cat populations is a very reasonable 43 per 15,000-acre area.

We are thus led to the conclusion that an uncontrolled bobcat population *could* increase to the point that it consumes about half the annual reproduction of a 300-animal herd with a 25 percent reproductive rate on a 15,000-acre area. This level of drain, in addition to that due to stray dogs, would be capable of wiping out an established herd and certainly capable of preventing the establishment of a new herd.

In contrast to stray dogs, which are domesticated animals rather than a part of the native fauna, bobcats should be considered to have a rightful place on wildlife management areas. In addition to the interest they engender, they also serve a useful purpose in removing weak and diseased animals, thereby preventing disease outbreaks. Reasonable control could probably be exerted by classing them as game animals and restricting hunting to declared open seasons.

PREDATION BY OTHER PREDATORS

Predation on deer by panthers in the southeast appears to be limited to the State of Florida (table 3). However, only one of the five Florida area reports showed the species present, with an estimated population of only five animals.

While bears are much more widespread, only a few North Carolina area managers listed them as potential predators. Only one "known" kill was reported and another report indicated fawn hooves in the spoor of a bear. The relatively low population of bears and the fact that their season of heavy feeding is in late summer leads us to discount the species as a serious predator of deer. In our opinion, bear feeding on deer is probably limited to carrion consumption.

Foxes were listed as suspect by several North Carolina area managers but none reported any "known" kills. Similarly, coyotes were listed as predators by area managers in several other States but none reported any deer kills by them.

Six of eight Arkansas wildlife area managers reported substantial populations of wolves but only two of the six indicated predation on deer. In one case an estimated population of 170 wolves was shown as killing an estimated 20 deer on a 150,000-acre area. On another slightly smaller area the wolf population was estimated at 185 and their predation on deer at 12. There were no cases of "known" kills of deer by wolves reported.

MISCELLANEOUS MORTALITY

Deer mortality by running into motorized vehicles was reflected at significant levels in most States. It is felt that this type of mortality is probably more obvious than that due to other causes and it is likely that these mortalities are much higher on less remote deer range than that of wildlife management areas covered by this study. Of 912 deer mortalities due to miscellaneous cases in 11 southeastern States (table 3), 73 percent were attributed to cars, 12 percent to fences, 5 percent to trains, 2 percent each to falling off cliffs and tick bite, 1 percent each to drowning and disease, 3 percent to unknown causes, and a trace each to cold water shock and study collections.

The overall average of these deaths on all southeastern areas was 4.6 per 15,000 acres per year. In a herd of 300 animals reproducing at the rate of 25 percent per year this would amount to a little over 6 percent of the annual increment. While this average value is not especially significant, individual values on some areas were very substantial. For example, 12 known car mortalities on a 7,000-acre area in Missouri made up 37 percent of the annual drain. In Arkansas, miscellaneous mortalities, mostly due to cars, accounted for 16 percent of the annual drain on eight reporting areas. On a 42,000-acre area in Tennessee, miscellaneous mortalities accounted for 26 percent of the annual drain. They accounted for 27 percent of the annual drain on a 100,000-acre area in Mississippi, and 30 percent on a 14,000-acre area in Oklahoma. Virginia data showed a statewide loss to vehicles of 1,502 deer in 1967.

ILLEGAL KILLS AND UNRETRIEVED LEGAL KILLS

Deer hunting on North Carolina wildlife management areas covered by this report is by daily permit and hunters are required to submit their bag for examination when they leave the area. Hence a complete record is secured of all legal kills. The areas have well developed road and foot trail systems in which the overall objective of having no part of any area more than ¼-mile from developed access has been brought to near accomplishment. Thus, it may be presumed that there are relatively few unretrieved kills.

Illegal hunting is held to a minimum by intensive patrolling, at the average rate of one wildlife protector per 15,000 acres. Boundaries are painted and posted with appropriate signs and large entrance signs are placed at major points of entry. Hunting and use restrictions are substantially more severe than those applying to adjoining "nonrefuge" public lands. Enforcement of hunting regulations on "nonrefuge" lands by "county" protectors averages about 200,000 acres per protector. Thus, intensity of protection on the management areas is about 13 times as great as throughout the State generally.

In spite of this intensive development and protection, there is a substantial loss to illegal hunting throughout the year, and to illegal kills during the hunting season (table 1). In addition a substantial number of legally killed deer are not retrieved. On 23 manned areas in the western part of North Carolina averaging 15,000 acres each, an average of 4.3 people were arrested per year for hunting deer illegally. The "known" loss to illegal hunting other than during the hunting season averaged 2.0 and the "estimated" average loss was 8.0 deer per year. The "known" loss due to illegal deer kills during the hunting season averaged 3.4 per area and the "estimated" number was 14. The "known" loss due to unretrieved legal kills averaged 3.2 deer per area and the "estimated" loss averaged 9.1.

Thus the total drain due to illegal hunting and ur retrieved kills was estimated to average 31.1 deer pe 15,000 acres per year. This amounted to 40 percent c the checked out legal kills which averaged 77 per 15,00

Table 4.—*Annual drain of deer on individual wildlij management areas in southeastern Unite States (based on estimates of area managers*

State	Predation by		Misc.	Hunter kills	
	Dogs	Other	mortality	Illegal	Legal
	Percent				
Arkansas	5	55	0	6	34
	0	25	2	18	55
	0	10	3	24	62
	19	0	23	58	0
	0	0	55	45	0
	0	0	10	31	59
	0	0	2	52	46
	2	4	33	7	54
Florida	Trace	0	17	4	79
	1	2	10	25	62
	6	2	6	15	71
	3	5	2	29	62
Georgia	2	2	1	12	83
	10	5	0	17	68
	3	0	3	20	74
	30	1	0	12	57
	14	0	12	12	62
	11	0	0	5	84
	2	0	2	10	86
Kentucky	3	0	20	13	63
	2	0	6	48	44
	0	0	0	25	75
	10	0	14	14	62
	3	0	15	25	56
Louisiana	0	0	1	2	96
	5	9	4	8	74
	0	0	1	1	98
	0	0	0	4	96
Mississippi	Trace	Trace	7	25	69
	26	0	27	15	32
	23	0	23	6	48
Missouri	0	0	0	5	95
	3	3	5	2	88
	3	0	37	29	31
Oklahoma	24	9	11	37	18
	10	0	30	44	60
	2	3	11	4	80
South Carolina	25	5	0	54	17
	3	1	7	4	84
	5	5	6	9	75
	4	2	5	7	81
Tennessee	0	0	1	36	63
	15	0	1	15	70
	9	6	17	10	58
	3	0	26	10	61
	1	0	4	10	85

acres. This is also three times the loss to stray dogs and five times the loss to bobcats. Thus, more deer are wasted by sloppy and illegal hunting than through both dog and bobcat predation combined. Man is not only the most effective predator but also the most wasteful.

LEGAL HARVEST

Legal harvest of deer on southeastern wildlife management areas open to hunting accounts for only a little over half of the annual drain (table 3). On some areas it is estimated to be as low as 14 percent of the annual drain while on others it is estimated to be 98 percent. On about three-fourths of the areas it ranged between 40 and 80 percent of the annual drain.

We feel that one of the primary objectives of management is to insure that as much as possible of the annual drain be in the form of legal harvest. In examining the data from areas showing low percentage of legal harvest the major competing factors were cited as illegal hunting and stray dogs in all cases and, in addition, highway kills in some cases, and other predators in others.

In view of the fact that only a little over half the annual drain is consumed by legal hunting on these intensively protected areas, it is interesting to speculate what proportion is taken by legal hunting in less protected localities. In regions where hunting regulations are not sufficiently stringent and where the protection staff is inadequate, legal kills may constitute less than 10 percent of the annual drain.

In our opinion an "ideal" ratio of legal kills to annual drain would be about 85 percent, with about 10 percent going to unavoidable kills such as vehicle collisions and another 5 percent going to wild predators such as bobcats.

COMPONENTS OF ANNUAL DRAIN

Man, of course, is the primary predator and the extent to which we can restrict annual drain to licensed hunters marks the degree of success of our management. It is somewhat startling to note, therefore, that in spite of intensive protection, legal hunter harvest constitutes only a little more than half the annual drain on North Carolina management areas.

The primary predator, other than man, in North Carolina, is the uncontrolled dog. The only other predator listed by area managers was the bobcat but some also suspected the black bear and foxes.

Dogs and bobcats were listed as the primary predators in the other States responding to our questionnaire. Wolves were cited in a few western States of the southeast region and coyotes were suspected in several. It is interesting to note that only one State (Florida) listed panthers.

Other causes of mortality were cars, fences, trains, drowning, cliffs, ticks, cold water shock, and disease. No States listed starvation.

From table 3 we find that hunting by man accounts for 85 percent of the annual drain but only 63 percent is legal harvest. The other 22 percent is taken illegally or lost in the woods. Predators account for an average of 8.5 percent of the annual drain with free-running dogs getting 6 percent and bobcats only 2 percent. Miscellaneous mortalities account for 6.3 percent with cars killing 5 percent and the remainder succumbing to a variety of causes.

The percentage composition of annual drain indicates that the pattern in regard to predation is rather varied on individual wildlife management areas in various States (table 4). Estimates of loss to dogs range from 0 to 30 percent of the annual drain. Estimated values for miscellaneous mortality ranged from 0 to 55 percent and their individual values averaged about the same as those of losses to dogs. Estimated losses to wild predators also ranged from 0 to 55 percent of the annual drain on individual areas but they averaged only about one-third of the magnitude of losses to dogs or miscellaneous kills.

SUMMARY

A questionnaire survey of 79 wildlife management areas in 11 southeastern States indicates that predation on deer is largely limited to free-running domesticated dogs and to bobcats. Our analysis of data received indicates that the dogs do three times as much damage as the bobcats and that their combined impact accounts for only about 8 percent of the annual drain. However, the data also indicate that when no control is exerted these two predators could effectively prevent herd establishment or increase.

Some Considerations for Diseases and Parasites of White-Tailed Deer in the Southeastern United States

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Accounts of catastrophic white-tailed deer mortality in the southeastern United States provided the impetus for establishing a regional wildlife disease diagnostic and research service. This joint-State organization is described with emphasis on a philosophy that pertains to diagnosing diseases of wild animals. Twelve fundamental causes of wildlife morbidity or mortality are presented. Deer populations of the southeast can continue to thrive even though they are affected by many diseases. The real threat to deer is anticipated to be from foreign shores as an infectious entity that currently does not exist in this country. The Southeastern Association of Game and Fish Commissioners fully recognized this potentiality, and preventive measures were enacted by game and fish agencies throughout the region. Merger of wildlife and domestic animal interests are discussed. Similar efforts have not been inaugurated on a nationwide basis, but inference was made that progress is underway for accomplishing this final objective.

Scattered records from preconservation years in the southeastern United States suggest that white-tailed deer *(Odocoileus virginianus)* experienced numerous "die-offs" from unknown causes. Following the Civil War era, however, wanton slaughter of these animals far exceeded deaths from natural phenomena, and at the turn of the century only isolated remnants of this one-time great resource remained.

It was not until after World War I that serious consideration was given to restoration of white-tailed deer in this region; and not until after World War II that earnest efforts were inaugurated to accomplish this goal. Immediate results were limited but spectacular, with many individuals and agencies rightfully proud of the progress made.

Perhaps the first authentic disease threat to this big game animal restoration program occurred in the late summer and early fall of 1949. At that time, fishermen reportedly were the first to observe unusual numbe of bloated deer carcasses along streams. Untold numbe of deer were lost throughout the mountainous secto of the southeast, and mortality on some manageme areas was estimated to be in excess of 90 percent. Cor cern and consternation naturally were precipitated, bu before positive action could be taken, the mysteriou killer vanished as suddenly as it had appeared. In it wake, heavy losses had been inflicted and many hope were dampened.

During the early 1950's optimism was restored, an regional deer restoration programs flourished. It wa evident that white-tails would return to their onc prominent position in the social and economic structu of the southeastern United States, and the 1949 kille was soon forgotten. The period of reassurance wa short-lived.

In 1954, at the same time of year, KILLER X struc again; then in even greater intensity only 12 month later, in the late summer and fall of 1955. Heavy dee mortality occurred from the Appalachians into th Ozarks, but once again the strange marauder defie diagnosis, leaving only skin with bones and much con jecture.

Sportsmen and game officials alike had skirmishe enough with the sinister intruder, which on three occa sions had gained entrance without provocation and lef without notice. A serious threat therefore was recog nized, and a regional approach was conceived as th most expedient way to cope with future misfortunes o this type.

As a result of untiring efforts and encouragement b many individuals, the Southeastern Association of Gam and Fish Commissioners approved a joint-State organ ization to be supported on a pro rata share basis. Thu on July 1, 1957, these collective endeavors were realize and designated as the Southeastern Cooperative Dee Disease Study, headquartered at the University of Geo gia's School of Veterinary Medicine.

[1] From the Southeastern Cooperative Wildlife Disease Study, Department of Pathology and Parasitology, School of Veterinar Medicine, University of Georgia, Athens. This is the first regional diagnostic and research service established in the Unite States for the specific purpose of investigating diseases of game animals. Participating States include: Alabama, Arkansa Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and We Virginia. Study sponsored and coordinated under auspices of the Southeastern Association of Game and Fish Commissioner the Federal Aid in Wildlife Restoration Act (50 Stat. 917); and through Contract No. 14-16-0008-777, Bureau of Sport Fisheri and Wildlife, U. S. Department of the Interior.

The authors' indebtedness extends so widely that standard acknowledgements could not approach an adequate covera of all persons and agencies who have made this report possible. This academic courtesy had to be forgone, whereby th authors respectfully commit themselves to the magnanimity and understanding of many wildlife biologists, conservatio officers, and game officials throughout the southeastern United States.

Invaluable information also has been drawn from Proceedings of the First White-Tailed Deer Disease Symposium hel in 1962 at the University of Georgia.

Further indebtedness is expressed to Mr. Leonard E. Foote, Southeastern Representative of the Wildlife Manageme Institute, Dr. C. W. Watson, Federal Aid Supervisor (Ret.), Region 4 of the Bureau of Sport Fisheries and Wildlife, and innu merable other individuals and agencies actively involved in the early conception of this regional wildlife disease study. Speci appreciation is extended to the Congress of the United States for making possible the basic research from which much data an many concepts have been procured for inclusion in this report.

Shortly after inception of this pilot program, a most disheartening experience for those involved was realization of the relative dearth of information on diseases of white-tailed deer. In comparison to the wealth of data pertaining to human health and livestock diseases, the few individuals of that day working with wildlife diseases were essentially "functioning in a vacuum." Accelerating pressures also were being exerted for procuring of vital information on disease interrelationships which may exist between wild animals and man or domestic livestock.

The Southeastern Association of Game and Fish Commissioners readily appreciated the increasing demands upon the newly created Southeastern Cooperative Deer Disease Study. The title subsequently was changed to the Southeastern Cooperative Wildlife Disease Study, thus encompassing all forms of wildlife, and the annual pro rata budget was increased proportionately. Through the interest and efforts of the Southeastern Association of Game and Fish Commissioners, in 1963 the Congress of the United States enacted an annual appropriation for support of basic research delineated by this regional organization, with funds to be administered and research coordinated by the Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior.

Significant means thereby were provided for closing the dangerous gap in information relative to the expanding association of wildlife with domestic animals and man. Concomitant with the collective efforts of 13 southeastern State game and fish agencies, many other individuals and institutions throughout the region became interested and actively engaged in similar research programs directed toward fathoming the multitude of mysteries shrouding wildlife diseases.

Although within the last decade a tremendous amount of progress has been made in this field, the surface of adequate knowledge has as yet only been scratched. It must be recognized, however, that inclusion of even the limited data now available far exceeds the scope of a manuscript of this type. Therefore only the highlights of 10 years' experience for projection of a practical approach toward investigating, controlling, and preventing deer diseases will be presented.

Upon receipt of a State call to investigate deer mortality, we first consider population density of the animals affected. We then must be keenly concerned with the association of diseased animals and other fauna in the area. The location within the region is equally important, with consideration given for soil types, drainage systems, recent weather conditions, season of the year, and past experience in similar areas. With these factors in mind, augmented by case histories obtained via telephone or other communications, we then engage in an initial process of elimination based upon what we currently consider 12 fundamental causes of morbidity or mortality within a wildlife population. These are itemized as follows: Anomalies, Stress, Trauma, Suffocation, Neoplastic Diseases, Toxicologic Diseases, Nutritional Diseases, Viral and Rickettsial Diseases, Bacterial Diseases, Mycotic Diseases, Parasitic Diseases, and Senility.

While an investigative field team is en route, it is routine to carefully critique the above potentialities. Thus we usually narrow the disease probabilities from 12 to three or four most likely factors. Although this is rather elementary, we often have found it advantageous in minimizing lost motion upon arrival at the destination. A resumé of this approach therefore is presented for consideration.

Anomalies.—Significant mortality due to congenital or genetic abnormalities is not expected and usually confined to an occasional animal. Under normal circumstances a subject of this kind soon succumbs to the rigors of environment. The history of the area frequently will reveal similarly affected subjects. Conditions of paramount concern include: cleft palate; cauliflower antler; wooly coat; piebald; opaque cornea; lack of rods and cones; lack of iris and lens; congenital cataract; lack of eyeballs; undershot mandible; curled tendons; hydrocephalus; two-headed fetus; antlerless males; antlered females and hypogonadism. Anomalies are rare in wild animal populations and exert little impact on deerherds in the southeast. Anomalies usually are of academic interest only.

Stress.—Varying degrees of mortality may be associated depending upon the nature of stress or stressors. History and study of the area involved frequently will reveal source(s) of stress which may include: adverse weather conditions such as prolonged drought, deep snow, high water, etc.; excessive dust, usually localized; poor nutrition; chronic toxicity; chronic infectious disease; chronic ecto- or endoparasitism; and head injury resulting in a brain abscess. Stress is considered to be a specific response to nonspecific stimuli, but population pressures alone are not a mortality factor for deer in this region. The stress syndrome usually reflects other conditions and is of only academic interest relative to white-tailed deer mortality.

Trauma.—This frequent cause of mortality often is manifested by discovery of occasional carcasses over a large area. Sometimes trauma cases may be concentrated, giving the initial impression of an infectious disease entity or toxic condition. A careful investigation in the immediate vicinity frequently suggests a source such as: collision with an automobile; collision with a wire fence or similar object; gunshot wound; previous fighting during rut; and occasional attacks by dogs. The most common traumas of wild deer result from automobiles and light caliber gunshot. Only the latter thus far has been incriminated as a source of major deer mortality and usually this is restricted in location.

Suffocation.—The degree of mortality usually reflects the type of asphyxiation. History of the area and careful investigation frequently will reveal the nature of involvement, which is usually: drowning; collapsed trachea resulting from trauma; or verminous pneumonia. Of these, drowning and collapsed trachea are rare among white-tailed deer, but under certain circumstances verminous pneumonia can inflict widespread unthriftiness and substantial mortality.

Neoplastic diseases.—Significant mortality among white-tailed deer has not been attributed to neoplasms, but quite a variety of tumors has been reported. Occasional possibilities in this regard include: adenoma; tumor of adrenal cortical type cells; fibroadenoma; fibroma; lymphangioma; lipoma; osteoma; carcinoma; malignant hepatoma; mesothelioma; lymphosarcoma; and sarcoma. Skin fibromas of viral origin appear to be by far the most prevalent tumor affecting white-tailed deer in the southeast. One or two animals so affected can precipitate much public concern, but from a practical point of view fibromas are of academic interest only.

Toxicologic diseases.—Toxicities are capable of inflicting substantial mortality in localized areas, and often give rise to overwrought public sentiment. Thorough investigation of the area for a source of poison is essential. Experiences to date in the southeast involving confirmed poisoning of appreciable significance among wild deer include: arsenical cotton dust; pine oil concomitant with starvation; potassium dichromate plus copper sulfate; pesticide, including several chlorinated hydrocarbons plus perhaps one organophosphate; petroleum products of uncertain origin; and fescue poisoning associated with adverse weather conditions. Poisoning often is difficult to diagnose and must be approached with extreme caution. It is not as common among white-tailed deer as often thought to be, which may suggest a word of warning to the investigator.

Nutritional diseases.—Significant deer mortality in the southeast seldom is due to starvation alone, but malnutrition predisposes an animal to other mortality factors. A direct relationship appears to exist between nutritional level and the degree and intensity of parasitism, with associated unthriftiness and light to severe mortality. Diminished reproductivity of a deerherd also seems related to the nutritional status. Under certain circumstances, a low nutritional level predisposes deer to excessive consumption of available toxic products. History of the deerherd, management practices, and environmental conditions prior to mortality should be carefully studied. Additional factors to be considered include: soil fertility; mineral deficiency; vitamin deficiency; artificial food-patch planting; abundance of mast on area; climatic conditions; and others which would make food unavailable. The most direct approach for studying nutrition of deer appears to be through actual ruminal analyses rather than field investigations of browse which can be rather subjective in nature. There also are strong indications that available mast may be far more significant for white-tailed deer than current opinion would have it. Certain aspects of many timber stand improvement programs therefore appear to leave a lot to be desired. A new look may well be directed toward a "multiple-use concept," which is coming into increasing prominence throughout the region.

Viral and rickettsial diseases.—Infectious entities under this category are potentially devastating to deer populations and probably were responsible for the previously cited catastrophes of 1949, 1954, and 1955. Lesions described from animals examined on those occasions strongly suggest epizootic hemorrhagic disease as a prime suspect. Paramount considerations for viral and rickettsial diseases include: epizootic hemorrhagic disease; bluetongue; and vesicular stomatitis. Epizootic hemorrhagic disease may prove to be identical to bluetongue. Vesicular stomatitis occurs in deer of the southeast, and the lesions are indistinguishable from foot and mouth disease. Constant concern therefore must be manifest for early detection and differentiation of the above conditions. Diagnosis of viral and rickettsial diseases may be difficult, since the causative organisms cannot be grown with ease in the laboratory. No doubt there are many viral diseases of white-tailed deer which have not been identified or defined.

Bacterial diseases.—Deer are vulnerable to an array of bacterial diseases, some of which are capable of inflicting extremely high morbidity or mortality, especially when deer density is high, facilitating spread of the organism. Infectious entities within this category are extremely numerous, therefore only a few major offenders have been selected as follows: anthrax; blackleg; enterotoxemia; leptospirosis; listeriosis; various types of abscesses; and occasionally arthritis. Of the above, anthrax has the greatest potential for reaching epizootic proportions in deerherds of the southeast, since it is particularly prevalent in areas of periodic flooding. Enterotoxemia, or overeating disease, also produces rather spectacular mortality and is associated with the sudden availability of a high protein/carbohydrate diet following a maintenance ration. For differential diagnoses of the many bacterial diseases to which white-tailed deer are susceptible, careful cultural procedures are mandatory.

Mycotic diseases.—Fungal infections do not rank among the leading etiologic agents affecting white-tailed deer, and known occurrence in the southeast is practically nil. The following conditions nevertheless should be considered: actinomycosis; mycotic stomatitis; aspergillosis; ringworm; and mycotoxicoses, such as ergot or related toxins. Perhaps the most prevalent of the mycoses of white-tailed deer is actinomycosis, which causes a distortion of the lower jaw. Most fungus infections found in deer are reflected by a general unthriftiness and are restricted to isolated cases. Fungi often are secondary invaders to other disease conditions, and care should be taken in ascertaining the true causative agent. Culture of the suspect organism will facilitate diagnosis.

Parasitic diseases.—Helminth parasites are the most frequent cause of significant and widespread deer mortality in the southeast. Mortality due to parasitism usually is associated with overpopulation and subsequent malnutrition, although several nematodes are capable pathogens in their own right. At least 30 different helminths are harbored by deer in this region, but the most capable pathogens are: lungworms, including adult and immature forms; large stomach worms; medium stomach worms; and hookworms. Lungworms or large bloodsucking nematodes often cause considerable fawn mortality. Heavy stomach worm burdens usually reflect overcrowding and food shortages. Meticulous parasitologic examination of deer carcasses is imperative since the most pathogenic forms are near-microscopic or microscopic in size and are easily overlooked. Quite often, the most spectacular-appearing parasites are inconsequential to a deerherd. Perhaps it also should be mentioned that studies of parasitism among deer may prove to be an aid to management. Evidence indicates that certain helminths are density dependent, and the concept of "indicator parasites" may prove valuable. In this regard, both numbers of individual species and the total number of species encountered vary with host density. Thus parasites may be used to reflect carrying capacity of the range, or the nutritional status and feeding habits of the host.

Senility.—Old age is not considered a significant mortality factor for white-tailed deerherds, but when it occurs it is restricted to old does. Little stock is placed in the "old barren doe" concept, however, since sufficient observations have been made to demonstrate that older does can conceive, undergo successful parturition, and raise healthy fawns. Hunting regulations reflected by proper management will rectify the few losses that are attributable to senility.

Upon arrival of a field team at the location of deer mortality, a general conception of the problem usually has been established through the suggested processes of elimination. At least, the situation has been reviewed, conditions appraised, and the more likely possibilities chosen. Caution nevertheless must be exerted to avoid a "specialty bias," which can frequently creep into field activities. The chief investigator therefore must strive to be a *diagnostician,* and not a specialist in any given field. Also it should be recognized that seldom is everyone pleased or satisfied by the end results that are obtained. If these prior reconciliations are not made, the road to a successful field operation will be mudded with tears!

An experienced and well-organized investigational team should arrive at a sound *tentative diagnosis* within a matter of 2 days to 1 week. For many conditions, considerable laboratory work is in order at the base of operations, but with proper facilities and adequate ingenuity on the part of supporting staff, a *confirmed diagnosis* no longer is shrouded by the mysteries of yesteryear.

It is hoped that oversimplification of a major problem is not suggested by this approach in investigating deer diseases. In fact, as a result of drastically changing socio-economic factors predicted for the next three decades, disease problems involving white-tailed deer will greatly increase, and demands will be intensified for procuring information on the many interrelationships that exist between swelling deer populations, human health problems, and production of domestic livestock.

The relatively new billion-dollar white-tailed deer industry of the southeast nevertheless will continue to thrive regardless of any disease or vectors thereof currently existing on the continental United States. Although there will be setbacks at local levels, and on occasions entire deerherds may have to be destroyed, this big game animal resource will survive any condition presently known in this country.

The major disease threat to white-tailed deer and other Cervidae of this country therefore is not from *within* but from *without,* in the form of a devastating foreign disease. For example, authorities in the field no longer use the word *if* but *when* foot and mouth disease (FMD) is reintroduced into this country.

Greatly accelerated military/tourist/business travel, increasing demands for importation of meat and byproducts thereof, worldwide use of biologics, etc., pose an immediate likelihood of *accidental* foreign disease introduction. The *purposeful* introduction of a devastating pathogen also cannot be ignored, which would be capable of exerting a tremendous impact on vital segments of the Nation's entire economy. White-tailed deer subsequently would be intricately involved, with staggering losses of these animals inevitable. Early detection followed by immediate eradication constitutes the only recourse for minimizing the awesome consequences of this type national emergency.

Game and fish officials throughout the southeastern United States have fully recognized the ever-increasing threat of foreign animal diseases, which at any time may wreak havoc with the Nation's multibillion-dollar game animal resources with concomitant impact upon the entire livestock economy and associated industries. Therefore, during October, 1966, the Southeastern Association of Game and Fish Commissioners adopted a resolution which afforded a merger of efforts between wildlife and domestic animal interests. A modified version of the resolution is as follows:

"WHEREAS: At any time a devastating exotic animal disease can be accidentally or purposefully introduced onto the Continental United States, which could seriously jeopardize the entire livestock economy;

"WHEREAS: Various forms of game animals can serve in the capacity of unrestrained carriers of a foreign disease transmissible to domestic animals, i. e., white-tailed deer as carriers of foot and mouth disease (FMD);

"WHEREAS: An enemy of this nation could utilize various methods of introducing a devastating foreign disease into wild deer, which could spread rapidly with eventual introduction into domestic livestock;

"WHEREAS: Tremendous expansion of white-tailed deer populations has placed a virtual blanket of these animals over the southeast, thus affording an unbroken chain of susceptible animals through which a foreign disease could spread;

"WHEREAS: Early detection of a highly infectious entity is absolutely mandatory for the continued welfare of certain big game animals and domestic livestock;

"WHEREAS: Animal Health Division officials of the Agricultural Research Service (ARS), United States Department of Agriculture (USDA), offer to provide game and fish personnel with training necessary to participate in a program designed for early recognition of potentially dangerous diseases;

"AND WHEREAS: In the event an exotic disease is suspected, the Animal Health Division (ARS, USDA) will afford diagnostic services essential for early detection, with control measures thereafter being delineated in accordance with accepted procedures based on valid scientific data;

"THEREFORE BE IT RESOLVED: That the Southeastern Association of Game and Fish Commissioners support an exotic disease surveillance program in cooperation with the Animal Health Division (ARS, USDA)."

This vital alliance between game animal and domestic livestock interests was officially enacted July 19-21, 1967, when the Animal Health Division (ARS, USDA) sponsored a regional Foreign and Emergency Disease Surveillance Training Program in response to the above resolution. The program was coordinated by the Southeastern Cooperative Wildlife Disease Study of the University of Georgia's School of Veterinary Medicine and held at the Georgia Center for Continuing Education. Participants included game officials, biologists, and law enforcement personnel from 15 southeastern States: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Virginia, and West Virginia. The program was conducted by internationally recognized specialists from the U. S. Departments of Agriculture and the Interior.

Major objectives of the conference agenda are quoted as follows:

" . . . to relate and emphasize to Southeastern Game and Fish Field personnel the full ramifications of possible foreign disease outbreaks in this country;

" . . . to describe the position white-tailed deer and feral swine now will occupy in the event of foreign disease introduction into the southeast;

" . . . to familiarize Game and Fish personnel with the elaborate nationwide emergency disease eradication organization of the Animal Health Division, ARS, USDA, and specify the vital role wildlife interests hereafter may play in that program;

" . . . to train Game and Fish personnel to immediately recognize and report evidences of a possible foreign disease outbreak;

" . . . to establish liaison between attending Game and Fish personnel and the Veterinarian-in-Charge (ANH, ARS, USDA) in their respective States for inaugurating exact reporting procedures for all suspicious cases;

" . . . to provide basic information and visual aids with which attending Game and Fish personnel can return to their respective States and relay to co-workers instructions received during the training programs."

After 2 days of intensive lectures with accompanying visual aid sessions, a test exercise was conducted, involving all Animal Health Division Veterinarians-in-Charge (VIC) of the 15 States represented. Game management specialists and law enforcement staff from each State actively participated in this exercise, whereby a hypothetical introduction of FMD into wild deer of the southeast afforded much food for thought for all parties concerned.

In followup of the regional program, all southeastern States have completed or are in the process of planning similar training sessions at the State level. These conferences encompass the full complement of technical and law enforcement personnel, which essentially adds from 200 to 300 trained people per State. These men are becoming well versed on the full ramifications of foreign disease introduction and the necessity for immediate reporting of any suspicious case involving wildlife or domestic animals. Thus conservation officials and game biologists are establishing direct communications with Animal Health Division officials (ARS, USDA) and excellent liaison between their respective State veterinarians and diagnostic laboratories.

As a result of these cooperative efforts, southeastern wildlife interests now are in position to make paramount contributions in the eventuality of foreign disease introduction. The only regret today is that these cooperative activities thus far have been restricted to the southeast. It is hoped, however, that within the near future similar resolutions will be adopted by other regional game and fish associations, with wildlife and domestic animal interests ultimately combining forces on a national front. This will be invaluable insurance toward the preservation of countless thousands of big game animals, millions of domestic livestock, and billions of dollars. Such investment today will pay unprecedented dividends tomorrow.

Critical Factors in Habitat Appraisal

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In appraising habitat the appraiser must go beyond enumerating the factors limiting deer numbers and consider what factors control the habitat itself. Several criteria for judging habitat quality are presented.

Before discussing the critical factors in appraising white-tailed deer *(Odocoileus viriginianus)* habitat in the South, let us consider for a moment how habitat quality is measured. Is there a uniform standard of measure? The biologist will answer, yes, habitat quality is measured in terms of carrying capacity. But does carrying capacity alone fully describe habitat value?

Unfortunately, carrying capacity is not absolute, but is relative. It fluctuates seasonally and annually with rainfall, temperatures, mast and browse yields, interspecific competition, and to some extent with the size of animals supported. Carrying capacity may be the accepted measure of habitat quality, but it is not a very precise one. Appraising habitat on the basis of carrying capacity alone is like valuating a house on the basis of square feet of living space without regard to other considerations.

In appraising habitat, the appraiser must go beyond merely enumerating the factors limiting deer numbers, and consider what factors control the habitat itself. Factors controlling the habitat are, for example, inherent soil fertility, floods, droughts, temperature extremes, the pressure of land use trends, physiography, forestry practices and other factors. Thus habitat appraisal involves more than counting twigs, calculating acorn production or plotting the location of year-round water sources. Habitat quality cannot be computed, only judged.

What are the critical factors in habitat appraisal? The word critical, as used in the title of this paper, means decisive. What are the decisive factors an appraiser must measure? Which can he ignore?

What may be critical will depend, somewhat, on the purpose of the manager—his goals and objectives, and the management options open to him. One might appraise habitat as a guide to managing either the herd, the habitat, or both.

The herd manager, whose responsibility is primarily to the hunter, will consider those factors critical which alter carrying capacity, annual fawn production, average animal weights, antler development, hunter success, etc. His primary management tool being harvest regulation, he may need to know how habitat quality varies with herd density, what temporary conditions, such as droughts, alter habitat quality, or what features of the habitat influence harvest rates.

The habitat manager, whose responsibility is primarily to the landowner, may be concerned with increasing the yield of deer from a specific unit of land or determining the impact of deer on the habitat itself. His primary tool being the allocation of land and resources to deer habitat purposes, he needs to know the relative value of various inputs in terms of habitat outputs.

Hence, it is apparent that habitat appraisal is rather pointless without having first a clear statement of deer management objectives. How will appraisal data be used? Is a sustained yield of deer the objective or is it simply the quantity or sport realized? Is the naturalness or artificiality of the habitat of any consequence? What is the reason for making the appraisal? The answer will help determine what to measure.

SOME CRITERIA FOR APPRAISING HABITAT

At the risk of overworking a cliche, the white-tailed deer is a highly adaptable creature. It thrives or survives in every forest type in the South. It would be virtually impossible to enumerate precisely all the factors limiting habitat quality over such a wide range of situations. However, the most frequently identified criteria in appraising habitat are:

1. Inherent soil fertility.
2. The abundance and variety of palatable forage available to satisfy the seasonally changing dietary requirements of deer.
3. The degree of interspersion of food and cover components.
4. The nature and extent of escape cover serving to reduce legal or illegal hunting harvest and predation by dogs.
5. The resistance of the habitat to severe weather stress.
6. Water.

Inherent soil fertility.—Inherent soil fertility is reflected in the nutrient quality of plant materials consumed by deer and ultimately in the physiology of the animal(s). French *et al.* (1956) established minimum nutritional demands for crude protein and phosphorus for growth and body maintenance of deer. These elements are often lacking in southern forage grown on infertile soils. Thus, soil fertility may affect such herd characteristics as population densities, productivity, average weights, and antler development.

Thorsland (1967), reporting on a nutritional analyses of seasonally selected deerfoods from seven areas in three physiographic provinces of South Carolina, writes:

"There was a relationship between mineral contents in the soil samples and plant mineral content, which was especially evident with the mineral phosphorus. A poor soil was usually reflected by plants with low mineral values.

"The analyses showed that the Broad River Management Area (Piedmont Plateau) has the most nutritious plants. In general, plants from this area contained the highest mineral contents. This was supported by the average live weight of deer killed on the Broad River area during 1965-1966 being higher than that of deer killed on any other area involved. The plant species from the Belmont area and the Francis Marion National Forest (both Lower Coastal Plain) were lowest in nutritional contents. This was substantiated by these areas having soils with the lowest mineral contents and the average live weights of deer killed on these areas being lower than those for deer killed on any other study area."

Trace elements typically deficient in some soils may influence productivity rates. Postulating on the variable productivity of Florida herds, Harlow and Jones (1965) state:

"Evidence to date strongly indicates that the low reproductive rate of does from the flatwoods and deep sands of central Florida are a result of the lack of iron carbonates and/or cobalt in the soil and not from an over-abundance of deer or a lack of available foods.

"This information does not emphatically imply that deer populations, where reproductive rates are low, cannot reach densities approaching populations on good range, but it does indicate that herd increases will occur at a much slower rate."

The inhibiting effect of deficient trace elements on the productivity of cattle grazing native ranges in the South is well documented. Mineral diet supplements are widely applied by cattlemen to increase calving rates and to reduce anemia.

The above examples indicate the critical bearing that soil fertility has upon deer habitat. There are many such references in the literature. Fertile, alluvial soils and soils derived from limestone and metamorphic rocks tend to support more nutritious plants, a higher carrying capacity and more productive herds than soils derived from infertile, acid shales, sandstones, and coastal marine deposits.

A key step in any habitat appraisal should be to determine how and to what extent soil fertility may limit deer management potentials. The literature is not consistent, however, on techniques for remedying mineral deficiencies on an extensive basis.

The abundance and variety of palatable forage available to satisfy the seasonally changing dietary requirements of deer.—Probably the most distinctive characteristic of habitat quality is the abundance, variety and nutritive quality of forage available to satisfy the seasonally changing dietary requirements of deer. Forage is defined as all the unharvested plant materials available for animal consumption. Deer were once considered to be browsers—feeders upon the twigs and shoots of shrubs, trees, and vines. But, alas, deer feed with equal relish upon grass, annual and perennial forbs, fruits, flowers, fungi, foliage, and twigs with little regard to the form or part of the plant consumed and with utmost regard to palatability, succulence, availability, and nutritional content of foods ingested. Deer are frugivorous and herbivorous opportunists, not browsers.

Untold man hours of time and money have been expended measuring browse supplies, i. e., woody twigs which furnished but a minor proportion of the total diet of southern deerherds. Is it wise to measure browse? If deer take such a variety of foods (Lay 1967b) based on availability, quality and preference rather than form, what should the habitat appraiser measure? The answer is: measure those aspects of the forage supply which by their nature lend themselves to reliable inventory, which local food habit studies indicate are important indicator items during the season in question; and which can be correlated with herd dynamics, productivity, and animal and range condition.

The following excerpts from the writings of biologists working throughout the South testify to the above:

Dunkeson (1955), Missouri, wrote: "The pattern of deer browsing in Ozark woodland had the following outstanding features: (1) Green forbs supplied the major part of deer food through the period from March to November and were an important part of deer diet throughout the year; (2) grasses, shrubs, fungi, fruits, seeds, and acorns were important seasonally; (3) a number of plants were consistently unpalatable and others were palatable for only a short time during the growing season.

"Little winter use was made of deciduous woody twigs and evergreens were so low in palatability that these types were not good indicators for determining the condition of deer range during the winter.

"Shrubs which were palatable for a long period during the growing season appear to be the most sensitive indicator plants to show destructive overbrowsing. Three . . . were browsed to the point of destruction on the same areas where forbs were not clearly affected by overuse."

Chamrad and Box (1968) reporting the food habits of deer from south Texas grassland-brushland complex say: "White-tailed deer were primarily grazers rather than browsers during the winter-spring periods . . . . Complexity of the diet reduced the importance of any one or several species in the diet. Among high priority forage species perennials were more important than annuals. Deer food habits varied according to availability and phenology of range vegetation, and were further modified by forage preferences."

Harlow and Jones (1965) in Florida identified 23 major species or species groups in deer stomachs collected in fall and winter from the flatwoods and sand pine-scrub oak types. The gamut of plant parts eaten included acorns, fruits, berries, leaves, twigs, grass and sedge stems, and blades, and the entirety of mushrooms. Yet in separate studies in the same types, Harlow showed that in spite of the variety of foods eaten, a strong correlation could be drawn with the abundance of acorns and palmetto berries and the weights of deer in the 1½ and 2½ year age classes, and the percent of 1½ year old bucks harvested 2 years later. What should be measured?

Segelquist and Green (1968) reporting the progress of the Sylamore studies of penned deer in Arkansas oak-hickory types substantiated the inverse relationship between mast availability and forage usage reported by Korschgen (1962) and others. When mast was available, deer ate little else. When mast yields were low, forage use increased and forage use was heavier where green herbage and evergreen browse were most plentiful. Important unpublished studies underway at Sylamore may yet link fluctuations in deer reproduction and survival rates with fluctuating mast yields, and the nutritional quality of native woody browse. What should be measured?

Various investigators throughout the South and southeast have seriously questioned the value of woody twigs as deerfood while underscoring the value of fruits, acorns, foliage, mushrooms, legumes, grasses, and palatable evergreens. Woody twig tips and buds remain important only during early spring when growth is rapid, succulent and highly nutritious.

Goodrum and Reid (1962) and others have demonstrated how critical food shortages may occur in late summer when the nutritional value of available succulent foods is submarginal for deer growth. At this time the availability of composite flowers and fruits may be highly important.

Lay (1967a) sums it up succinctly: "A major limitation of browse surveys is that browse provides less than half and possibly as little as one-fourth of the deer diet on such fully stocked ranges . . . . Fruits, including acorns, are more important. Mushrooms are especially attractive and nutritious. Herbaceous green stuff is important. Browse, however, has the advantage of year-to-year stability. It is more permanent and more measurable."

What should the habitat appraiser measure?

He should measure those characteristics which are most readily and most consistently measurable with precision. He should measure those factors which are density-dependent and reflect an upward or downward trend in range condition as caused by foraging pressure of the herd. He should measure those density-independent items which can be most readily correlated with population dynamics of the herd. He should measure those items subject to manipulation through methods at his disposal.

The degree of interspersion of food and cover components.—Several authors have commented on the sedentary nature of southern deer—preferring to stay and starve than to migrate in search of food. It is generally accepted that southern deer do not migrate with the seasons although some shifting between types within the home range may occur. Recent telemetry and tagging studies have verified the limited range of southern deer, being from about ½ mile to 1½ miles in radius and covering from 200 acres in good habitat with high populations to 3,000 acres in poor habitat. Recent investigators have attempted to show a diminishing radius of movement with increased herd density (Marchinton and Jeter 1967; Marshall and Whittington 1969). Apparently as populations increase, a higher degree of interspersion is needed to compensate for diminished movements.

The foregoing simply means that quality habitat must possess a high interspersion of food and cover components, for not only is the daily range of deer small, but the variety of foods they require is great. These foods originate from a diversity of plants occupying many different sites, types, soils, aspects, age classes, and successional phases in the forest.

Among the critical factors controlling the degree of interspersion are:

1. Physiography, or the distribution of intermingled soil types, sites, and aspects (Byrne and Zeedyk 1966).
2. The complexity of land use patterns, i. e., agriculture, industry, etc.
3. Forest management practices.

Is it not logical that, given a population at carrying capacity, a high degree of interspersion should result in the most efficient use of the low quality elements intermingled with the high quality portions of a range?

The nature and extent of escape cover serving to reduce legal or illegal hunting harvest and predation by dogs.—Little effort has been directed toward defining the importance of escape cover in southern deer habitat. In many areas where protection from poaching and dogs is less than adequate, the presence or absence of satisfactory escape cover, such as dense, watery swamps, may be a critical factor in survival. Excessive escape cover is also vexing to deer management. Dense cover curtails legal harvest throughout much of the Coastal Plain where high density populations are common.

In the Appalachian Mountain, Piedmont and Cumberland Plateau Provinces, insufficient escape cover makes deer particularly vulnerable to dogging. Secondary losses to disease and parasites and of fawns occur where weakened deer successfully evade dogs, but do not survive the ordeal.

The habitat appraiser should decide whether the character of escape cover adversely affects either protection or harvest, and determine whether protection, harvest regulations, or habitat management practices need to be modified accordingly.

Resistance of habitat to severe weather stress.—The ability of habitat to withstand the stress of severe weather and provide adequate food and shelter for the duration of need might be termed its resistance to severe weather. The emphasis here is on abnormal stresses. Throughout the South, temporary severe weather including floods, hurricanes, snow, freezing, rain, drought, prolonged heat or cold, and unseasonal frosts occasionally create periods of stress. Its ability to resist such stress is an attribute of high quality habitat whereas the lack of this capability is a mark of poor habitat. Usually, but not necessarily, the mechanism for survival is the chance distribution of limited acreages of "key areas." A critical appraisal will isolate and identify those properties which lend severe weather resistance to habitat.

Resistance to stress is a function of such diverse factors as the availability and nutritive quality of "stored" reserve forage not otherwise used, elevated sites in areas prone to flooding, a source of succulent vegetation in areas afflicted by drought, aspects sheltered from killing frosts, and so forth.

The literature contains many references to habitat which was or was not capable of carrying normal populations through brief periods of severe weather, for example:

Burnett (1959) reports, "The Tensas (Louisiana) deer herd was exposed to disastrous floods in 1912, 1913, 1916, 1922, and 1927, especially was this true of the flood in 1927; this flood almost wiped out the herd." Harlow and Jones (1965), referring to Florida Everglades, state, "Due to periodic die-offs of deer (as a result of high water levels forcing deer on tree islands over extended periods until the food supply has been depleted) from starvation the population of 'Glades' deer fluctuates widely." The above illustrates how a single limiting factor, lack of elevated areas with adequate food, results in a low resistance to flooding and reduces the value of otherwise high quality habitat.

The importance of succulence as a feature of palatable forage is generally accepted. In a reference exemplifying how a source of succulent vegetation fortified a habitat against droughts, Chamrad and Box (1968) state, "Deer concentrations on the dry lake beds are most pronounced during periods of severe drought. Under such conditions some green vegetation persists for longer periods in these depressions than on the surrounding upland sites."

Other examples could be shown to illustrate the concept of resistance to weather as a feature of high quality habitat.

Water.—The literature is inconsistent on the importance of free water to deer. Strode reports little use of known water sources during dry periods in the sandhills of the Ocala National Forest. On the other hand, Michael (1968), reporting on the drinking habits of deer at Welder Wildlife Refuge, Texas, noted the presence of open water and/or the distribution of succulent, green vegetation affected the distribution of deer during late summer droughts. Michael inferred from data collected over a period of 2 years that deer use any water available, drink more in hot seasons than in cold, that some deer lick dew from leaves and apparently never drink, and pregnant does drink more than nonpregnant deer. He noted that the tendency of deer to concentrate near succulent vegetation in dried up lake and river bottoms might have a bearing on management and influence census data.

Biologists of the Ouachita, Ozark, and Daniel Boone National Forests assumed that artificially constructed waterholes on the dryer ridges and above barrier cliffs would favorably influence the distribution of deer. This assumption is essentially unproven except that such waterholes are heavily used in early autumn when ridgetop mast crops ripen and free water is especially scarce. Use is heavy where attractive food plots are nearby. However, there is no evidence of an overall increase in deer numbers attributable to the presence of artificial waterholes.

SUMMARY

Habitat appraisal is a complex task calling for an evaluation of many factors. The appraiser should not be satisfied with merely counting twigs or fruits produced and consumed, but should explore those underlying factors which control the habitat itself. To be meaningful, habitat appraisal should relate habitat condition to herd dynamics and vice versa. The appraisal should be interpreted in terms of the variables the manager can manipulate or accept as controlling.

Several criteria are listed above as critical in judging habitat quality. The list is not exclusive and may not apply equally well throughout the South. It may prove useful, however, in stimulating the deer or habitat manager to take a more careful look at what critical factors really are.

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Deer Habitat Quality of Major Forest Types in the South

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This paper reviews reports of deerfood yields in southern forest types. Yields, correlated with animal requirements, are indicators of carrying capacity. The four major forest types differ widely. Bottom-land hardwoods are the best habitats for white-tailed deer, followed by the shortleaf-loblolly pine hardwood, the upland hardwood, and the longleaf-slash pine forest types.

The first step in effective management of deer habitat is to determine the amount of food available. Food yields, when correlated with animal requirements, are indicators of carrying capacity. Though the assessment of habitat productivity by forest types was suggested at least 30 years ago (Stegeman 1937), researchers only recently have been able to investigate food yields thoroughly. This paper reviews current information on deerfood yields in the four major forest types of the South.

Deerfood consists of more than herbage and browse, though most reports emphasize these two components. Fleshy fruits and mast crops are also very important. For example, in a Missouri study, acorns made up 42 percent of the deer diet over a 5-year period, and little else was eaten while they were available (Korschgen 1962). A recent study in east Texas showed that browse averaged only about 30 percent of the annual diet; acorns, mushrooms, fruits, grasses, and forbs made up the rest (Short, H. L., unpublished manuscript). Lay (1967) has also questioned the validity of range appraisals based only on browse quantity.

The four major forest types are: bottom-land hardwoods, loblolly-shortleaf pine-hardwoods, upland hardwoods, and longleaf-slash pine (fig. 1). They cover 220 million acres from Virginia to Texas (Wheeler 1966). In 1965, they harbored about 2 million white-tailed deer, 250,000 of which were legally harvested.

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Bottom-Land Hardwoods

Bottom-land hardwoods occupy 38 million acres and are the best of all southern forest habitats for white-tailed deer. In nearly all Southern States, hunters have taken the most deer in this timber type (Anonymous 1968; Stransky and Halls 1967).

Deer prefer bottom-lands for a principal reason: the fertile, well-watered soils produce more food than upland soils. The superiority of bottom-lands to other forest types has been demonstrated many times.

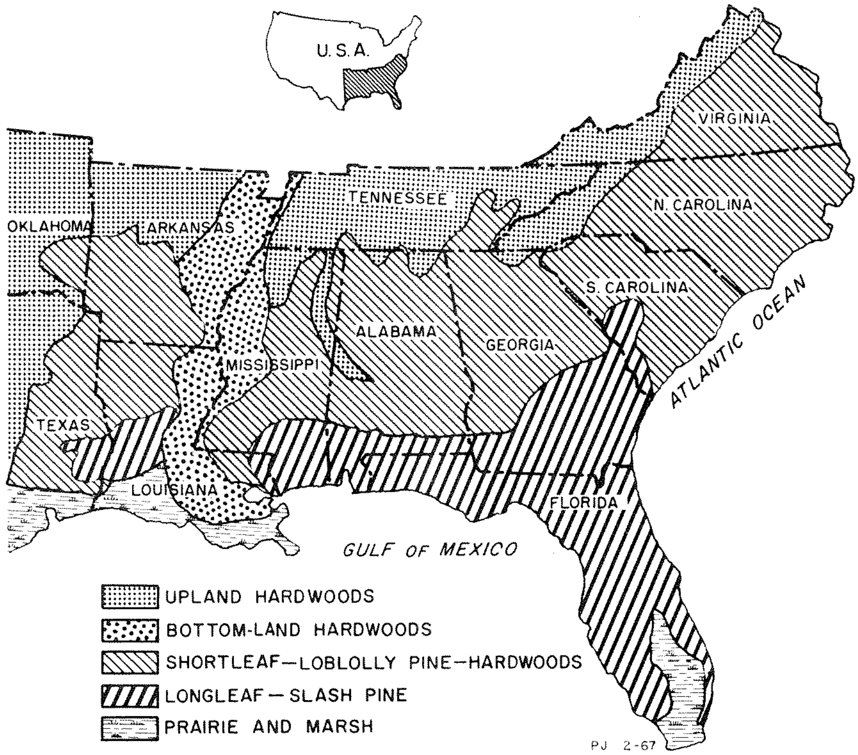

Figure 1.—*Southern forest types.*

In Louisiana, Collins (1961) reported that bottom-land oaks produce more acorns per tree than upland oaks. Some acorns were available every year from both red oaks and white oaks; if one failed to produce mast, the other complemented the yield.

Bottom-land forests in an Alabama study contained less herbage than longleaf pine forests but nearly three times as much browse: 300 pounds per acre versus 120 (Gaines *et al.* 1954).

Lay (1965) found that east Texas bottom-land habitats have more mast-bearing trees and fruiting shrubs than upland habitats. He concluded that ranges with a large variety of fruit-producing hardwoods contribute more to the diet of deer than those offering little but browse.

In the Georgia Piedmont, bottom-land hardwood forests contained more browse than loblolly pine forests (Moore and Manney 1962). In another Georgia study, hardwood types had significantly more browse than slash and pine-hardwood types (Moore *et al.* 1960).

In South Carolina, Moore (1967) found that bottom-land sites contained many more desirable browse species than upland sites. He estimated carrying capacity at one deer to 13 acres in bottom-lands, as compared to 30 to 50 acres in loblolly pine-hardwood, and 78 acres in the longleaf pine type.

Even though the timber stand on it was dense, the stream-bottom hardwood type was second only to open cedar glades in the production of herbage and browse in a study in the Arkansas Ozarks (Segelquist and Green 1968).

Unfortunately for deer, bottom-land hardwoods are being cleared rapidly for agricultural crops in some areas (Stransky and Halls 1967). Through habitat manipulation, the loblolly-shortleaf pine-hardwood type might be improved to offset the loss of deer range in bottom-lands.

Loblolly-Shortleaf Pine-Hardwood

This forest type, which covers 79 million acres, is dominated by the two pine species; the proportion of hardwoods varies. Lay (1967) showed that, next to bottom-lands, this type has the greatest variety of fruit-bearing plants. This variety is important to deer, because fruits and browse are thus available in different seasons of the year (Halls and Alcaniz 1965; Lay 1967). Acorns are not as abundant as in bottom-lands and are probably available for shorter periods throughout the fall and winter; mast failures are also more frequent.

In north Georgia, Ripley and McClure (1963) estimated carrying capacity at one deer to 39 acres. Also in Georgia, Moore *et al.* (1960) noted that in carrying capacity the type was between the bottom-land hardwoods and the slash pine types. In South Carolina, estimated carrying capacity was one deer to 30 to 50 acres (Moore 1967). In North Carolina, it was one deer to 26 acres (Moore and Strode 1966).

Overstory density influences forage yield. For example, yields from east Texas were as high as 1,600 pounds per acre on clearcut areas, 727 pounds under shelterwood, 853 pounds under selection cutting, and 426 pounds in uncut loblolly-shortleaf pine-hardwood stands (Schuster and Halls 1963). These totals are high, because the stands had unusually dense understories of shrubs and young hardwoods. It should be noted too that high yields often include much unpalatable and emergency food.

In the Oklahoma Ouachitas, Segelquist and Pennington (1968) found no significant browse yield differences between pine-hardwood and upland hardwood forest types. They noted, however, that with leaf fall browse declined by 85 percent, to about 19 pounds per acre, 14 pounds of which were preferred browse. They concluded that low winter browse availability there may limit deer populations.

Intensified management of the loblolly-shortleaf pine-hardwood type may increase the acreage of pine plantations. The plantations may yield high amounts of browse for the first few years, but after the crowns close, little or no browse will be produced for 15 to 25 years (Stransky and Halls 1967). Blair (1967) found that thinning increases production of forage in plantations. After planted trees have reached sawtimber size, browse is again plentiful (Schuster and Halls 1963). Retaining portions of the original mast-bearing hardwood component would undoubtedly be beneficial to deer.

Upland Hardwoods

The upland hardwood type occupies 57 million acres, mostly along the northern boundary of the southern forest belt. It is also found to some extent in the Carolinas and Florida. Principal tree species are oaks and hickories in association with southern pines, elm, gum, maple, and redcedar. Production of deer forage is usually low, but in good mast years food is abundant.

Dalke (1941) reported that upland hardwood stands in Missouri contained at least 200 plant species of interest to deer: 89 in fall, 70 in winter, 78 in spring, and 115 in summer. Heaviest browsing on woody stems took place in winter. He reported that the post oak-blackjack oak association yielded 140 pounds of forage per acre, and the black oak-hickory association 110 pounds.

Dunkeson (1955) noted that mushrooms in upland hardwoods of the Missouri Ozarks may make up as much as 25 percent of the deer diet at times. He also found that deer browsed heavily only when acorns were scarce. Segelquist and Green (1968) made the same observation in Arkansas; forbs were the major food items during the growing season.

Ehrenreich and Murphy (1962) measured forage yields of 155 pounds per acre in the blackjack oak-post oak association and 110 pounds in the black oak-scarlet oak. Associations that included cedar had much grass, a characteristic also noted in the Arkansas Ozarks by Segelquist and Green (1968).

Springfield Plateau forests in Arkansas yielded 57 pounds of grass, 166 pounds of forbs, and 326 pounds of browse per acre. Boston Mountain forests yielded 195 pounds of grass, 234 pounds of forbs, and 440 pounds of browse per acre. In an open meadow, grass production was higher, 917 pounds per acre, but forbs (99 pounds) and browse (84 pounds) were less than on the wooded sites (Halls *et al.* 1960).

In north Georgia, deer browse yields were only 33 pounds per acre in upland hardwoods and 42 pounds under pines (Ripley and McClure 1963). Browse yields were also low (76 pounds per acre) in the Ozarks (Segelquist and Green 1968), but higher (121 pounds) in the Oklahoma Ouachitas (Segelquist and Pennington 1968). In recently thinned stands in the Ouachitas browse yields rose to 171 pounds per acre. In both the Ozark and Ouachita studies, mast yields were five to 10 times greater than average winter browse.

Longleaf-Slash Pine

This forest type occupies 26 million acres, mostly in the Lower Coastal Plain. Longleaf and slash pine grow in association with other southern pines, oaks, and gum. The stands are mostly open and provide some of the best cattle grazing in southern forests. Browse and fruit yields are usually low (Goodrum and Reid 1959), and deer habitat quality is generally poor (Stransky and Halls 1967).

In Florida, Harlow (1956) found only a small variety of woody browse plants available to deer during the winter in habitats of longleaf pine, turkey oak, and pine flatwoods in the Lower Coastal Plain. Harlow and Jones (1965) rated the carrying capacity of flatwoods low: one deer to 82 acres. They rated the carrying capacity of longleaf pine-oak uplands high, one deer to 34 acres, probably because of the large proportion of hardwoods. The abundance of scrub oak acorns was closely related to annual weight differences in deer and to the percent of bucks harvested (Harlow and Tyson 1959).

Moore (1967) rated the capacity of longleaf forests in South Carolina at one deer to 78 acres, and of young plantations at one deer to 104 acres.

In Georgia, slash pine forests contained less and poorer browse than either the bottom-land hardwoods or the loblolly pine-hardwoods type (Moore *et al.* 1960). In east Texas, longleaf pine forests had fewer species of oaks and fruit-bearing shrubs than bottom-land hardwoods or loblolly pine-hardwood types (Lay 1965).

The low productivity of longleaf pine lands for deer is further illustrated by the average kill of one deer to 2,000 or more acres in longleaf forests in Louisiana (Haygood 1966). Similar data have been reported elsewhere in the South (Stransky and Halls 1968).

CONCLUSIONS AND OUTLOOK

Even though the data on food production and deer populations are fragmentary, it appears that the major forests differ widely in carrying capacity. Bottom-land hardwoods are the best habitats for white-tailed deer, followed in order by the loblolly pine-hardwood, upland hardwood, and longleaf-slash pine types. Prime bottom-land acreage, however, is dwindling by the day. In loblolly pine-hardwood stands, intensive timber management may reduce browse and mast supplies. Possible solutions to these problems are reserving certain areas for game, intensifying habitat management on others by supplementing natural forage with food plots, or encouraging the growth of native browse plants in permanent openings (Halls and Stransky 1968; Halls and Alcaniz 1968).

A systematic and statistically valid field inventory is needed to evaluate the total food potential of the major southern forest types. In most cases, habitat evaluations have been based only on part of the food supply, and on conditions at a particular time and place with little regard to seasonal and year-to-year variations.

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Agricultural Clearings as Sources of Supplemental Food and Habitat Diversity for White-Tailed Deer[1]

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Forage clearings have been used in deer and turkey management since 1935 and by 1965 over 30,000 acres in 22 States were devoted to this practice. The estimated replacement value of these clearings is $3.7 million and it is estimated that $4 million has been spent in maintenance. Habitat diversity and production of supplemental food are the principal reported aims of the practice, but an ecological fact base commensurate with costs cannot be established to support this program. More research on quantitative and qualitative aspects of natural deer foods, population estimation, and deer and hunter behavior is needed to show whether such costly and intensive management programs are desirable. Reduction in expenditures for pasture-type clearings and more emphasis on developing better methods to assess the effects of habitat change are recommended.

DEFINITIONS

Agricultural food clearings are openings in forest habitat, either natural or man-made, which produce a natural or planted forage crop requiring some periodic agricultural management. Sprout clearings, seeded roads, trails and rights-of-way are not considered as food clearings in this discussion. Forage is herbaceous agricultural or native plants, as opposed to woody browse species.

HISTORY

Agricultural clearings, or food plots, have been employed in deer and turkey management in southeastern and southern forests since about 1935. By 1966 over 30,000 acres were devoted to this practice in 22 States. Between one-third and one-half of this acreage has been cleared on National forest land. In most cases, clearings are created and maintained by State wildlife agencies on State lands or on National forests under agreement with the USDA Forest Service. Halls and Stransky (1968) point out that most of the permanent openings in southern forests are not planted, but about 70 percent of the more than 14,000 acres specifically created for wildlife planting in these States were being maintained in 1965 (Larson 1967a).

With some exceptions, clearings are created by removing trees and stumps from areas ranging in size from 1/10 to 60 acres. A seedbed is prepared, lime and fertilizer added and seeds sown. About 75 species and varieties of plants have been tried but clovers and grasses are most popular. Maintenance practices vary and mowing is most common. Intensity of maintenance runs from mowing once every 2 years to complete renewal (plowing, fertilizing, seeding) on an annual basis.

Many early programs called for installation on a grid to achieve even distribution and to put from 3 to 10 percent of a management area in clearings. In practice terrain often made these goals impractical and too costly. Many managers settled for whatever percent or pattern the topography would permit.

The cost of creating and maintaining clearings varies depending on topography and cost accounting practices. State wildlife agencies tend to utilize appropriated funds as lump sums for management of given areas, making cost accounting for specific practices very difficult. The USDA Forest Service requires that depreciation of equipment, road time, mileage, administrative overhead and related costs be computed and assigned to each project. Their quoted costs usually exceed those provided by States. Installation costs run from a low of $15 per acre to a high of $1,000 per acre. The lower figure represents the minimum cost to rejuvenate an old field site and the higher amount, the cost to create a clearing in rugged wooded mountain terrain. Usually costs in the Coastal Plain and Piedmont run from $15 to $100 per acre and from $200 to $400 per acre in the mountains for a new clearing. Annual maintenance costs depend on the intensity of the management program. Simple mowing and top dressing is $15 to $45 per acre and complete renovation runs from $50 to $90 per acre. These costs do not reflect construction of access roads where needed. Roads cost from $50 to $1,000 per mile depending on topography.

Conservative estimates of $100 per acre for cost of installation and a ¼-mile access road per clearing amount to a minimum replacement value of $3.7 million for clearings existing in 1965. If $25 per clearing was spent annually in maintenance, by 1965 $4 million would have been spent to keep clearings in the desired condition.

European countries have employed food clearings, but under conditions including a nearly complete census of game and highly selective harvest.

THE RATIONALE AND ROLE OF CLEARINGS

The origin of clearings lies in an attempt to provide diversity and food in the forest environment. Wildfires originally provided a disruptive ecology which favored deer. Fire protection and the succession of old farmlands to pole-stage forest has created habitat lacking diversity. The first clearings were hand-cut openings which favored sprout growth and released ground-level vegetation. The advent of power equipment soon made it possible for managers to create pasture-like openings which would resist succession and retain predominantly herbaceous vegetation for a longer time.

[1] Based largely on earlier studies by the author (Larson 1967a, 1967b).

[2] U. S. Bureau of Sport Fisheries and Wildlife, Massachusetts Division of Fisheries and Game, Wildlife Management Institute and University of Massachusetts (College of Agriculture, Experiment Station, and Extension Service) cooperating.

Today wildlife managers believe that the major role played by clearings is to provide supplemental food. A secondary role is to increase "edge effect." Influence on game harvest, public relations, and animal distribution are other roles less frequently cited. Turkey and deer are the species for which clearings are created. Pasture-like clearings are more common than the infrequently mowed or brushed type.

PROS AND CONS

Positive aspects.—Diversity of habitat is necessary for successful management of deer populations and where this is lacking a system of clearings can provide openings, "edge," and diversity of food species. The most striking evidence for this that I have observed is in the large pine plantations of the Piedmont and Coastal Plain of South Carolina. Here the clearing program probably is the key to maintaining turkey populations. Although we are discussing deer habitat the example is still appropriate. Where man creates an artificial monoculture it is axiomatic that remedial measures to benefit wildlife must be artificial also.

Lush green clearings with abundant evidence of deer use (droppings, tracks, and grazing) are tangible evidence to the public that "something is being done" for wildlife on a management area. Openings and clear vistas in an otherwise closed forest present good opportunities to observe deer from concealed vantage points.

Where otherwise lacking, clearings and their attendant access roads provide avenues of hunter use. Bow hunting may be nearly excluded where clear openings frequented by deer are absent.

Negative aspects.—Installation and maintenance of clearings are very expensive practices, especially when carried to the point of operating a pasture improvement program. Maintenance costs can easily exceed installation costs by several-fold. Habitat diversity can be provided through a well planned revenue producing forest management program. Cuttings, log landings, skidroads, millsites and the like can provide openings, edge and a diversity of natural foods. Seeding for erosion control can be designed to add forage species otherwise absent. These openings are less permanent than managed pastures, but they are byproducts of a profitable program and under forest harvest rotation new openings can be regularly added within the confines of the management area.

With few exceptions an extensive clearing program cannot be justified on an ecological fact base. If clearings are actively supplementing the food base of any management area we cannot prove it because we do not know *what is being supplemented.* Quantitative measurements of forested deer range are largely restricted to woody browse. Qualitative measurements are almost unknown. Comparisons are frequently made between planted forage and woody stems, shrubs, and vines. Comparisons with native volunteer herbs and forbs, of the type encouraged by minimum mowing and fertilizer on South Carolina clearings, are lacking. Unless the surrounding forest range condition is known, quantitatively and qualitatively for all major food sources, we have no way of knowing what supplemental role clearings play or ought to play.

We have no sound evidence of the effect of clearings on wildlife production, movements, and harvest. To my knowledge no "before and after" data are available to support the common assumption that clearings increase harvest and hunter success. We know hunters use the access roads and clearings, but we do not know what this means in terms of man-animal contacts or how we might manipulate hunter distribution in relation to harvest.

Without this knowledge we cannot intelligently discuss the relative values of forage species we might plant, the proper fertilizer or lime applications, or optimum sizes, shapes and distribution of clearings. Yet these are topics which today consume time and money in many southeastern and southern deer management programs. The relatively new questions about possible parasite and disease exchange on clearings are not going to be resolved until we know how clearings, or any other habitat manipulation for that matter, affect distribution and feeding patterns of deer.

AVAILABLE AND NEEDED KNOWLEDGE

Current knowledge.—The literature contains abundant references to the need for habitat diversity and to techniques for creating clearings. Leopold's (1933) edge effect concept, Stoddard's (1936) turkey observations, Blakey's (1937) Ozark turkey range recommendations, Mosby and Handley's (1943) turkey management monograph and Wheeler's (1948) turkey work in Alabama have been particularly influential in establishing forage clearing programs first for turkey and then for deer. On the whole these studies are based on broad habitat evaluation in the field and support the need for diversity in vegetative types. Some encourage establishment of clearings to achieve this, but none include detailed studies on the effects which one might expect for such a costly practice.

More recently a few studies have approached this goal. Lay (1957) and Blair and Halls (1968) found the southern forests low in protein and phosphorus requirements for livestock and suggested that supplemental pasture providing these elements for deer might be important. By and large these studies considered woody stems, shrubs, and vines. We have comparatively little knowledge about native herbs and forbs. McGinnes and Ripley (1963) reported that inclusion of clearings in the long term management research program on Broad Run, Jefferson National Forest, Virginia, did not increase the deerherd. English and Bramble (1949) showed that deer use of clearings can be related to soil type and its subsequent influence on plant nutrient content. Added lime and superphosphate on deficient soils will attract deer.

Lewis (1967), in central Tennessee, determined by statistical analysis that turkeys were sighted significantly closer to clearings than would be expected if they were distributed systematically over the forest. The average number of turkeys per observation was significantly higher for fields 10 to 20 acres in size. What implication this may have for deer is not clear, but certainly this shows that statistical analyses are not too sophisticated for evaluation of this management practice.

Research on "edge effect" since Leopold (1933) presented the concept has been sparse. Most work concerns

songbirds, where positive correlations have been established between "edge" and nest abundance, and quail where call counts and fall coveys are related to certain types of "edge." Barick (1950) found that all "edge" types are not equally valuable for deer in the Adirondacks, and Cross (1963) found deer tracks in the Adirondacks avoided clearings in the winter unless they had southerly exposures. Currently there is little evidence to support the claim that "edge" created by clearings provides any positive benefit to deer.

Many workers have examined production and utilization of food species planted in clearings. This type of work has been reviewed elsewhere (Larson 1967b). Tracks, droppings, and bales of forage are not end-products of a wildlife management program. They are only indices which have yet to be related to animal numbers and distribution.

Research needs.—If intensive and costly habitat management practices, such as forage clearings, are necessary, much better information will be needed in four areas:

1. Quantitative and qualitative information on all deerfood resources. Research in the past has concentrated on woody browse but lead deer studies in Pennsylvania (Watts 1964; Healy 1967) indicate that deer feed heavily on herbaceous species. Segelquist and Green (1968) have found that natural cedar glades in the Ozarks were important heavily used sources of herbaceous forage when mast was not plentiful. Stiteler and Shaw (1966) seriously question the importance of browse to deer in the northeast, and unpublished work by Cushwa, Downing, Urbston, and Harlow similarly questions the importance of browse in the southeast. Much improved understanding of how deer extract food needs from natural forest range will develop a reference point for evaluating the true role of clearings as supplemental food sources.
2. Our total environment is changing and wildlife management decisions once suitable for application to whole States or large portions of States may be inadequate for smaller areas because we are unable to accurately measure deer numbers and population changes under eastern forest conditions. Only large changes in population numbers, and the influence of large environmental factors, can be detected using present techniques to estimate animal numbers. Clearings in most cases are relatively small environmental changes, and if their effects are to be detected, then very substantial improvements in population estimation are needed. I suggest that high dollar costs associated with forage clearing management should be linked with an ability to estimate the effects on the principal animal species being managed.
3. The effects of clearings need not be measured only in terms of animal numbers. Manipulating animal distribution and man-animal contacts can be valid objectives of a management program. Telemetry appears to offer the greatest potential for evaluating deer behavior in relation to habitat components. Such studies should permit evaluation of "edge effect," and define optimum size, shape, distribution and effect of clearings on deer behavior. Marchinton and Jeter (1967) found that a common movement pattern of radio-tagged deer in Alabama and Florida involved feeding in open areas or forage clearings at night and a return to wooded areas at dawn, but a limited number of animals were traced. More intensive studies directed at the role of clearings in the deer's ecology would be highly informative.
4. The study of hunter behavior, with specific reference to clearings, appears to be well suited to the techniques employed in recreation research. The relation of bow hunting to clearings appears self-

evident. James *et al* (1964) found that all deer kills by all methods in the North Carolina Piedmont were within 1,800 feet of a road or trail, and in the mountains nearly all were killed within 2,400 feet of similar access ways. Roads and trails appeared to serve equally in distributing hunters, and they speculated that the difference in use of "off-trail" areas might be due to differences in the hunting habits of urban and rural sportsmen. If this is the case, certainly there are many other hunter attributes and preferences of which we know little and which may have importance in habitat management programs.

CONCLUDING OBSERVATIONS

If the expenditure of nearly $8 million in creation and maintenance of clearings has been an entirely satisfactory investment then this discussion is academic. I suspect that this is not the case. Wildlife managers who contributed their data and the benefit of their experience to my studies were not in agreement regarding the roles clearings played in their management programs. As early as 1936 Gabrielson (1936) doubted the economics of clearings. Essentially the same questions were raised by Bailey *et al.* (1951) in West Virginia, Krefting (1962) in the Lakes States, the Northeastern Forest Wildlife Research Committee and myself today.

Wildlife managers at the 1962 Northeast Wildlife Conference were reminded by Longwood (1962) that, "Confronted with a task too big for our manpower and facilities we have a tendency to dive into the physical part of the work without adequate advance planning. It is difficult for us to sit back and go through the processes of analysis and planning when so much needs to be done. It is easier to get at the job and leave the detailed planning until later. This is where expediency overcomes our better judgment."

With due regard for the need for "action programs" in the early days of wildlife management, I suggest that the extensive use of costly clearings is the type of practice to which Longwood refers. Major emphasis on a single management practice in hopes of effecting a positive response by deer ignores the admixture of variables which make up deer habitat and is a high risk venture.

I recommend that we draw the line on adding more of the intensively managed pasture-type clearings and reduce the maintenance costs to a minimum on existing clearings. Where diversity in habitat is lacking, coordination with forest management will apply costs to several goals and keep single-purpose wildlife expenditures to a minimum.

More emphasis should be directed to bettering our ability to understand and predict the effects of habitat change on animals and man. The East has experienced one cycle of habitat destruction and recovery. In all likelihood we are approaching a period of renewed manmade threat to wildlife habitat as human populations and demands on resources grow. Development of effective methods for evaluating habitat change will find broad applications in environmental management.

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Philosophy of Deerherd Management

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A clearly defined philosophy of deerherd management has apparently not yet evolved as reflected by the variety of hunting regulations. Due to the inability to apply management techniques, other than hunting, on large percentages of deer producing land, it is suggested that hunting is the major influence presently available to manage the herd. It is further suggested that extensive work on harvesting methods by wildlife workers is necessary to efficiently use this tool. A plea is made for leadership by the wildlife profession in the adoption of objectives, further study of harvesting methods to refine regulatory processes, and to maintain a high quality of the hunting experience in regulation matters.

When I accepted the invitation to discuss the philosophy of deerherd management several months ago, the assignment seemed like a fairly simple one. However, it soon became more complex and it seems to me now that the most I can do is to discuss two basic problems. I have come to believe that the philosophy of deer management is reflected in the regulations governing the harvest. If this is true, a review of the variety of harvesting regulations indicates that a firm philosophy has not yet been developed. This is the first problem. The second is, that given a philosophy or clear set of objectives, it is doubtful if we are sufficiently knowledgeable to set regulations to effectively reach these goals. Put more simply, I don't believe we are in agreement on what we are trying to produce or how. If stating the problem is the first step in its solution, I hope then that this discussion will be a contribution to this program.

PHILOSOPHY OF DEER MANAGEMENT

For years we have met, with our department people, and argued long, loud, and often bitterly, to set regulations for the coming year. We are guided largely by scientific biological data, but also by personal opinions, some prejudice, often politics, and always a fair amount of tradition. The same traditions, which sacred as they are, were at one point instrumental in eliminating deer from all but a few deep swamps and private preserves in Georgia. Somehow we come up with successive sets of regulations which have permitted a steadily increasing deerherd and harvest. These regulations, at present, vary from 3 days with control of hunter numbers in some areas, to 80 days with dogs in others; from bag limits of one buck to a buck and a doe or two bucks season long; to some areas with either sex the last day and other variations. Somehow, it has worked, but I personally don't feel that deer management is quite that sophisticated, nor are we that artistic in setting effective regulations. Looking back over many sessions, it seems to me the cause of much of the controversy is that we have never been in agreement on what we are trying to do and how.

As an avid deer hunter, it is always my hope that there will be a place where I can enjoy what to me is quality deer hunting. We have always tried to be sure we have such opportunities in Georgia, and have been fortunate so far in being permitted this luxury, if it is a luxury. Quality seems important to me, but after many discussions on this subject I have found very quickly and often very bluntly that what is acceptable quality to me may be quite different from what is considered acceptable to other individuals, or other agencies. I'm not even sure we put the same ingredients into the matter for consideration, but believe it is important to establish some standards. I have served for some years on the Deer Harvest Subcommittee. At one of our meetings we decided to define "quality," as related to deer hunting; and we did, over and over again all day long and into the night. We defined it too, but I doubt if we ever agreed privately on the accepted definition, but rather gave in from sheer exhaustion. At least I did. The definition is as follows: "Hunting for a maximum period of time with a minimum of hunter contact and controls and a reasonable opportunity to see deer or fresh deer sign."

In the southeast, management areas have become an accepted fact of life. They continue to persist, probably after their original purpose as restoration areas has been served. Some might even be better off if abandoned. It seems to me that one of the things which permits them to live on is this matter of quality hunting. However, here again, these areas are hunted in a variety of ways. It is the hope of many of us that some guidelines might emerge if the experiences over the years on these areas were evaluated. The Forest Game Committee at one time proposed a "circuit riding brain picker" to study this matter. One thing is certain, the approaches to hunting these areas have been varied enough to give some interesting information, and to indicate there is some confusion on how they should be handled. In discussions on this subject, I have heard that "1 day is enough for anyone to hunt deer; get as many hunters as you can in 1 day; kill as many deer as necessary, and you're through with it for another year." Some recommend controlling hunter numbers by permits sold prior to the season. Still others suggest making the regulations complicated enough to limit hunter numbers and harvest, and many other approaches. In our State, we have problems keeping some areas open as long as we could, so far as deer populations are concerned, simply from the standpoint of administrative problems. Perhaps then we are "overadministrating" the hunts. On the other hand, and I know opinions vary on this, we believe that in many situations deer can easily be overharvested. We have one very popular area in Georgia on which buck hunting has become largely a nature hike, we believe, from overhunting bucks. Incidentally, this is accomplished in 6 days a year. Some years ago, a noted deer specialist gave some sage advice to a good friend of mine. His advice was, "Son, your only problem with deer is killing enough of them." We haven't found this to be entirely so in Georgia, and one can imagine the results if we shot "either sex" on the area mentioned in the spirit of that advice.

Several years ago a hunting club in deep south Georgia reported a kill of seven bucks during the 80-day season on 100,000 acres. The club members were quite happy, their only concern being to have enough deer to find one fresh track to have a chase with dogs. Such results can commonly be contrasted to other areas of equal size which would produce an annual harvest of 400 to 700 bucks. Obviously, there is a wide gap in results here, controlled almost entirely by hunting pressure, in this case motivated by tradition.

Most of us in the southeast have for years been involved in deer restoration programs, and I think with outstanding success. Most of the investigations and research projects have been done in line with production; i. e., reproductive rates, carrying capacity, habitat management, inventory systems, and others. This is all good and valuable information and the work must, of course, be continued. However, now that we have the deer to manage, I think it is imperative that more thought and study be expended in the direction of hunting, which is no doubt the most effective method we have with which we can rapidly and effectively apply controls to the herd. I would expect some criticism on this position, but first let me explain. Speaking for Georgia, let me evaluate the frame on which we have the opportunity to apply the "production influences," namely habitat management. At the present time we have approximately 1 million acres of public land in the State. Some 690,000 acres is USDA Forest Service, the remainder, Corps of Engineers, Department of the Army, and various other Federal and State agencies. This works out at approximately 3 percent of the total area of Georgia on which we have "some" direct influence, and I think all who are familiar with timber interests would agree that our influence has been minimal over the years. There is another 6 million acres of industrial forest lands, approximately 16 percent of the State, on which we also have "some" influence, in varying degrees from time to time. This leaves approximately 30 million acres of private forests and farmlands (80 percent) on which we have essentially no direct influence on habitat management. I would expect some comment on this point, which reminds me of some personal experience. My father and I were, in addition to being close friends, constant hunting and fishing companions. I think he valued his hunting as much or more than I, which is considerable. After my introduction to game management in college, I brought home ideas and proposals to improve hunting on the farm. Meanwhile the farm became more mechanized with fewer fences and more drainage, until today to my knowledge there is not a pheasant on the home place. Interested as he was in hunting, he was more of a farmer and so far as I know, I was never able at any time to modify in any way his desire for a "clean" farm. I think we are in this same position today with the various landownerships mentioned, without the advantage of the close family ties, and I think the results may be somewhat similar.

The variation in landownerships is one of our problems, both from the standpoint of production and harvest. I think we should expect more intensive production practices on public lands than on industrial forest lands and still less on private lands. It may also very likely develop that as harvesting techniques are refined the three classes of ownerships will require separate regulations. The pattern is probably somewhat similar over most of the southeast. It would seem clear to me then that deer are at present, and are destined to remain for the most part, a byproduct of the land. Therefore we will not have the opportunity to apply habitat practices primarily to produce deer.

We are left then with hunting as the one major influence with which to manage deer. To accomplish this, we meet 1 day a year with our commission, and as stated, "guided by some biological data, personal opinions, prejudice, politics, and tradition," we establish regulations governing the harvest. I think it could be said here that we are attempting to produce deer scientifically, and are harvesting them "artfully." I am not sure what impact complete freedom to manipulate the "production elements" would have from year to year on deer in the bag, if that is our goal, but I think it is clear that in a regulations session in which one of the above ingredients becomes dominant, that a major influence can be affected, often quite by accident. One of those ingredients often does become dominant, probably because we are largely guided by art rather than science in regulation matters and have little if any pertinent data to justify our recommendations as to the result which will be affected. Supposing research on parasites, disease, reproduction, range condition, or what have you, indicates an increase or decrease in harvest of the herd, or an age class within the herd. What happens? The thought is transmitted from the technician to the administrator, who is faced with the problem of carrying out the assignment, and incidentally, assuming the responsibility, with little or no information on what his actions, harvest-wise, will produce. He is furnished no reassuring data with which to convince himself and an often apprehensive commission and public that his proposal will achieve the desired results. What he needs is the same kind of sophisticated data on what a change in regulations will produce as went into the recommendation for the change. It seems then, that in order to provide this data, some serious research is in order on the harvesting of deer.

PHILOSOPHY OF DEER HARVEST

In order to approach this problem of harvest, it seems to me we should first arrive at some statement of policy or objectives on what we are trying to produce. I feel that the game people have a high degree of responsibility for leadership in directing this policy to maintain a high standard of recreation. We often hear that we should poll the public, determine what they want and then produce it. At the risk of sounding dictatorial, it is my feeling that being "experts" in the field of wildlife research and management, it is incumbent on us to take the leadership in determining what is best for the deerherd, within limits, which in the long run will be best for the sportsmen, and then promoting this policy. As an example, lacking this leadership and following the advice of the public, we doubtless would never have any either sex hunting. If we had allowed tradition to dictate the use of dogs statewide in Georgia, we probably wouldn't have the problem, since that would have long since reduced the deer to a point comparable to the yield of seven deer on 100,000 acres over much of the State. In situations where either sex hunting is acceptable to the public, it came about after a determined "sales" effort by wildlife workers. I think we all agree this is as it should be, and I believe some more such sales programs are in order, after developing a philosophy to sell. I think then we are back to the question of what we are trying to produce in deerherd management. From past experience, there are at least several answers to this, depending on who you ask. Among the answers are: to produce the maximum number of buck deer in the bag; to produce a trophy class animal in the bag; to harvest the maximum number of animals; to maintain an optimum deerherd on the land; and, to furnish the maximum number of man-days of recreation. An acceptable philosophy will probably be a combination of all of these factors, and more. Each of these goals or any combination, can be approached differently, but all will be controlled by hunting regulations.

In order then to briefly summarize the situation, at least as I see it, we are first faced with the need to develop a philosophy and to define objectives. I believe it is the responsibility of the professional game manager to take strong leadership in the establishment of these goals in order that they be reasonable in the light of what is possible or feasible under the circumstances. I think also it is incumbent on us to give quality of the hunting experience great weight in developing our objectives; otherwise, deer hunting could decline in quality to the level of put and take trout fishing, and the end product would hardly be worth the effort.

I belive an acceptable philosophy will provide for various goals in various places, but basically it should produce a maximum harvest of animals balanced against a maximum yield of quality recreation. This might be accomplished by segregating hunters by time and area and segregating hunts by buck only and antlerless only, and many other refinements.

Once our goals are defined, it is my feeling that the major influence available to us to manage a herd will be the application of hunting pressure. To use this tool accurately and wisely to assure the maximum product, be it man-days of recreation or maximum harvest, will require far more sophisticated information than is presently available to us. We need to know the results of regulations in terms of harvest and recreation. This will require answers to the question of effects of various opening and closing dates, number of opening days, length of season, size of bag limits, dogs versus still hunting, shotguns versus rifles, special seasons, effects of hunting various habitat types and various landownerships and many others.

This information will be necessary first to determine the proper regulations to accomplish our ends, second to establish some agreement within our departments, and third and more critical, to gain acceptance of our program by the hunting public. This will require extensive study on harvesting. Lacking this information, the setting of effective regulations will remain an art, subject to a variety of misjudgments and resulting in inefficient utilization of the deerherd.

Hunting Methods, Limits, and Regulations

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Deer hunting regulations, bag limits and hunting methods in the southeastern United States were studied through a survey of deer hunting information pamphlets.

Killing deer by use of artificial light at night, shooting deer in lakes or streams and pursuing deer with motor vehicles were generally prohibited. Legal methods included: still hunting on foot and from a stand, hunting from elevated platforms, driving deer by organized groups of hunters, and calling bucks by rattling of antlers.

Driving deer with dogs was legal in 10 of the 15 States.

Rifles, shotguns, muzzle-loaders and longbows were legal weapons in all 15 States. Seven States had some areas limited to use of shotguns only. Most of the States attempted to set restrictions on rifles. One State had no regulations on firearms. Shotguns loaded with buckshot were legal in the 10 States which permitted driving deer with dogs.

Daily bag limits were generally set at one deer per day but four States permitted a multiple daily bag. Season limits varied from one deer to 67 per season.

Length of the firearms deer seasons varied from 5 days to 120. Seasons began August 15 and continued through January 19.

The basic season was a "bucks only" season with any-deer being legal in restricted areas. Nine States permitted either-sex deer harvest in 1968.

Archery deer seasons averaged 58 days.

Control of the harvest is the most effective management method available for white-tailed deer. Deer regulations should be written to provide the maximum amount of recreational opportunity for the greatest number of hunters without endangering the resource. The current deer regulations seem to be accomplishing this objective, however, there is danger of overpopulation as a result of continued bucks-only harvest.

My subject, "Hunting methods, limits, and regulations," actually concerns control of the harvest. It is common knowledge that since the large native predators have been eliminated, harvest by man is the single most effective control on deer populations in the United States (Allen 1954, p. 140).

Deer populations were nearly eliminated from most of the United States by unregulated hunting during the pioneer era, with a low point in most States in the early 1900's (Allen 1954, p. 135). Through control of harvest, usually accompanied by restocking, deer have been restored to every State and deer are now hunted in all 50 States. The total harvest of white-tailed deer in the southeastern United States increased from 129,034 deer in 1955 to 559,645 in 1967.

The following summary of methods, limits, and regulations is based on copies of 1968 deer hunting regulations received from the 15 southeastern States involved. There was a wide disparity in completeness of the regulations received. Some of the pamphlets were complete, clear, and concise. Some were incomplete as to information on legal weapons, methods or other factors. In others, complete information could be found only after searching through the entire information folder. The greatest confusion occurred when attempts were made to incorporate all hunting (and even fishing) regulations into one pamphlet. As an outsider seeking specific information, I certainly appreciated the pamphlets which were devoted solely to regulations for hunting deer or closely related species.

METHODS

What should be the criteria for determining legal methods for harvesting deer? The methods permitted should be humane, sporting, and effective, but not so effective as to give the hunter an unfair advantage or endanger the resource. Killing of deer by use of an artificial light at night is an example of a method which fits the latter criterion. This method is just too effective, and is illegal in all of the southeastern States. A swimming deer is also very vulnerable and most of the States in our region prohibit killing deer in any body of water. Pursuing of deer by any motor driven conveyance on land or water is almost universally prohibited.

Most of the acceptable methods of hunting are legal in the southeastern United States. The most common method is probably stillhunting, by which I mean stalking deer on foot or waiting for them on stands. It has been my experience that pursuing deer on foot is the least effective of all hunting methods, especially in country where snow seldom occurs. Waiting on a stand is usually more productive.

The deer hunting stand is generally more effective if it is elevated. Platforms in trees are common, and in Texas I understand that special hunting towers are built. In Florida, deer are hunted from towers erected on motor vehicles. The restriction that these towers could not be higher than 8 feet above the lowest bottom surface of such vehicles was the only restriction which I found on the use of elevated stands for hunting deer.

Driving of deer by organized groups of hunters is an even more effective hunting method and appears to be acceptable throughout the region.

Driving deer with dogs is a method almost unique to the southeastern region. Dogs may be used legally in the pursuit of deer in 10 of the 15 States. The sporting ethics of using dogs to hunt deer appears questionable to me. However, it is contended by the advocates of "dogging" that this is the only method which can be used to harvest deer from swamps of the southern coastal areas. The use of dogs may be justified in the swamps, but what is the excuse for use of dogs in upland pine and and hardwood forests?

Calling of deer by the "rattling" of antlers is apparently confined to the State of Texas. Other types of calls are banned there and in most other States. Baiting and salting also are generally banned.

WEAPONS

Related to hunting methods is regulation of type of weapons which may be used to harvest deer. Both rifles and shotguns were permitted in all 15 States in 1968. Only Oklahoma had an area restricted to use of rifles. Seven States had some areas limited to use of shotguns.

In our region, the main reason for limiting hunters to shotguns seemed to be related to the theory that shotguns are safer than rifles. However, in Michigan, certain areas are restricted to use of shotguns as a means of reducing the numbers of hunters. Tradition dictates that deer should be killed with a rifle; therefore many of their deer hunters will not hunt with a shotgun and avoid areas which are restricted to shotguns.

What is considered an adequate deer rifle? The Sporting Arms and Manufacturing Institute recommends cartridges in caliber of .23 or larger, developing a minimum of 975 ft.-lbs. of energy at 100 yards. The Ammunition Division of Canadian Industries Limited recommends that a deer rifle should have 1,500 ft.-lbs. of muzzle energy.

Most States in the southeast have attempted to set restrictions which approximate the above recommendations. Rifles of .22 caliber, rimfire ammunition, full-jacketed bullets and automatic weapons are generally prohibited. Only Mississippi has no restriction on the type of firearms which can be used.

Shotguns smaller than 20 gage and larger than 10 gage are generally prohibited. In the 10 States which permit the use of dogs, shotguns loaded with buckshot are legal weapons. Shotgunners in other States are restricted to use of slugs.

Muzzle-loading rifles are legal in all 15 States. Most of the States set some minimum requirement as to caliber or grains of powder which are legal, but again the standards vary greatly.

Longbows are legal weapons in all States in the region. Some States set minimum standards for archery equipment but the standards vary widely.

Crossbows are legal weapons in Kentucky, Missouri, Oklahoma, and Arkansas. Arkansas is the only State which has a special season for crossbows. Legality of the crossbow was not clearly stated in regulations which I received from five States.

Both rifles and shotguns are legal weapons, statewide, in Missouri. We find that 91 percent of our hunters use rifles and 9 percent use shotguns. A few hunters use pistols which are legal in .38 caliber or larger.

BAG LIMITS

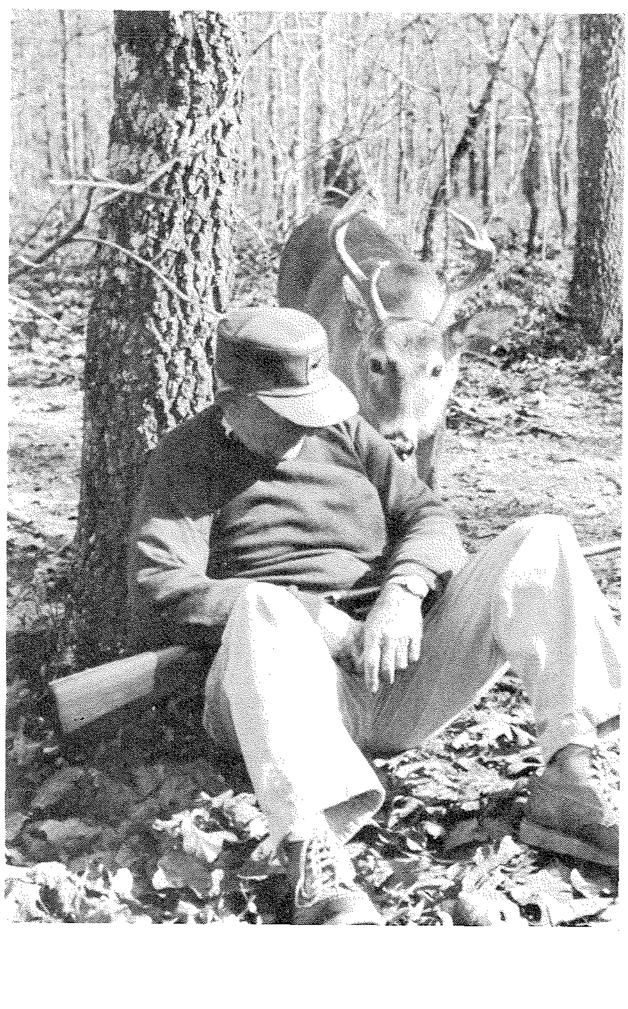
What is the purpose of a limit on the daily bag and possession of deer? The purpose should be to prevent overharvest, spread the harvest more evenly among the hunting population, and prevent "game-hogs" from slaughtering more game than they can utilize, thus wasting the resource.

Daily bag limits are generally set at one deer per day. However, in Florida, two deer (bucks) per day may be taken. The regulation pamphlets from Georgia and Texas indicated multiple bag limits but did not indicate whether these limits could be taken all on the same day.

Season possession limits varied from one deer (buck) per season in six States to a limit of one deer (buck) per day in Alabama which had a 67-day season. Four States permitted two deer per season and hunters were permitted five deer per season in parts of South Carolina and Texas.

FIREARMS SEASON HUNTING REGULATIONS

A well written deer hunting regulation should be concise, as simple as possible, but complete. It should provide a maximum of hunting opportunity with a minimum of restriction compatible with the best utilization of the resource. This objective apparently is very difficult to obtain. Deer populations, range conditions, and patterns of hunter distribution are not constant even within the boundaries of a single State. These factors result in a multiplicity of regulations designed to compensate for the variations. In addition, sociopolitical factors also complicate the setting of regulations in some areas.



Designation of length of season and sex of deer which may be taken are common to all regulations. Length of season varied tremendously in the southeastern region in 1968. The average number of days of firearms deer hunting per State was 47 days. Total days of hunting ranged from 5 in Kentucky to 120 in South Carolina. The total season in South Carolina encompassed 140 days, but hunting was not permitted on Sundays. Maryland, North Carolina, and Virginia also did not permit hunting on Sunday. A similar law exists in Georgia but evidently is enforced only on a local option. Seven States offered less than 30 total days of hunting with rifle or shotgun, one State offered 30 to 60 days, six States offered 60 to 90 days and one State offered more than 100 days.

Deer hunting began as early as August 15, in South Carolina, and continued as late as January 19, in Florida. A dyed-in-the-wool deer hunter (with plenty of money and time) could find 158 continuous days of deer hunting in the 15-State area.

The majority of States provided several seasons differentiated by season dates. Kentucky and Oklahoma confined all their deerhunting to a single statewide season. At the other extremity, Texas had 18 distinct seasons differentiated by season dates.

Other divisions of hunting territory in the southeastern States were achieved by areas closed to deer hunting, differential bag limits, and restrictions as to sex of deer, use of dogs, and weapons.

The entire harvest in six States was restricted to antlered males only. The remaining nine States permitted harvest of either sex in at least some portion of the State. Alabama and Louisiana prohibited the taking of spotted fawns during the either-sex seasons.

The definition of a legal antlered male during bucks-only seasons also varied between States. Six States required only that antlers be visible above the hairline. Seven States set minimum length limits ranging from 3 to 6 inches. Antlers with at least one fork on one antler were required in the other two States. In Texas, the definition of a legal male deer varied for different areas.

Greater similarity existed for shooting hours. Eight States had regulations which could be interpreted as meaning from sunrise to sunset. From ½ hour before sunrise to ½ hour after sunset was the legal shooting period in six States. Missouri was most definite, setting the shooting hours from 6:30 AM to 5:00 PM.

Hunters in five States were required to submit their deer for checking at stations authorized by the game department.

ARCHERY SEASON REGULATIONS

Archery seasons provide maximum recreation with a minimum of danger to the resource. Therefore, archery seasons should be as long as possible without conflict with other interests. All southeastern States permitted the longbow as a legal weapon during the regular firearms deer season. However, because the archer cannot actually compete with the firearms deerhunter, a special season for archers only is usually provided.

South Carolina does not provide a special archery deer season but, with the regular deer season open from August through December, it would be difficult to find time for a special archery season. In those States with relatively long archery seasons, the archery and gun seasons usually overlapped.

Seasons allowing only the longbow began as early as September 14, in Florida, and continued as late as January 31, in Arkansas. Average length of the specified archery seasons was 58 days. Four States provided an archery season over 90 days in length. Archers were permitted to kill deer of either-sex in all open areas in eight States. They were restricted to harvest of bucks only in at least some portion of the open territory in the other States.

MANIPULATION OF REGULATIONS

Control of the harvest is the most effective management tool available to the manager of white-tailed deer. Range research and improvement are useless if overharvest reduces the deer population far below the carrying capacity. Conversely, knowledge of nutrition and reproduction are wasted if underharvested deer populations exceed the carrying capacity.

What then should be the objective in using this tool? It should be to provide the maximum amount of recreational opportunity for the greatest number of hunters without endangering the resource.

Many case histories have demonstrated that underharvested deerherds will expand beyond the capacity of their range. Adequate harvest is needed to control this expansion. With the large numbers of hunters available today, deer managers can control expanding deerherds and could in fact practically eliminate deer from any given area if sufficiently liberal hunting regulations were set.

That's where the trouble starts. The setting of deer hunting regulations has generated more discussion and just plain argument than regulations for any other game species, with the possible exception of waterfowl. Deer managers almost invariably recommend more liberal harvests than the public or even personnel of their own department are willing to accept.

For a well documented and thoroughly interesting analysis of the biological, social, and political facets of the "rhubarb" which can result from attempts to liberalize deerhunting regulations (in New Jersey), I recommend that you read *Doe Day*, by Tillett (1963). He concluded, "This little tale highlights the importance of professional competence and skill in the direction of government bureaus and the administrative need for the qualities of persistence and courage along with quasi-political skill. The moral seems to be that the professional game-administrator should be a leader rather than a captive of his constituency."

The quasi-political skill is of most importance in those States in which game departments must still answer in some degree to the legislature for their hunting regulations. Bartlett (1949) stated, "The answer apparently lies, at least partially, in the fact that game managers often do not have the power to manage deerherds properly. Such regulatory powers often are vested in an unresponsive legislature—unresponsive possibly because game men may be poor educators."

The exact powers and authority needed were outlined by Hunter (1957), in discussing methods used to obtain hunter distribution in Colorado, "To obtain proper hunter distribution it is necessary that a game and fish commission, through its Director, have adequate authority for effective administration and management. Powers of the commission should include the authority to establish season lengths and dates, bag limits, shorten or extend, or close seasons on any species of fish and game within two 48-hour periods, designate the sex, species and the number to be taken, the manner and have the right to open or close refuges to hunting."

A common theme was found in most discussions of deer harvest regulations (Allen 1958; Bartlett 1949; Longhurst 1957; Ruhl 1956; Swank 1962; Swift 1951). This theme was a plea for more authority to set more liberal hunting regulations and for more understanding of the problem by department personnel, the public, and legislators. However, most of these papers were written by deer manager-administrators of the Northern and Western States where deer populations had increased to the level where range destruction and wholesale starvation of deer were occurring. They were stuck with a buck law and couldn't get rid of it. All agreed that education of the public, of lawmakers and of their own personnel was of prime importance. The authority to hold either-sex deer seasons was the major goal of most of their programs. Longhurst (1957) found that the major factors preventing control of big game herds by hunting were: shooting bucks only—18 States, poor hunter distribution—13 States, public opposition—12 States, inaccessability—11 States and legislative restrictions—10 States.

How do the statements and conditions outlined above apply to the region we are discussing? Some of their statements regarding basic needs still apply. However, the overpopulations of deer which concerned the earlier authors do not exist throughout most of the southeastern region. Deer populations in much of the region are still recovering from lows of the early 1900's and any overpopulations are generally confined to local situations. As Gresham (1969) said, "It is difficult to see how deer hunting can continue to improve in the South year after year, but it does. The answer, of course, is that in many States of this region it had a long way to go. Deer had been eliminated from vast areas of the South during centuries of poor management, and now good management is putting them back."

Are the current regulations adequate or is there still room for improvement? Swank (1962) concluded that conservative seasons with no provisions for postseason hunts, multiple bag limits, or either-sex seasons stamped a State as being antiquated in its big game program. Progress apparently is being made to remove the southeastern States from the antique age. In 1949, only Virginia had an any-deer regulation (Bartlett 1949). In 1957, five States had any-deer regulations but Longhurst (1957) concluded that only two States were actually controlling the growth of their deerherds by hunting. In 1968, nine States had any-deer regulations. With relatively long seasons, harvest generally restricted to bucks and multiple season bag limits, it would seem that deer hunting regulations in the southeastern region are accomplishing the objective of providing maximum recreation without endangering the resource. However, the resource can be endangered by underharvest, even more than by overharvest.

From my limited knowledge of conditions in the southeastern region, it appears that present deer regulations are adequate for controlling deerherds in all States except Texas. Even there the problem seems to be one of economics and landowner acceptance rather than proper hunting regulations.

What of the future? There seem to be two routes. The first leads to problems with overpopulations of deer in those States which continue to shoot only bucks. The tradition of the bucks-only season, once established, is difficult to eliminate and it is not too soon to begin the educational process necessary to prevent establishing the tradition. The second route relates to the human population increase. The number of deer hunters in the United States increases annually while the total deer range shrinks because of changing land uses. This route leads to problems with hunter distribution and control of the harvest.

Allen (1958) reported that only about 10 percent of a deerherd is harvested under bucks-only regulations and nearly 20 percent is harvested under any-deer regulations. Illegal kill also becomes excessive in States which have nothing but buck seasons. It would seem that under a multiple bag limit of bucks, such as exists in several States in our region, that the harvest would exceed 10 percent. However, Teer *et al.* (1965) reported that despite longer seasons and multiple bag limits the annual harvest in the Llano Basin in Texas averaged only 14 percent of the standing crop. With a three deer limit, one of which must be antlerless, the harvest took only about 20 percent of the herd. Harvest of more than 30 percent of the standing crop is needed to control a healthy deer population.

Hunter distribution can be a problem even with authority for setting liberal seasons. In Missouri, we tried to move hunters from an area near St. Louis by publicity to the effect that the area was overharvested and hunting success was decreasing. The publicity was ineffective, but when we changed the regulation to bucks-only the hunting pressure was reduced by about 50 percent. We have also found that hunting pressure was affected by the day of the week on which the season opened (Murphy 1966).

Colorado has made an intensive effort to achieve good hunter distribution. Hunter (1957) reported that the opening date, length of season and type of season (e.g. either-sex, antlered only, antlerless only, two deer on a license, multiple licenses, two deer multiple licenses, pre-, extended and post-seasons) all were useful regulation manipulations to influence hunter distribution. The multiplicity of regulations which I mentioned in reviewing current regulations indicate that deer managers of the southeast region are well aware of and are using these techniques when applicable.

One technique which apparently has not been necessary, as yet, in our region is zoning and quotas. This system usually is necessary when the herd needs harvesting but hunting pressure is so great that unrestricted numbers of hunters would damage the resource during an any-deer season. Several States in the midwest have adopted this system. We may see similar types of seasons appearing in the southeast region if the number of hunters continues to increase at the present rate.

I would predict also that the use of dogs for hunting deer will eventually be prohibited. Tradition is hard to overcome, but in my talks with deer managers of the southeast I can detect that even now some of them would like to make this restriction. I believe that restriction on use of dogs will be brought about when numbers of hunters far exceed the available resource. The north-central States, which do not allow the use of dogs, have high numbers of hunters which in nearly every case can control the deerherds without the use of dogs (Ruhl 1956).

The Southeastern States have developed several fine cooperative programs and could provide another example by standardization of deerhunting regulations. A region-wide adoption of uniform regulations on nonresident license fees, definition of a legal deer rifle and a requirement that guns be unloaded and cased during transport are some possibilities.

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Managed Hunts by State Agencies

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State game agencies conduct managed deer hunts on 15 million acres of public and private lands in 12 Southeastern States. Managed hunts are essential in the management of wildlife on recreational areas. The public has accepted the concept of controlled hunting. Although participating landowners are benefited, favorable public relations and monetary returns must be continued and maintained at a higher level in the future. Supervised hunting programs are costly, but are not as difficult to justify as other programs and practices frequently employed by State game agencies.

State agencies are legally responsible for the regulation, control, and management of resident wildlife (although there are current disputes questioning this jurisdiction). Therefore, State agencies must provide the leadership in maintaining wildlife resources in the best public interest (Berryman 1961). Effective leadership requires the development of programs which insure the public interest. Increasing recreational demands, population growth, and habitat destruction have, however, made the task increasingly difficult to accomplish on private and public lands which are available for public use. "Controlled" hunts are insuring a level of hunting opportunity not otherwise afforded. This form of hunting has become especially necessary and popular in white-tailed deer management.

For about 40 years supervised hunting has been used on specific areas where needed as a management technique in order to provide public hunting at the same time. The practice has increased in popularity, especially for forest game species, during the past 10 to 15 years and it is a subject of widespread discussion.

Managed hunting is "any form of hunting during which controls more rigid than those imposed by general hunting laws are exercised over the hunter on his method of taking various species of wild game" (Mosby 1952). Managed hunting is employed to manipulate hunters while managing wildlife.

My literature review on the subject verified Mosby's (1952) opinion that managed hunts are not reported in the literature to the degree they should be. To obtain background material, we submitted questionnaires to wildlife agencies in 15 Southeastern States. All of the States responded to the inquiries enabling the following discussion on the philosophy and current status of managed deer hunts in the Southeastern United States.

CURRENT STATUS

Approximately 30,000 deer are harvested annually on controlled hunting areas in 12 Southeastern States, and an estimated 1.2 million man-days of deerhunting are provided.

Controlled deer hunts are conducted on approximately 15 million acres in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Missouri, Mississippi, North Carolina, South Carolina, Tennessee, and Texas. The acreage includes approximately 10 million acres of private lands and approximately 5 million acres of public lands. During the past 18 years there have been few significant changes in the amount of public lands available for this use. As an example, there were 4.2 million acres of public land open to hunting in 11 Southeastern States in 1951 (Frye and Swindell 1951) as compared to the current estimate of 5 million acres in 12 States. The number of supervised hunting areas on public lands has increased, but the data provided by questionnaire respondents do not permit a valid estimate of the increment. In 1951 there were 50 separate areas in 11 States. There are now over 60 in seven States. In 1951 eight of the 11 States required special permits and six of the 11 States charged for the special permit (Mosby 1952). During the 1968-69 hunting season 12 States required special permits. Six of the 12 issued free permits.

MANAGED HUNT OBJECTIVES

The primary purpose of managed hunt programs is to provide hunting opportunity consistent with commercial and other recreational land uses. Hunter control, supervision, distribution, and deer management are secondary objectives according to most of the States responding to the questionnaire. Hunting opportunity is being insured and higher levels of sustained use are realized on areas where managed hunt programs are implemented.

The degrees of control imposed on the hunter vary widely and may be more varied than the objectives on each area where hunts are conducted. Controls often include special permits and restrictions on the number of hunters, harvests, methods of taking wildlife, camping, use of intoxicants, vehicle types, days and hours of hunting opportunity, types of firearms, use of campfires, and other activities. In addition, hunters are often restricted to specified zones within open hunt areas and are frequently required to check in and out and report their kill.

MANAGEMENT IMPLICATIONS

White-tailed deer management is, as it is being practiced, dependent on current data regarding populations, herd dynamics, animal condition, and hunter pressure and success. The maintenance of this information, particularly in the extensive forested areas of the southeast, provides a reasonable base for management (Ripley and Halls 1966). Supervised hunts provide a good opportunity for the collection of management data. Checking stations are the most common means of obtaining the data (Thompson 1951). Supervised hunting is both desirable and essential for intelligent wildlife management of recreational areas according to Mosby (1952).

PUBLIC ACCEPTANCE AND HUNTER SUCCESS

Although managed hunting means greater regimentation, the concept is not as distasteful to the hunting public as some resource administrators may believe. Some people oppose everything, but most sportsmen will abide by and accept the degree of control imposed when they understand the reasons for the controls (Mosby 1952).

There are hunters who prefer supervised hunts. Their reasons include greater success, safety, quality hunting, more favorable hunting conditions, and the existence of public use facilities (toilets, wells, developed campsites, boat ramps, etc.).

The question of public acceptance is of little consequence in a few States where managed hunt areas provide the only form of hunting opportunity. A significant number of the hunters who visit the areas are satisfied on the basis that these areas afford them their only opportunity. Ten States expressed unqualified public acceptance to managed hunt programs and two expressed mixed public feelings. In addition, nine States indicated that hunter success was greater and three States felt that the same level of success is realized on uncontrolled areas.

LANDOWNER ATTITUDES

Cooperative agreements and leases with public, private, and industrial landowners are the foundation of many recreational programs (Frye 1967). Few State game agencies own an appreciable amount of public hunting lands. Private landowners must benefit and receive compensation for the use of their lands. Their cooperation is necessary. The occurrence of a situation where an individual owner feels a moral obligation to allow hunters access to what is traditionally public property (game) is rare. There are, however, land holdings in the hands of realistic, civic-minded concerns or individuals who recognize the problem of supplying hunting and are willing to do their part (Frye 1967). This is particularly true when the landowner retains complete control over his land and its particular resources that are unquestionably his private concern (Frye 1967).

Although occasionally a few landowners become disenchanted with managed hunt programs, they are generally satisfied and all are benefited according to the 12 States which responded to the questionnaire.

Better public relations and greater financial returns are the primary benefits to private owners. State agencies are sometimes able, by virtue of normal development and maintenance activities, to offer services equivalent to financial support (Frye 1967). These services include fire protection, controlled burning, posting of perimeter boundaries, fence repair, assistance in maintaining capital improvements, and technical assistance involving general land management practices. Routine patrol by State personnel provides a degree of control over, and protection from, fence cutting, vandalism, rustling, littering, trespassing, and theft.

State administration and control of hunting in itself benefits the owner. Individual hunting arrangements, hunter supervision and enforcement are responsibilities that few owners wish to accept. The majority of cooperating individual and corporate landowners are willing to be relieved of these responsibilities as well as those involving wildlife management.

Liability relief is a major benefit and a prime incentive to landowners in leasing land for managed hunting. Limited liability relief is available to landowners who make their lands available to the public for recreational purposes in 10 of the 15 States surveyed (Fowler 1967). Florida and North Carolina were the first to adopt legislation of this kind in 1963. It has been a definite help in acquiring managed hunting lands.

Although the relationship between State game agencies and landowners is usually favorable, public hunting creates problems for both. The hazards of wildfire, vandalism, property damage, theft, and littering are difficult for owners to ignore. Consequently, private owners are in a position to demand certain compensations and State agencies are often required to make additional concessions when agreements are renewed. Concessions may be costly and involve such things as damage payments, services, increased protection, and higher lease rates.

Problems on public lands are usually a result of conflicting land use practices. However, general land use policies governing the use of public land negates the need to discuss the few instances where public agencies are competing in the management of renewable resources and land use. Multiple use policies are providing more access and additional hunting opportunities. A review of managed hunt regulations in the southeast indicates that fewer hunter controls are exercised on public lands and free access is more common than on private lands.

MANAGED HUNT COSTS

The cost of conducting supervised deer hunts varies with the intensity of management and the degree of control imposed.

Supporting data provided by nine States indicated an average expenditure of 8 cents per acre per year. The estimated costs provided ranged from less than 1 cent per acre to 18 cents per acre. The respondents indicated that approximately 1.2 million man-days of deer hunting are provided at an average cost of $1.08 per day. Cost estimates provided by individual States ranged from 20 cents to $3.25 per man-day.

Managed hunts are expensive to conduct. However, State game agencies are making a direct contribution to the hunting public and the involved costs are often easier to justify than other programs and practices frequently undertaken, as pointed out by Mosby (1952).

CONCLUSION

The demand for supervised public hunting areas and intensive use of existing areas is increasing. The degree of hunter control and the number of managed hunts are expected to increase proportionately. Managed hunting programs have been successful in providing opportunity and controlling use.

The ability of State agencies to maintain controlled hunting in the future will be increasingly important, particularly with regard to the acquisition of additional areas. Large industrial landowners will continue to make their lands available if recreational use can be controlled. The extent to which private owners cooperate in future programs is also contingent on the ability of State agencies to regulate hunting. Favorable public relations and the respect for private property are contributing factors and will require considerable attention.

The problem of providing participating private owners with additional financial return is critical. Private leasing is steadily removing managed hunt areas from cooperative management programs. Public financial support is necessary and it can be justified. Public benefits including associated outdoor recreation opportunities are products of managed hunt programs that could be supported by a larger segment of the public. To date, the hunter has shouldered the majority of the financial burden. Future programs will require a more equitable distribution of the financial burden.

State agencies would be remiss if they did not recognize the importance of a supervised hunting area as a proving-ground to demonstrate sound management techniques for private enterprise. Private investment has already established a number of successful managed deer hunt areas in the southeast which are open to the public on a fee basis. Their continued success will encourage them to continue to voluntarily provide for the fuller use of their lands "in the public interest."

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Effects of Timber Harvest and Regeneration on Deerfood and Cover

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Forest management activities on major forest areas of the National Wildlife Refuge System demonstrate how sound silviculture management techniques can be modified to provide timber, deer, and associated benefits near optimum levels.

A multiple purpose forest environment productive in timber, wildlife, and public use is in great public demand. Combined management efforts of both foresters and wildlife biologists are required if maximum forest values and benefits are to be achieved.

Timber cutting versus no timber harvest is no longer the basic question concerning habitat improvement on forested lands. Now the primary concern of land managers is more related to the effects of various methods of timber harvest on wildlife habitat. Planned programs of management both in forestry and wildlife require a close working relationship between forestry and wildlife technicians. When this exists, an enlightened land-management and multiple-use program results. The end objective is to develop and to perpetuate a forest environment suitable for harmonious production of both plants and animals.

Timber harvest and subsequent forest regeneration profoundly affect deer food and cover: Lay (1967), Goodrum (1949), Harlow and Jones (1965). Aldo Leopold *et al.* (1947) went so far as to say "brush in the sun" was always a necessary condition for deer irruptions in the East."

The other extreme is demonstrated on park-like areas where timber management has been limited to continuous protection. Under this form of management, deer habitat eventually fails to produce enough food for wintering herd requirements.

In the past, research in the respective fields of timber and wildlife resources has supplied general management guidelines for one or the other, but rarely has research provided specific technical recommendations for combined management. Considerable knowledge exists regarding the necessity of providing diversified food and cover requirements within the normal home range of deer and other wildlife.

This paper describes the timber management approach being taken on national wildlife refuges to benefit deer and other wildlife. Special emphasis is devoted to the even-aged management opportunities on one national wildlife refuge of the Lower Piedmont.

ACKNOWLEDGMENTS

The authors are indebted to refuge managers, foresters, and biologists who manage the national wildlife refuges and provide annual reports on the renewable timber and wildlife resources.

STUDY AREAS

Primarily through timber harvest techniques, it has been possible for the Bureau to develop high-quality wildlife habitat conditions for deer and other species of wildlife on major refuges with sizable forested areas. This group includes White River National Wildlife Refuge, Arkansas; Noxubee National Wildlife Refuge, Mississippi; and Piedmont National Wildlife Refuge, Georgia. The timber quality on these areas, although responding favorably to intensified management efforts during the 1960's, remains somewhat under par; the scars of mismanagement in the 1930's, prior to Bureau acquisition, are still evident. Refuge forests are committed to multiple-purpose objectives; primary emphasis is to develop a suitable forest environment for the broad spectrum of wildlife, with special concern for migratory birds and rare or endangered species. Shallow winter flooding of bottom-land hardwoods at White River and Noxubee usually attracts more than one-half million ducks annually. These same lands produce deer and other wildlife and timber products near optimum levels. Management techniques on refuge lands are also modified to favor wood ducks and species like the red-cockaded woodpecker that are highly specific in their habitat requirements.

SOILS, CLIMATE, AND VEGETATION

A variety of soil characteristics, climate factors, and numerous cover types makes it impossible to generalize on forest and wildlife recommendations throughout the southeast.

The White River National Wildlife Refuge in eastern Arkansas is representative of the Delta flood plain and demonstrates a rapidly growing forest of mixed hardwood species.

Noxubee National Wildlife Refuge in eastern Mississippi represents a combination of forest types. Delta hardwoods, Appalachian hardwoods, pine and mixed pine-hardwood timber types of the Piedmont.

The 33,000-acre Piedmont National Wildlife Refuge is typical of the pine-hardwood forest common to the Piedmont region. Generally, hardwood sites are on the more productive soils which flank the streamcourses. About 20 percent of the refuge is suitable for commercial hardwood production; 75 percent is in pine; and approximately 5 percent is maintained in fields or openings free of timber growth.

These refuges are widely distributed and include most of the major forest types. This makes them excellent proving grounds for research and offers tremendous demonstration possibilities for multiple-purpose management.

TIMBER AND DEER YIELDS

The multiple use forest management program now in effect on White River, Noxubee, and Piedmont refuges is representative of several major forest types and geographic conditions of the southeast. These combined programs will provide some insight into the scope and success of timber and wildlife management as it relates to timber harvest and deer yields.

These three major forest areas encompass approximately 170,000 acres. Combined peak deer population totals 10,000. Population estimates for the bottom-land hardwood forest at White River, the mixed pine-hardwood forest at Noxubee, and the predominately pine forest at Piedmont are 7,000, 1,800, and 1,200, respectively. These overall population estimates amount to one deer for each 17 acres. According to the above deer estimates White River, Noxubee, and Piedmont support one deer to 14 acres, one deer to 22 acres, and one deer to 25 acres respectively.

The following table reflects the timber and deer yield on White River, Noxubee, and Piedmont Refuges for the past 7-year period. Habitat conditions on these three refuges have been greatly improved through intensive timber harvest practices. The combined overall annual deer yield for these areas amounts to one deer for each 71 acres. When unreported deer kill estimates, crippling losses, trapping and other pertinent factors are considered along with the legal harvest, the annual yield should approach 30 to 35 percent of population estimates.

Table 1.—*Deer and timber harvest on White River, Noxubee, and Piedmont National Wildlife Refuges, 1961 to 1968*

Refuge	Forest acreage	Deer harvest		Timber harvest	
		Annual	Total (7 yr.)	Annual	Total (7 yr.)
				Million b. f.	
White River	100,000	1,678	11,744	15	110
Noxubee	40,000	349	2,444	5	37
Piedmont	30,000	340	2,382	6	40
Total	170,000	2,367	16,570	21	187

Current timber harvest operations remove only about three-fourths of the annual growth. Once the timber stands reach optimum stocking levels the annual allowable cut will be balanced with annual growth. These operations can best be described as improvement thinnings, which are designed to increase the quality of the forest environment for wildlife, timber, and people. These periodic partial cuttings will fit into the broad criteria of either all-aged or even-aged silviculture management.

Prescribed burning, long recognized as an excellent habitat management tool in southern pine forests, is utilized under the even-aged management concept without conflict with forest regeneration requirements. Hardwood units located adjacent to pine are excluded from prescribed burning because of their susceptibility to fire damage. Prescribed burning makes its greatest contribution to forest management when utilized in conjunction with periodic thinnings spaced throughout the rotation period.

The 33,000-acre Piedmont Refuge is typical of the flora and fauna found on approximately 26 million acres of the Piedmont Plateau. This pine, pine-hardwood, and hardwood forest is managed under an 80-year rotation with an 8-year cutting cycle. Regeneration units average approximately 50 acres, with a maximum of 100 acres and a minimum of 10 acres. Under this modified even-aged approach, 1/80th of the forest area is being regenerated in small units on an annual basis.

Forest types are favored according to site capabilities. On this basis, hardwood composition objectives are to develop and maintain 20 percent of the forest area in hardwood. These better sites now support pine-hardwood, but the pine is beng removed. Pine types occur on 75 percent of the area and approximately 5 percent is being maintained in suitable openings, free of timber growth.

In addition to composition variety, stand age is balanced and distributed throughout the forest to insure continuous seasonal habitat conditions for wildlife and will provide for an even, sustained flow of timber products. Following the completion of the first 80-year rotation, 20 percent of the timber will be of precommercial age, 30 percent will be pulpwood, and 50 percent will be sawtimber. Also at the end of the first rotation, each 500 acres will support 10 major age groups, one for each cutting cycle. The precommercial age timber will have two of these basic age groups, three will be in pulpwood, and five in sawtimber.

Distribution pattern of forest composition will be coordinated with site capability and seasonal habitat requirements within the normal cruising range of deer and other wildlife. More than one-half of the forest composition will be maintained in large trees suitable for mast production. The value of mast is broadly recognized and has been emphasized by Lay (1957).

REGENERATION PRACTICES

Regeneration techniques usually vary with each major forest type within each geographic area. Foresters can predict with a reasonable degree of accuracy what regeneration method is best suited for each local situation. Regenerated stands usually provide excellent feeding areas for deer and other wildlife during the early years of development. Once the young trees grow beyond the height suitable for feeding they still provide excellent cover for deer.

Cromer and Smith (1968), reporting on the results of a deer browse study in Appalachian hardwoods, indicated that "any type of economical timber harvest apparently produced more than enough stems of preferred species to support a population of at least 13 deer per square mile without appreciable damage to reproduction of desirable tree species. Thus, the need to produce deer browse is not of vital importance to timber managers in this area and their cutting practices can be oriented towards other objectives. Under situations where the objectives of game management envision a large deerherd, it is obvious that deer density will reach a point when increasing available browse would be a valid goal of cutting."

Based on the results of refuge forest management practices throughout the southeast, deer populations of one deer to 17 acres do not prevent regeneration from developing into quality stands. Where the forest is managed under long rotations and frequent cutting cycles, deer food is usually abundant, and although deer utilize regeneration areas, the degree of use is compatible with the development of regeneration for commercial purposes.

Seventy-five percent of the 100,000-acre hardwood forest of the White River National Wildlife Refuge in Arkansas is subject to periodic flooding. During these floods the refuge deer population is frequently confined to 25 percent of its normal habitat. Deer populations on these unflooded areas sometimes exceed one deer to 5 acres. These flooded conditions may persist for only a few days or remain for several months.

Prior to beginning timber harvest operations, this concentrated deerherd depleted its food supply and began to destroy agricultural crops on adjacent farmlands. Following light thinning operations over a part of this unflooded area, habitat conditions improved and depredation of agricultural crops declined. Although these initial thinning operations improved feeding conditions, the large deerherd continued to destroy regeneration. Heavier thinnings were extended over larger areas, thus producing adequate browse and sufficient regeneration survived for timber production. This situation, although somewhat unique, points out that considerable latitude exists whereby the forest can be successfully regenerated under high deer population densities.

Regeneration practices should and most often are selected primarily for reestablishing a stand of timber for commercial purposes. The practice selected should be modified when required to fulfill wildlife or other multiple-use objectives.

Partial cuttings and frequent cutting cycle intervals are needed to develop and maintain high quality, continuous deer habitat conditions. Seed tree or shelter wood regeneration techniques at maturity are nothing more than a partial cut, and a modification of these practices may be included in the regeneration process of clearcutting.

Balanced and continuous seasonal habitat conditions within normal cruising range of deer are of greater significance to them than the regeneration method used. Partial cuttings are employed on wildlife refuges to provide the continuous habitat required. Even-aged management—now the predominant silviculture system—can best be perpetuated through clearcutting at rotation's end. Species composition, distribution, and unit size control of even-aged stands may be the best methods of maintaining habitat balance within normal deer range.

Seasonal variety can best be provided by unit clearcutting under the even-aged concept. Interspersion of small stands of softwoods and hardwoods along with proper age distribution can best be provided under this system. Prescribed burning is more acceptable under the theory of even-aged management than under the concept of all aged management. Fire can be more readily applied in the softwood type and excluded from the hardwood stands, which is highly susceptible to fire damage. Even-aged units should be large enough to be managed economically and small enough to insure habitat variety.

Artificial regeneration, usually with intensive site preparation, is utilized rather extensively in the Coastal Plain. Stoddard (1937), Strode (1952), and Beckwith (1967) reported excellent deer use following site preparation by mechanical methods.

Both planting and seeding have been used extensively on prepared sites. Seeding may benefit deer more than planting since more openings may occur in stands from the time canopies close until they are first thinned. However, the benefit to deer is believed to be insignificant compared to the merits of selecting one or the other for timber production.

WILDLIFE RESPONSE TO MANAGEMENT

These once depleted refuge lands were restocked with wild turkey and deer. Given a high degree of protection, these species and other wildlife responded very favorably to applied habitat management techniques. Improvements resulted primarily from timber thinning of both the pine and hardwood timber types. Prescribed burning, in addition to timber cutting, in the refuge pine forest proved extremely valuable in improving forest floor habitat conditions.

Expanding deer populations overflowed to adjacent ownerships, and some animals were removed through trapping for transplant purposes. Finally annual hunting programs were initiated to maintain population-habitat balance.

Approximately 25 percent of the deer population is harvested annually. This percentage will increase considerably when crippling loss and unreported harvested deer are considered. In addition to the deer, other wildlife have also benefited from intensified management. Turkey hunting is permitted on each of these areas, and annual squirrel hunts are conducted at White River and Noxubee Refuges. White River Refuge alone yields a harvest of more than 30,000 squirrels annually.

SUMMARY

Resource managers are now confronted with a greater ecological, economical, and social challenge than at any other period in our history. Single-phase forest management should yield to multiple-purpose management. Sound silviculture principals permit considerable latitude for developing habitat for wildlife—especially for deer.

The merits of the even-aged forest management system for timber production have been proven and accepted by both the USDA Forest Service and industry. The future opportunities for forest wildlife management rest with this silvicultural method.

The multiple-purpose forest management program on National wildlife refuges has demonstrated that both timber and wildlife can be produced near optimum levels under sound silviculture practices without serious conflict. Refuge forests are managed under long rotation and frequent cutting cycles. Aside from keeping the forest in a vigorous growing condition throughout the long rotation, thinnings provide an economic return and proper crown spacing allows sufficient sunlight to reach the forest floor enabling growth of food plants for deer and other wildlife.

Even-aged forest management on the Piedmont National Wildlife Refuge, as illustrated in a recent brochure "Piedmont Wildlife and Timber" offers one example of how harvest and regeneration techniques of even-age silviculture can be modified to benefit deer and other wildlife.

Sound silvicultural practices are vital to our Nation, as are wise use and enjoyment of the renewable forestry resources. Timber regeneration in small units at the end of a sawtimber rotation can provide a suitable forest environment for optimum deer management.

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How Size and Distribution of Cutting Units Affect Food and Cover of Deer

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Decisions relating to the size and distribution of cutting units are dictated by several considerations. Multiple Use Guides in use by some southern forests are presented. Shape of clearcuts is discussed as a necessary element in the planning for cutting. A hypothetical situation is offered which indicates the maximum number of deer home ranges which are contained in clearcuts of three sizes and three different widths. Generally, long and narrow clearcuts affect more deer than large square or circular cuts. Smaller cuts of 25 to 50 acres are more desirable. Clearcuts up to ¼ mile wide appear to be reasonable. Cover for deer in southern forests is not considered to be a particular problem, especially when unregenerated strips are left on each side of clearcuts and where cuts are small.

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An obvious fact in studying the question of size and distribution of cutting units, is the paucity of literature on the problem. Where research facts are lacking, management practices may be based upon opinions evolved from experience and dictated by economics. One point should be evident from this paper, research is needed on the question of size and distribution of cutting units. It is imperative that facts be forthcoming since even-aged management is a proven forestry practice.

The South contains vast acreages of many forest types; however, this paper will not be specific for types but will consider only the broad aspect of the problem. It is my intent to provide guidelines from representative southern forests, philosophies behind management procedures, a review of research reports, and an examination of hypothetical situations into which are inserted known factors. Hopefully, from this synthesis will come stimulation for further research, new philosophies, and critical evaluation and reorientation of existing forest wildlife management policies.

Attention will not be given to intermediate cuttings. This does not mean, however, that intermediate cuttings have no value to deer; they can enhance the forage supply. I assume, however, that the forest management is even-aged; that the regeneration cut has a greater impact on deer than other cuts, determines stand distribution, and is crucial to habitat composition for future deer populations.

Before optimum size and distribution of cuts can be determined, several other factors should be considered. The average size of a deer's home range must be taken into account. Cuts so large they remove all timber from the deer's range may be detrimental. Deer will be forced into new habitat. Very small cuts will have little if any beneficial effect upon the animal, although this condition is difficult to envision.

The home range for whitetails is smaller than was believed a few years ago. Zeedyk (1968) reported that deer use only 100 to 300 acres. A study by Petcher (1967) within a 2,400-acre enclosure in Virginia revealed the average home range size of adult female deer to be 172 acres. Wohlgemuth (1968) using telemetry reported that a doe's range was 140 acres, and a buck's, 340 acres during the rut. The Multiple Use Guide for National Forests in Texas suggests the average deer range to be approximately 1 square mile (640 acres).

DISTRIBUTION AND SHAPE

Cutting units should be distributed to provide maximum benefit to the greatest number of animals; this implies a wide distribution through space. Shape of cut areas can have a marked effect upon deer habitat. Although the question of shape was not part of the assigned scope of this paper, it cannot be overlooked. Any disturbance to the forest which alters the vegetative pattern produces an edge-effect. Edge is a valuable byproduct of cutting. Long narrow cuts will provide more edge than will square or circular cuts. Table 1 shows the peripheries or edge which would be provided by area cuts of different shapes, each 1 square mile in size. The

Table 1.—*Perimeters or "edge-effect" in different size cutting units each 1 square mile*

Shape and dimension	Edge
	Mile
Circular	
0.56 mile radius	3.5
Square	
1 mile x 1 mile	4.0
Rectangular	
¾ mile x 1 mile	4.2
½ mile x 2 miles	5.0
¼ mile x 4 miles	8.5
⅛ mile x 8 miles	16.2

[1] Supported cooperatively by the Bureau of Sport Fisheries and Wildlife, Virginia Polytechnic Institute, Virginia Commission of Game and Inland Fisheries, and Wildlife Management Institute.

narrower and longer the cut, the greater edge it provides. The shape least productive of edge is the circular cut.

Openings, natural or created, should be examined for their contribution to the problem of size and distribution of cuts. Clearcuts are essentially like openings for a few years and the optimum size of these openings (cuts) can be determined when we know how far deer will venture from cover into open terrain.

FOREST SERVICE GUIDELINES

How large should a cutting unit be to provide the maximum food and cover for deer? This is a major question on which there is little information. The USDA Forest Service, however, has general guidelines for their operations.

The Forest Service Handbook for Region 8 (1969a) directs that in planning and conducting stand regeneration projects, work will be directed toward the creation of even-aged timber stands of 40 to 200 acres. Regeneration of large (over 200 acres) contiguous stands in any 10-year cutting period is to be avoided where possible, and two or more regenerated areas in a compartment or in adjacent compartments are to be separated by unregenerated areas of stand size. Regenerated stands as small as 20 acres are permissible where justifiable, but should average not less than 5 chains wide. There is no limitation on the maximum regenerated area, but a decision to regenerate any stand larger than 200 acres must be supported.

Multiple Use Guides for a sample of southern National forests are given here. The Daniel Boone National Forest in Kentucky specifies that regeneration treatments should work toward creating even-age stands of 40 to 200 acres (minimum 20 acres). Cuts in excess of 200 acres require approval. The guideline of this forest provides no restrictions on shape of cuts since stand boundaries normally conform to topographic, site, soil, cultural features, and other practical limitations. The Daniel Boone Forest Guide (1968) further states that regenerated stands will be separated by and interspersed with unregenerated stands preferably 40 acres or larger in size (20 acre minimum). Normally, not more than 30 percent of a compartment need be regenerated in the same cutting period. Cutting in adjacent compartments in the same 5-year period is to be avoided. At least one stand in each compartment should be regenerated during each cutting period where stands qualify for regeneration cutting.

National forests in Florida (1966) specify that the manager will leave uncut small (20 acres or less) isolated stands of oaks and all hardwoods along ponds, bays, lakes or streams. These uncut areas should contain 200 square feet of mast-producing stems per 40 acres. Live oaks up to a stocking of 200 square feet per 40 acres are to be left uncut. The Florida guideline is specific in directing that the land manager regenerate no more than 160 acres (320 acres in sand pine) in 1 square mile in one cutting period, scrub oak excepted. This is a significant figure because if the home range of a white-tail encompasses 1 square mile, the maximum allowable cut would be one-quarter of the deer's range. This appears to be a reasonable portion to be regenerated from the viewpoint of the deer's welfare. Hardwood types are to be treated by clearcutting strips 20 chains wide and leaving 20-chain strips uncut between the clearcut strips. The untreated strips will be cut 20 to 40 years later.

Virginia's Jefferson National Forest policy requires that not over 25 percent of a compartment will be regenerated in one cutting cycle (Malcolm and Edwards, personal communication). Regeneration areas should be less than 20 chains wide, when possible. If they must be wider than 20 chains, key wildlife areas of 1 or more acres are to be retained as inclusions. An attempt is made to retain 50 percent of each compartment in mast producers. This forest has the rule-of-thumb that for every 40 acres of area which is cut, 1 acre must be left uncut to provide for den trees, cover and mast.

Although the Guide for the National forests in Texas (1967b) states that the normal range for deer is approximately 1 square mile, no size or distribution pattern for cut areas is defined. They do, however, prescribe a distribution pattern for hardwood areas that will provide hardwood mast within the normal range of deer throughout the forests; hardwoods will be retained and developed. Maximum allowable distance between hardwood areas in pine stands is ½ mile. The hardwood component should be 200 square feet per 40 acres, either in clumps or individual trees.

The Big Levels Wildlife Management Area on the George Washington National Forest in Virginia is receiving the even-aged system of timber management where clearcutting is done in blocks of 20 to 200 acres (Thornton 1969). When timber is clearcut in relatively large blocks, logging or pulping is economical. The number of sales is increasing annually and the acreage cut is providing much-needed browse for deer and cover for other game species, according to Thornton.

SIZE OF CUTS

So little work has been done to ascertain optimum size and distribution of cutting units for white-tailed deer that a study in spruce-fir forests in Arizona takes on significance and may provide useful knowledge for management of white-tails in our southern forest (Reynolds 1966b). Reynolds measured accumulated dropping groups from mule deer, elk, and cattle to evaluate use of natural and created openings. The latter were blocks of 10 to 30 acres that had been clearcut about 6 years previously. Relative use by deer declined sharply as size of opening increased. Areas larger than 20 acres were little used; as openings became smaller, relative use increased. Reynolds concluded that theoretically, circular openings larger than 20 acres (526 feet radius) would be little used, except next to forest borders. This study implied that for best habitat effects from even-aged timber management, clearcut areas should be widely dispersed, less than 20 acres in size if in patches, and less than 1/5 mile across if in strips.

Reynolds (1966a) reported another Arizona study in ponderosa pine which has a direct bearing on size of cutting units. Dropping groups again were used to compare use of timbered areas and natural openings within a cutover forest. Deer droppings were slightly higher in openings than within the forest for about 600 feet from the forest border. Deer droppings were absent beyond 1,200 feet into the opening. Reynolds thought that these forest border relations suggest that distance across an opening influences use by deer, i. e., they do not like to get too far from cover. Reynolds stated that "evidently deer and elk do not use openings to any extent that are more than 2,200 to 2,600 feet across, respectively. For openings to be used as high or higher than adjacent forest for both deer and elk, distance across an opening should not exceed 1,600 feet." The management implication from this study is that openings less than 1,600 feet across would best coordinate deer habitat improvement with timber management when clearcuts are in strips, blocks, or natural tree groups.

Harlow and Downing (1969) studied the effects of size and intensity of cuts on some deer foods in the Pisgah National Forest. Although comparisons were made between clearcuts and heavy selective cuttings, the clearcut data gave some indication of optimum size of cutting units. Stands of 1, 21, 51, 54, and 55 acres, nearly 1 mile apart, were clearcut in an area of high deer density. An index of deer activity was secured during winter by pellet group counts. Vegetative transects provided data on seedlings and sprout numbers 1 and 3 years after cutting. Three years after cutting, the three areas of 50 or more acres contained such a tangle of sprouts and vines that deer could not penetrate into the interior. Browsing declined significantly in the 1-acre clearcutting because of disappearance of desirable plants due to intensive utilization. The 21 acre clearcut appeared to be superior to either the 1 acre or the 50 acre clearcuttings. The workers concluded that when too large, clearcuttings produce overabundant woody growth. After 2 years the cuts became dense and unattractive to deer. When clearcuttings were too small, the more desirable browse plants were soon reduced in numbers. Perhaps the best clearcut size is between 20 and 50 acres in the Pisgah area where deer are abundant.

Zeedyk's (1968) appraisal of even-aged management asked the question of how big a clearcut should be. He answered that "cuttings should be big enough to insure regeneration of desirable timber species yet not so large as to waste the valuable browse resource." Zeedyk points out that since a stand is regenerated only once in a rotation, we cannot afford to squander the rich supply of food created by clearcutting stands that are too large. He warned that the bigger the clearcuts, the more of the resulting stands there will be back to back. He urged that clearcuts be scattered, be kept as small as is economically possible, and leave some clumps and patches of unregenerated stems within stands.

Beckwith's (1967) study in the sandhills of central Florida, an evaluation of the effect of site preparation on wildlife and vegetation, offered data on deer use of treated plots which were large enough to compare with cut units. Three replications of four plots, each 1 square mile in size, were studied. One plot of each replication was completely cleared of vegetation and planted to slash pine. The second plot was three-fourths cleared and planted; the third plot was one-half cleared and the fourth plot was left untreated as a control. Uncleared portions of the second and third plots consisted of strips of natural cover 10 chains wide. Deer use was estimated from track counts. Partially cleared plots received about twice as much use as the cleared plots or 40 percent more than the uncleared plots. The investigator concluded that "complete clearing of tracts as large as a square mile, is therefore, detrimental to white-tailed deer, at least during the early successional period. Leaving from 25 to 50 percent of the native vegetation on the plots makes them more attractive to these animals than uncleared areas." We could interpret these findings to mean that a clearcut of 640 acres would be relatively unattractive to deer. However, if ¼ to ½ of the square mile were left in uncut strips, we could anticipate deer use to be double that of the larger clearcut. While these data relate to planted clearings, one fact emerges and that is, a 1 square mile clearcut appears to be too large for deer.

A clearcut or any disturbance of the overstory sets back ecological succession and greatly increases seedlings, sprouts, grasses, and forbs. Forest openings are generally created by clearcutting and may or may not be planted. It is during the first few years following clearcutting that these areas are similar to created openings in vegetative changes and attractiveness to deer. Studies of openings in the forest can help us to resolve the questions of size and distribution of clearcuts. Wisconsin biologist McCaffery (1967) reported on a study of deer use on more than 100 openings. Data consisted of counts of droppings in fall, spot-lighting from spring to fall, and road track counts. The openings were used intensively during spring and fall but little during midsummer. As many as 125 to 150 deer per square mile of openings were spotlighted during May, September, and October; surrounding forest densities were 25 to 40 per square mile. Areas of several square miles in size with few or no openings had less than 10 deer per square mile, while 25 to 40 per square mile were found in more favorable areas. These observations would indicate that open land is necessary for good deer range. Significantly, McCaffery reported that small openings, less than 5 acres in extent, were used more intensively than larger openings.

If a clearcut were 5 acres and square, it would seem reasonable that deer would readily traverse and use the 466-foot width of open terrain. The greatest distance a deer could travel from the forest edge in such a situation would be 233 feet. A 5 acre clearcut may be too small to be economical, except in unusually productive situations; however, there is evidence that deer make intensive use of these smaller breaks in the forest canopy.

Since decisions relating to size and shape of clearcuts are not based on data, I devised a hypothetical situation. Assumptions were made that deer were evenly distributed on three areas with annual ranges of 640 acres, 160 acres, and 40 acres. Widths of clearcuts were ⅛ mile, ¼ mile and ½ mile. Sizes of cuts were 50 acres, 200 acres, and 500 acres. Each rectangular cut of established width had its length determined by acreage of the cut. Templates scaled to the size and shape of the cuts were placed on a grid representing home ranges of the three sizes. The question to be answered was: What is the maximum number of deer ranges encountered by a given size and shape of clearcut? Table 2 represents the results of this test. Figures 1, 2, 3 show how the clearcuts of different widths and acreages intersect different size deer ranges.

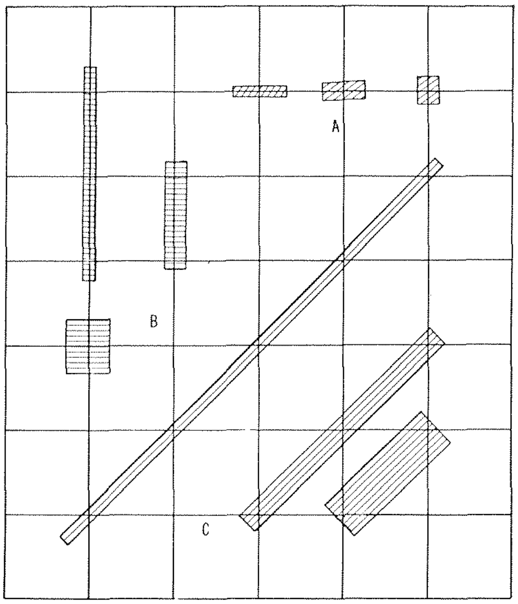

Figure 1.—*Hypothetical situation of maximum number of deer ranges (one deer per 640 acres) encountered by 50(A), 200(B), 500(C) acre clearcuts, each 1/8, 1/4, and 1/2 mile wide.*

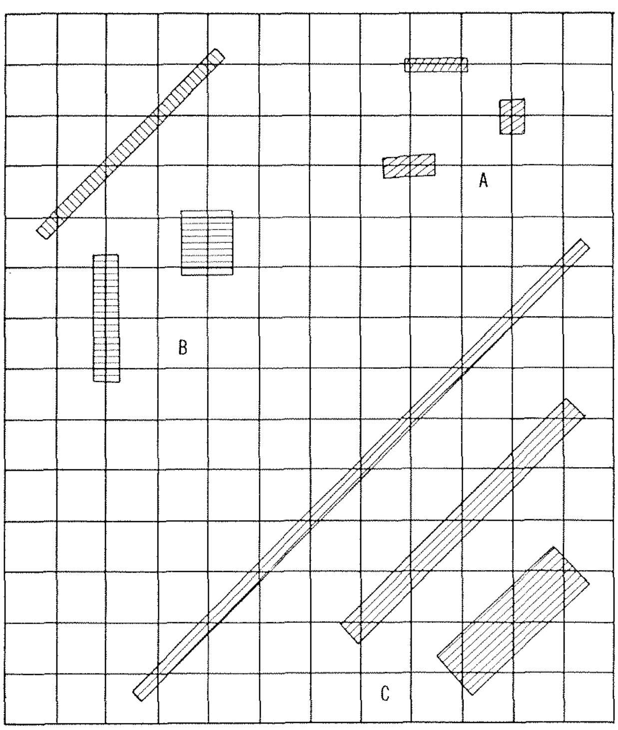

Figure 2.—*Hypothetical situation of maximum number of deer ranges (one deer per 160 acres) encountered by 50(A), 200(B), 500(C) acre clearcuts, each 1/8, 1/4, and 1/2 mile wide.*

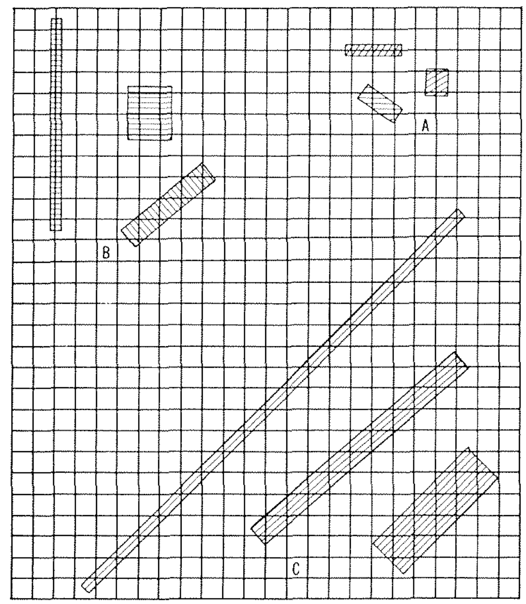

Figure 3.—*Hypothetical situation of maximum number of deer ranges (one deer per 40 acres) encountered by 50(A), 200(B), 500(C) acre clearcuts, each 1/8, 1/4, and 1/2 mile wide.*

Table 2.—*The maximum number of deer ranges encountered by three hypothetical sizes of clearcuts at three hypothetical deer densities*

Annual ranges	Clearcuts								
	50 acres			200 acres			500 acres		
	1/8 mi.	1/4 mi.	1/2 mi.	1/8 mi.	1/4 mi	1/2 mi.	1/8 mi.	1/4 mi	1/2 mi.
640 acres	4	4	4	8	6	4	16	10	7
160 acres	6	4	4	13	8	6	28	16	10
40 acres	8	7	6	22	14	14	55	32	24

The narrower and the longer the cut, the greater the number of deer ranges affected. Where widths are narrow, in all probability the clearcut would not drive the deer from its home range; however, a clearcut strip 1/2 mile wide might conceivably disrupt a deer's home range pattern and cause abandonment of the immediate area. The 1/8 mile wide clearcut affected the largest number of deer in each case; however, the length of this narrow strip becomes impractical when large acreages are involved, especially in rugged terrain. The 200 acre cut 1/8 mile wide is 2 1/2 miles long; the 500 acre cut of this width is 6 1/4 miles in length.

From the foregoing, either the 1/8 or 1/4 mile wide clearcut appears to be a suitable width. If a strip is 1/8 mile wide (660 feet), deer could never get more than 330 feet from cover. In the case of the 1/4 mile wide strip, a deer would be 660 feet from cover in the middle of the clearcut. These widths would not destroy a great percentage of any one deer's range; rather the total edge would be great.

DEER COVER

The subject of deer cover was not stressed in this paper. While cover does not appear to be as important to southern deer as it is to deer in the North, they need it to escape from cold winter winds and hunters, and for shade, fawning, and resting. Usually, cover is sufficient over most southern deer range. Creek bottoms, small hollows, and coniferous stands one or more acres in size provide good cover. If cutting is done in strips and if unregenerated areas of stand width are left uncut, there should be no lack of adequate cover. Furthermore, slash left from cutting operations may provide immediate cover. Where hardwoods sprout readily or seedlings grow rapidly, cover will be provided shortly after the cutting.

CONCLUSION

Even-aged management of forests is the order of the day. To be most effective in deer management, long range planning will be required to give a good distribution of stands in all stages of succession. Cuts must be big enough so that some reproduction will survive deer browsing if deer are numerous, but not so large as to permit a waste of food. The regeneration cut is the important one. Mast producers must be considered and provision made for a constant supply of this important wildlife food throughout the area under management. The wildlife manager must take into account the density of deer in his area, the type of vegetation, the terrain, and the economics of logging before deciding on what size, shape, and distribution of cutting units to employ. No two situations will be alike. Generally, the smaller cuts (25 to 50 acres) will be most desirable. Long narrow cuts give greater edge and benefit more deer than wide cuts, or large square or circular cuts. Optimally, a clearcut should be no more than twice the distance which a deer will move from the forest edge; this appears to be 600 to 800 feet. Clearcuts up to ¼ mile wide appear to be reasonable. The suggestion to have an unregenerated strip on each side, as wide as the clearcut, offers excellent distribution of cuts, provides cover, and may contribute to the vital mast supply.

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Short and Long Rotations in Relation to Deer Management in Southern Forests

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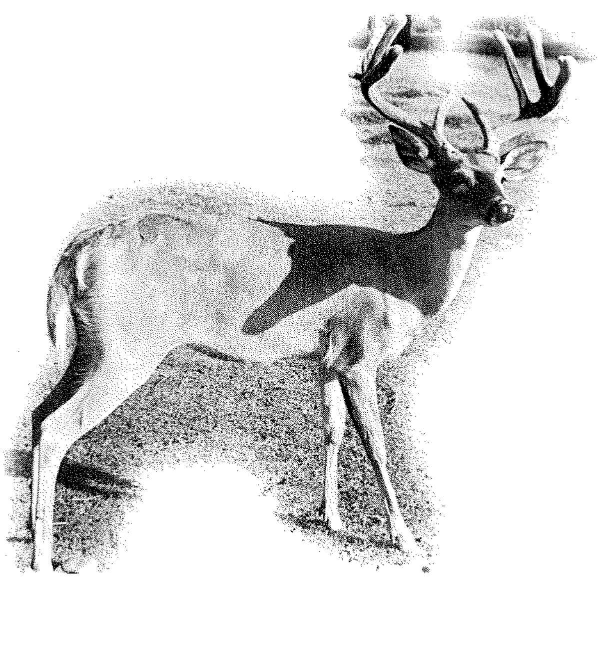
It seems evident from research that forest manipulation through long-rotation management will produce a better deer habitat than short-rotation management. Long rotations offer greater flexibility in the use of management techniques for producing adequate amounts of nutritional forage, mast, and other foods over a long and continuing period. Long-rotation management also permits preserving and maintaining a variety of plant species and stand conditions which are essential to a good deer habitat. In short-rotation management, browse may be produced in great abundance for short periods of time.

Deer management involves two main considerations: the manipulation of the herd and the manipulation of the habitat.

Manipulation of forest habitat for deer will be discussed in this paper with emphasis on short- and long-rotation harvesting, the two prevailing systems in forestry. Short-rotation management may be described as the harvesting of forest trees at comparatively early ages, ranging primarily from 15 to 40 years, depending upon the species. In long rotation the trees are harvested when larger and older, in the range of 40 to 100 years or older. Size and height at a given age will depend on the fertility of the site, which may influence the length of the rotation.

There are four criteria in evaluating a forest habitat for deer: (1) Abundance of palatable forage. (2) Productive capacity for mast, including soft fruits. (3) Variety of vegetative species and mixture of types. (4) Condition of vegetative cover.



The trend in forest management toward one species stands strongly indicates a need for manipulations that would produce better deer habitat.

REVIEW OF LITERATURE

In a young pine plantation in Louisiana that was subject to short rotation, Blair (1960) found that heavy thinning produced 52 percent more palatable browse than light thinning, but that unpalatable browse was about the same in light, medium, and heavy thinning. The plantation contained no mast-bearing trees.

Krefting (1962) cited a study in a mixed conifer swamp in Michigan that showed clearcuttings in strips and shelterwood cuttings produced 161 and 184 pounds of browse per acre, respectively, while no cutting and light selective harvesting produced 46 pounds per acre. Block and diameter harvesting yielded 130 and 134 pounds, respectively. His study of deer use of these cuttings indicated greater use in the 66-foot-wide strips adjacent to uncut woods because of better cover in the untreated area. The experimental area contained no hardwood mast-bearing trees. He also said that "uneven-aged stands produce a larger variety of habitat conditions favorable to deer than large even-aged stands."

Bryan (1950), writing on the results of experimental cuttings in the Appalachians of North Carolina to improve deer browse, observed that clearcutting produced too much browse and other growth, and that light selective harvesting produced too little. He concluded that selective cutting somewhere between these extremes on small acreages appeared to be the best procedure.

Zeedyk (1968) suggested short-rotation clearcuts for browse production with not more than 10 percent of an area being harvested in this way. He also emphasized that under even-aged management, harvesting of trees should be done on a long-rotation basis, 80 to 100 years, so that hardwood trees could reach the age of substantial mast production. Zeedyk recognized the problem of providing mast in pine types and suggested that patches of hardwoods be preserved or established within such stands or be maintained as an admixture throughout the stands.

Farrand (1963) noted that harvesting selected trees from a stand in Pennsylvania resulted in an increase of browse and improved species composition and variety of stand conditions.

McKnight (1966) favored the long-rotation system, applied within the structure of uneven-aged silviculture, in southern hardwood forests. He emphasized that cuttings should be made in patches or groups of trees for regeneration, with careful attention being given the condition of individual trees in the groups selected. He said that this variable selection system would result in a good hardwood forest and provide the maximum range of stand conditions in contiguous patches for wildlife and recreation. This system would also take advantage of good, current growing stock.

Summarizing a discussion of southern hardwood management, Miller (1957) said, "The principal requirements of hardwood forest habitat for multiple wildlife species then are as follows: (a) a mature overstory providing mast and dens, (b) a thrifty understory of palatable browse and desirable reproduction, (c) forage and game food plants in the ground cover, and (d) available water." He suggested that this could be achieved by making improvement cuts that would open the tree crowns to approximately 60 percent of closure.

Schuster and Halls (1963) found that palatable deer browse could be produced in adequate quantities (853 pounds per acre) by selective cuttings every 5 years in a near-mature pine-hardwood forest in eastern Texas. Forage production was closely related to the midstory crown cover. In this instance the midstory had a coverage of 37 percent while the dominant overstory was 32 percent.

Stransky and Halls (1968), among others, have pointed out the need for permanent openings in pine-hardwood forest deer habitat.

Mixed stands of conifers and hardwoods proved to be better habitat for trees as well as game in Russia (Pogrebniak 1962). Forests composed of several conifers, conifers-hardwoods, or mixed hardwoods were healthier and grew faster than unmixed stands. Mixed stands also created more lime, nitrogen, phosphorus, potassium, and magnesium in the surface soil. Furthermore, the soils contained greater populations of microflora and mesofauna. It is noteworthy that Pogrebniak recorded similar results by research foresters in Germany, Czechoslovakia, Sweden, and Poland.

Perina (1962) called attention to the fact that the lack of suitable food in the all-coniferous forests in Czechoslovakia caused big game, presumably red deer (*Cervus elaphus*), to suffer severe malnutrition, so that they damaged the forests. He said that efforts had been underway there for many years to reconvert the pure stands to mixed stands by planting beech (*Fagus sylvatica* L.), linden (*Tilia europaea* L.), and carpinus (*Carpinus betulus* L.).

Perina also said that timber yield had greatly declined in pure stands of Norway spruce (*Picea excelsa* L.) and Scotch pine (*Pinus sylvestris* L.) in Czechoslovakia. This reduction was attributed to reduced soil fertility, insect infestation and disease, and decreased water retention capacity of the soils. It is interesting to note that this condition, according to Perina, has created a very unsatisfactory water flow downstream in other central European countries. A majority of central European rivers rise in the country of Czechoslovakia. As of 1960, only 11 percent of the forests in Czechoslovakia were fully active hydrologically.

RESULTS AND DISCUSSION

Short Rotation

From the work that has been done, it seems clear that adequate amounts of palatable browse and other forage may be produced for a period of from 3 to 5 years in the short-rotation system of a 30-year cutting cycle.

During the regeneration phase of the short-rotation management of pine, there is usually a great surge in the growth of palatable browse along with other secondary growth, provided a seed or coppice source is present. In a few years, however, the pine crowds out most of the browse, and that which persists is of poor quality and vigor. Furthermore, the dense pine precludes any significant production of mast, either hard or soft, in future years. Hardwoods such as oak and gums, even if their height growth keeps pace with the pine, cannot reach seed-producing age by the time of the next timber harvest, when the site is again prepared for planting. Thus, for the long term, or over several rotations, it is difficult to predict the eventual abundance and welfare of browse species. Each site preparation will likely destroy or reduce the regeneration potential of browse species so that eventually the stand will be largely limited to those species that were planted. Thus, in short rotation the variety of forage plants will be limited, and no hardwood mast will be present unless trees of seed-bearing age are retained in the stand at the beginning of the rotation.

If short rotation must be used, wide spacing of planting stock and small cutting units within the home range of deer should be better than close spacing and large cutting units.

Long Rotation

Long-rotation management usually involves some form of selective harvesting. The production of palatable forage and mast for deer depends upon tree harvesting procedures and other manipulation techniques such as prescribed burning. From available data it appears that light selective removal of trees will not produce the needed browse, tree regeneration, or mixture of vegetative species and type. Light tree removal does appear to favor mast production in overstory trees but may keep yields of understory mast at a low level in old forests. Instead of light removal, the current trend is to make clearcuts in strips or patches. Such cuts should be comparatively small and not cover more than a limited part of the area. In making clearcuts it seems wise to retain some of the best mast-bearing trees because of the long periods of time required for some species, especially oaks, to reach the age of maximum seed production. The long-rotation system lends itself to thinning operations, which give greater flexibility in maintaining a stand structure suitable to deer and other wildlife. Short cutting cycles (Schuster and Halls 1963) in pine-hardwood forests will maintain relatively good forage production as well as good mast yields throughout the long rotation.

Variety and Cover

One of the principal objectives of forest wildlife habitat management is to maintain a variety of vegetation in the habitat and I believe this principle, in general, is indisputable.

Experience in central Europe and Russia has shown that mixed forests result in better growth and health of the trees and thus a superior habitat for game. For more than a century foresters in these countries have been reconverting all-conifer forests to a mixture of hardwoods and conifers to achieve a variety of species and mixtures.

Deer will eat a great variety of forage food if it is available. However, among the many species of woody browse a comparatively small number is palatable to or preferred by deer. The average habitat contains only 15 to 20 percent first-choice browse species, while 35 to 45 percent is medium-choice and the remainder low-choice or starvation food (Lay 1967a; Goodrum and Reid 1962; Lay 1967b). This led Lay (1967b) to conclude that the quality of the forage is more important than the quantity. He summed up the importance of variety by saying, "Forestry practices, which favor variety and not just browse, may be expected to increase deer carrying capacity . . . . The forest with the maximum mixture of stand types, ages, species, and treatments, together with well distributed clearings, will produce more food for deer than even-age pine stands in large blocks."

Small clearcuts within a dense forest are as desirable as variety in the vegetation because they provide open or semiopen fawning areas for deer as well as a place to loaf and play. Such areas also "green up" a little earlier in the spring, thus providing green food in the form of forbs and young grass before browse species begin growth. Left alone, however, these open areas will be short-lived because of quick recuperation of the forest vegetation. For proper management, some of them should be kept permanently free of trees and heavy brush.

CONCLUSION

It seems evident that forest manipulation through long rotation management will produce a better habitat for deer, as well as for other wildlife, than short-rotation management. The advantage comes from greater flexibility in the use of management techniques for producing adequate palatable forage over a long and continuing period, maintaining mast yields, and preserving a variety of plant species and stand conditions as well as openings in the forest. In short-rotation management browse may be produced in great abundance for short periods of time.

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Timber Stand Density Influences Food and Cover

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Forage and fruit production for deer on forest lands is generally related inversely to timber stand density. Growing timber at a minimum density that will yield an acceptable economic return can increase light penetration to the understory, thus improving the environment for growth of food and cover vegetation.

Within a forest community, growth of food and cover plants for deer is primarily a function of timber stand density. As trees develop from regeneration to harvest, they and the plants beneath compete for light, moisture, mineral nutrients, and growing space. Availability of these factors and the physiological tolerance levels of understory plants determine the ecological development of the forest.

This paper emphasizes food production. It is more critical for deer than cover, which seldom is a limiting factor. And the same plants that furnish food generally provide adequate cover.

LIGHT AVAILABILITY AND PLANT GROWTH

Of the environmental factors influencing composition, growth, and vigor of plants, light is the one most easily modified and controlled by stand manipulation. It may become the dominant factor if the canopy is dense enough to reduce light intensity below 20 percent of full sun.

Beneath uneven-aged hardwood stands in the Central States, light intensity varied by stand density (Minckler 1961). In stands of about 40 square feet of basal area per acre, light transmission at midday varied between 25 to 30 percent of full sun. The trees, pole size or larger, were in full leaf. As basal area increased to 70 square feet, the intensity declined to about 17 to 22 percent, and to around 9 to 13 percent at 100 square feet. Timber size had no apparent effect.

Within openings, average light transmission was related to the size of the openings. Even those as small as 18 to 30 feet in diameter received two to three times more light than beneath a hardwood canopy (Minckler 1961).

Pine stands generally let in more light than hardwood stands of comparable age, basal area, and crown closure (Lull and Reigner 1967; Schomaker 1968). But even in young, dense conifer stands, light transmission may be less than 5 percent of full sun—under which condition understory vegetation tends to disappear (Shirley 1945).

Because many species of forage- and fruit-producing plants can grow and reproduce at low light intensities, they can be managed as a component of the forest understory.

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OVERSTORY DENSITY AND FOOD PRODUCTION

Forage Yield

Production of grasses, forbs, and browse is generally inversely related to the overstory density. The relationship is often expressed as a curvilinear function where increasing stand density in square feet of basal area or percent of canopy cover restricts the weight of forage produced (Halls *et al.* 1956; Ehrenreich and Crosby 1960; Halls and Schuster 1965; Blair 1967).

Herbage production in the South ranges as high as 3,000 pounds or more of dry matter per acre on cutover forest lands and among newly established pines (Duvall and Hilmon 1965). Beneath a forest canopy yields decline as stand density increases (Rhodes 1952; Gaines *et al.* 1954; Ehrenreich 1960; Schuster 1967). Production may average less than 100 pounds of dry matter per acre in fully stocked plantations of pole-size pines or natural pine-hardwood stands with a basal area of 100 square feet or more per acre (Rhodes 1952; Blair 1967).

Browse plants respond to stand density in much the same way as herbaceous plants. Dry matter production of 1,440 pounds per acre has been reported in forest openings in Florida (Strode and Chamberlain 1959). Beneath a tree canopy woody forage declines with increases in stand density. In east Texas, browse in a mixed pine-hardwood stand increased from 300 pounds of ovendry material per acre where the stand density was 96 square feet of basal area to over 700 pounds on an area with 26 square feet (Schuster 1967).

Beneath a canopy the current growth of browse generally exceeds that of herbaceous plants, especially where fire has been excluded or is seldom used (Rhodes 1952; Halls *et al.* 1956; Blair 1967).

In most southern pine-hardwood forests the understory growth is strongly influenced by a hardwood midstory beneath the dominant pine canopy. As the stands develop much of the woody understory grows beyond reach of the deer and forms a dense, multilayered midstory of young hardwoods and large shrubs (Schuster and Halls 1962; Blair 1967). The combined influence of overstory pine and midstory hardwoods governed browse productivity in a 30-year-old loblolly pine (*Pinus taeda* L.) plantation that had been thinned at 20 and 25 years of age (Blair 1967). The multilayered midstory grew progressively denser and when crop trees were 35 years old it primarily determined browse growth. The higher and less dense pine canopy exerted little influence.

Effects of density are lessened in older pine stands where a midstory is sparse or absent. Although basal area may be greater, trees are fewer and taller. Considerably more light reaches forage plants than in younger stands with low, dense canopies or in older stands with a dense midstory.

Heavy litter accumulation is often associated with reduced plant growth, and leaf cast is directly related to basal area density of the overstory (Gaines *et al.* 1954; Blair 1960). As pine needles and hardwood leaves accumulate, many seeds never reach bare soil to germinate, and young seedlings are often smothered. Moderate litter accumulations, on the other hand, are beneficial as they insulate the soil and minimize temperature extremes and moisture losses.

Floristic Composition

Floristic composition in the understory is also a function of stand density. As light is reduced shade-tolerant plants predominate. Many browse species palatable to deer, such as Japanese honeysuckle (*Lonicera japonica* Thunb.), yellow jessamine (*Gelsemium sempervirens* (L.) Ait.), and arrowwood (*Viburnum dentatum* L.) are tolerant of shade, and are often more abundant under a canopy than undesirable species as waxmyrtle (*Myrica cerifera* L.) and persimmon (*Diospyros virginiana* L.) (Schuster and Halls 1963; Blair 1967).

Development of the overstory may cause undesirable changes in both the growth and composition of herbaceous vegetation. As stand density increases, desirable grasses often give way to less desirable species (Martin *et al.* 1955; Halls and Schuster 1965). Growth of most composites, legumes, and other forbs declines as light decreases (Blair 1960; Ehrenreich 1960; Schuster and Halls 1963). Reduced light intensity may have greater influence in decreasing the number of forbs and their vigor than in determining the composition.

Mast and Fruit Yields

Timber density significantly affects production of fruit and mast, which are important for deer in seasons when other sources of energy are scarce.

Acorn yields vary according to timber density and species (Goodrum and Reid 1956; Sharp 1958). Southern oaks with small crowns appear to tolerate a denser overstory than large-crowned species, yet yield much mast. Sound, uncrowded trees growing in a dominant canopy position or in openings generally are the best producers of acorns (Sharp 1958). Average yields per tree for turkey oak (*Quercus laevis* Walt.) in Florida were highest in stands with 15 to 80 stems per acre, but yields per acre were greatest where there were 150 to 160 acorn-bearing trees (Harlow and Eikum 1965). Oaks growing in deep shade are generally poor producers.

Amount and frequency of fruit production by understory shrubs appears inversely related to timber stand density. Fruit yields of several browse species in east Texas, such as yaupon (*Ilex vomitoria* Ait.), American beautyberry (*Callicarpa americana* L.), and flowering dogwood (*Cornus florida* L.), were suppressed more by the overstory cover than forage yields from the same species (Halls and Alcaniz 1968). Yields of fruit from plants growing in the open were several times greater than from those beneath an overstory of 70 square feet of basal area per acre. The hardwood midstory, characteristic of these stands, had been eliminated. Presence of this midstory would have further restricted light transmission and yields.

In central Louisiana, Hastings (1966) found that fruit yields declined slowly, but progressively, as the basal area in a pine-hardwood stand increased. Yields were average or better in stands of 60 to 80 square feet of basal area but dropped sharply at higher overstory densities.

He also reported that stand structure, canopy form, and composition appreciably affected the fruiting of shrubs. Yields were highest and most consistent in forest openings. Below canopies yields were affected least in stands with a pine overstory and most beneath a pine canopy with a multilayered midstory of hardwoods.

IMPROVING FOOD AND COVER ENVIRONMENT

Commercial forests are generally managed to provide a favorable environment for tree growth and regeneration. They can also be managed for production of deerfood and cover.

Cultural practices that manipulate overstory density and minimize midstory formation are important in providing adequate light to the understory. Reducing stand density may also reduce competition for minerals and moisture among forage- and fruit-producing plants, as well as among crop trees. Removal of excess litter would help provide a seedbed conducive to the establishment of understory plants.

To achieve the desired benefits for both timber and deer, management plans must be based on sound ecological principles. Factors such as the species of food plants desired and their growth requirements, age and structure of the timber stand, and type of forest products being grown should be carefully evaluated.

Adequate food and cover can generally be produced beneath the dominant canopy if there is enough light. Crop trees thus must be grown at considerably less than maximum density and the midstory must be limited to trees and large shrubs that bear fruit and mast. Timberland owners must be willing to manage their stands at a minimum density that will yield an acceptable economic return and will also provide a favorable environment for growth of palatable deerfood. The nutrient quality of the food must also be adequate.

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Effects of Hardwood Control on Food and Cover

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The importance of hardwoods in providing food and cover for white-tailed deer in the southern forest habitat is documented by pertinent literature. Hardwood control is, therefore, a matter of much concern in deer management. The most common types are burning, chemical, and mechanical. In one or another form, the practice is well established. There are direct relationships between hardwood controls (and timber management practices generally) and production of deerfoods. Effects depend upon intensity of treatment and on size and distribution of treatment blocks.

The importance of hardwoods as food for white-tailed deer in the southern forest habitat is well established. The works of Pearson (1943), Korschgen (1954), Lay (1957, 1961, 1967), Segelquist and Green (1968), Halls and Crawford (1960), Stiteler and Schrauder (1967), Stiteler and Shaw (1966), Collins (1961), Harlow (1959), Harlow and Tyson (1959), Reid and Goodrum (1958), Goodrum (1959), and Strode and Chamberlain (1959), among others, show the great importance of acorns and other fruit, as well as browse, to this species.

Acorns are heavily sought after by deer and comprise a very important part of the diet, even though production varies widely from tree to tree, year to year, and species to species. Individual trees may produce as much as 45 pounds of sound acorns some years though averaging 3 to 18 pounds (Collins 1961). Average annual expected yield of sound acorns per foot of basal area has been found to be 4.90 pounds for post oak, 6.59 pounds for white oak, 5.90 pounds for blackjack, 1.98 pounds for southern red oak, and 8.19 pounds for water oak (Goodrum 1959).

Aggregate production of fruit by small trees, shrubs, and vines of the understory may exceed acorn production per square foot of basal area (Lay 1961). Production of 20 to 65 pounds of fruit per square foot of basal area was found for five species in east Texas—dogwood, fringetree, blueberry hawthorn, flatwoods plum, and sweetleaf.

Utilization of these foods is shown by Lay's report (1965) of the examination of the woody seed content of 2,295 deer pellet groups collected over a 7-year period in east Texas. Thirty-one species or genera were identified, the most frequent being oaks, yaupon, American beautyberry, blackgum, and hawthorn. Some species of fruit were found during every month, though availability and occurrence were highest in fall and winter. Acorns were present in 14 percent of all pellets examined and in all 49 stomachs examined in November and December of a good acorn year.

Average browse production on four forest types in the Ozarks varied from 76 to 131 pounds per acre, ovendry (Segelquist and Green 1968) with an average of 101 pounds for the four types combined. On the Jefferson National Forest, Virginia, browse production averaged 37 pounds per acre, ovendry (Stiteler and Schrauder 1967). Forage production by trees in north Arkansas ranged from 254 to 1,525 pounds per acre, green weight (Halls and Crawford 1960). In Florida, Harlow (1959) found browse production running from 52 to almost 900 pounds per acre, airdry.

The importance of hardwoods in providing cover for white-tailed deer in the southern forest habitat is not so well documented as is the case in food production. A report by Davis and Winkler (1968) on brush versus cleared range as deer habitat in south Texas shows that while deer used cleared areas extensively, especially at night, they depended upon the hardwood brush for cover. A report by Krull (1964) on a study of deer use of clearcuttings in northern New York indicated that during severe winter weather the greatest deer use was in uncut areas. Main timber types were hardwoods and hardwood-conifers. In an area of longleaf pine-turkey oak in Florida, it was found that clearing all woody vegetation from plots 1 mile square caused a pronounced reduction in deer use. Removal of one-half to three-fourths of the native cover resulted in increased use by deer, again indicating the need for cover (Beckwith 1967). In general, hardwoods do provide the cover required by deer in the South, though probably not to the extent that they provide the food required. It is safe to say, at any rate, that in the southern forest habitat both food and cover required by white-tailed deer are furnished by hardwoods of various species.

Hardwood control is, therefore, a matter of much concern in deer management. In one form or another, it is an established part of land management practices in the region. The most common types are burning, chemical, and mechanical (Walker 1956). Burning has long been used for control of hardwoods, and has been well reported by Lotti, *et al.* (1960), among others. The next speaker on this panel will discuss this subject.

Chemical control using any of many available herbicides may be carried out by use of sprayers, injectors, or airplanes. Aerial-spraying and mist-blowing to remove undesirable hardwood competition from pine sites are in general use throughout the southeast by many woodland organizations. In 1960, approximately one-fourth of the total area treated chemically for hardwood control was by aerial and mist-blower application (Chamberlain and Goodrich 1962). This practice developed over a 5-year period, for prior to 1955, only a few small experimental plots had been treated with selective herbicides by aerial application. In 1955, Hiwassee Land Company conducted the first, large-scale aerial application of 2,4,5-T in the southeast. In July of that year it sprayed 2,000 acres of low value, inferior quality hardwood stands on the Cumberland Plateau in east Tennessee. In the years following, additional work has been conducted by Hiwassee Land Company and a number of other industrial and private timberland owners in the southeast. Helicopters are more commonly used for this purpose than are fixed-wing aircraft, due to their greater maneuverability. The helicopter passes back and forth over the area being treated, in adjacent flight lines 45 feet wide, and at a height of 25 to 50 feet above the timber. Rates of application vary from 1 to 2 pounds of 2,4,5-T acid per acre in a total volume of 3 to 5 gallons of solution per acre. A typical formulation consists of ½ gallon of ester (containing 2 pounds of 2,4,5-T), ½ gallon of diesel oil, and 4 gallons of water. The work is normally conducted from the latter part of May through early July.

Mist-blower application of selective herbicides to weed forest stands was first used in the South in 1957 by S. F. Potts of Crawford, Mississippi, who developed a lightweight compact blower for mounting on the back of a small crawler tractor. The technique involved with the mist-blower is to move across the area to be weeded in adjacent lanes 20 to 40 feet in width. The herbicide, rate of application, and formulation are the same as in aerial spraying.

Aerial-spraying may be used to remove either an overstory or an understory, while the mist-blower is designed to weed out the smaller, understory vegetation. In either case the purpose of the weeding treatment is to remove a sufficient number of hardwood stems to allow establishment and release of the pine seedlings that will form the new stand.

Aerial application of herbicide is widely used to control oak sprouting in mechanically-cleared site preparation areas. In such cases, oak control may be 85 to 90 percent effective and control of other vegetation 75 percent effective.

Aerial application of herbicide is frequently used to convert a commercially worthless type, such as swamp titi, to pine. With titi, approximately 95 percent of the plants may be killed back to the ground, so that subsequent seeding of pine can be done successfully. However, it appears that 50 to 60 percent of the plants may resprout at the base.

On general pine-hardwood sites, aerial and mist blower applications are widely used to achieve silvicultural weeding. Helicopter or fixed-wing aircraft application can be expected to kill 70 percent of the overstory (exclusive of pines), and mist blower applications 65 to 70 percent of the understory vegetation. Where a good burn is accomplished in conjunction with the herbicide treatment, understory reduction will be much more complete. This kill will occur over a period of 2 to 3 years. Total kill is not obtained because of skips in application, apparent inherent resistance of some species and individuals within a species and occasional unfavorable soil moisture conditions. Understory vegetation can be expected to increase considerably after the second year, so that it may become much more dense than originally. Grass and herbaceous growth may likewise increase.

A 6-year evaluation of herbicide treatments to improve deer browse in northern Idaho (Lyon and Mueggler 1968) showed some lag in mortality of undesirable species but also generally poor persistence of sprouting and relatively quick recovery from crown dieback in the desirable species. The most desirable species was killed by all treatments.

Mechanical methods of hardwood control include girdling, cutting, and use of heavy equipment with chains, brush cutters, and various blades. A study of resprouting from cut stumps by turkey and bluejack oaks in northwest Florida indicated that at least two additional treatments with heavy brush cutters 6 to 10 weeks apart during the main growing season were necessary to obtain good kills (Woods and Cassady 1961). In another study in pine-hardwoods stands in southern Arkansas, dense hardwood thickets were bulldozed clean. First-year sprouts were few, but after 3 years, one-fourth of the area was overtopped by sprouts. After 7 years, half the area was overtopped by sprouts averaging 6 feet tall (Grano 1961). A similar study in bottom-land hardwoods in west Mississippi showed that in 5 years sprouting produced about 7,500 stems per acre, 1½ inches d.b.h. and 15 feet tall (Johnson 1961).

The direct relationships between timber management practices and the growth and production of deerfood plants have been demonstrated by many studies. Schuster and Halls (1963) showed that forage production was almost four times greater in a clearcut and two times greater in a selection cut than in an uncut control area. Thinning of a loblolly pine plantation in central Louisiana at age 20 and again at age 25 to approximately 100, 85, and 70 square feet of pine per acre resulted in yields of deer browse ranging from 90 pounds per acre under light thinning to 137 pounds under heavy thinning (Blair 1960). Halls and Alcaniz (1968) reported that at age 5 years open-grown plants of seven browse species averaged 32 times more fruit and nearly seven times more twig growth than plants beneath a sawtimber size stand of pines. In mixed oak-pine forests of western Virginia improvement cuts that removed 30 to 80 percent of the basal area increased first-year browse production by three times for the lightest cut and 15 times for the heaviest. Four years after cutting, the increase was five times the control for the lightest cut and 24 times the control for the heaviest (Patton and McGinnes 1964).

Studies of acorn production in relation to thinning are less numerous. A report by Harlow and Eikum (1965) showed that heavy thinning (50 to 90 percent of stand removed) in a stand of turkey oak increased the yield per tree but the control, which had 150 to 160 mature trees per acre, produced five times more acorns per acre. Where mast-producing trees are to be removed selectively, care should be taken to retain the individual heavy producers.

The recent trend toward clearcutting, which is one form of hardwood control, has many implications in deer management. Ripley and Campbell (1960) reported on two tracts of typical mountain hardwoods in western North Carolina which were clear and selectively cut in 1949. Two years after cutting there were approximately twice as many seedlings and sprouts on the clearcut as on the selectively cut area. Browse utilization appeared to be lower on the clearcut area. Ten years after treatment the clearcut area had three times as many commercially valuable seedlings and sprouts as did the selectively cut area. Browsing was moderately heavy in the clearcut area and severe in the selective cut. More browse was produced than could be utilized in the clearcut area, permitting satisfactory regeneration.

Continued work on these same areas was reported by Della-Bianca and Johnson (1965). When the regenerated stands reached sapling stage, browse was out of reach of deer and crop tree growth greatly reduced. To overcome this, removal of all woody stems except desirable crop trees was tested on part of the area. Dense coppice growth resulted, and deer use was heavy. Browse production in the cleaned areas varied from 805 pounds per acre on lower slopes to 81 pounds on upper slopes. Untreated compartments, both lower and upper, had 3 pounds of browse per acre.

In southern Missouri, production of understory vegetation on undisturbed areas was less than on logging and TSI areas during a 10-year period (Murphy and Ehrenreich 1965). However, increases were not as great as expected. This was probably due to the fact that the type of timber management in effect during this time created small openings with minor reductions in basal area and crown cover.

The many studies which have been cited as having some bearing on effects of hardwood control have produced a multitude of data. As must be expected in so complex a problem, interpretation is difficult and summation is perilous. Whether hardwood control is good or bad for deer depends on intensity of the treatment, and on size and distribution of treatment blocks. Where section-sized tracts are completely cleared, deer habitat is lost. If clearcutting is done in 5 to 100 acre blocks, properly distributed and with necessary follow-up treatments, browse production can be much improved. At the same time, the importance of acorns and other mast and fruit requires that hardwood control be practiced in a manner which will not significantly reduce their production. Thus, hardwood control programs apparently must have the following characteristics to be most beneficial to deer:

(1) Treatment blocks should be about 5 to 100 acres in size.
(2) Blocks should be so distributed as to be within range of all deer in the area.
(3) Follow-up treatments should be made as necessary to maintain browse production.
(4) Production of acorns and fruit should not be reduced.

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The Effects of Prescribed Burning on Deerfood and Cover

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Prescribed burning for deer in southern pine forests is a highly recommended program of management. Used by game bird managers for years in the South, fire can be just as valuable for deer management in southern pine forests. It is an excellent timber management method. Not only economically, it provides more nutritious browse supplies and after about 2 years, generally produces more food than an unburned area. In pine stands, research is still needed on seasonal fires under various site, ground cover, and species conditions. In general, prescribed burning in hardwoods is detrimental.

About a 4-year winter prescribe burn rotation is the most beneficial burn for both understory vegetation growth and mast production. Palatable species of fleshy fungi occur abundantly following fire. High intensity fire produces higher significant increases of protein and phosphoric acid for a longer duration than low intensity fires.

Spring burns, range quality considered, are better than fall or winter burns, with summer burning probably being equally good. Annual summer burnings, however, result in a grassy habitat with reduced browse and mast supplies better suited to quail management than to deer management.

Forests of the future are going to be different than those we are used to seeing. Product values and land costs are demanding that forest management plan for maximum monetary returns. In most cases this requires highly marketable species at greater stand densities. The old "hit and miss" high graded forest which seemed to have produced fine game habitat, is now a thing of the past.

This new southland environment will require more knowledgeable and intensive manipulation of understory habitat, planning within land patterns, and a recognition that all species of game cannot be accommodated within every land pattern. The land pattern consists of (1) hardwood and pine managed for products requiring large diameter trees, for example, sawtimber and veneer, (2) pine managed for wood fiber, and (3) cultivated cropland and grassland pasture. The habitat quality of this environment will depend largely on: the area of forested land under long rotation, that under short rotation, agricultural lands—and how far they are apart. It is fortunate, in our opinion, that considerable acreage of forest lands will be managed in even-aged groups. This permits treatment of understory without damage to standing timber—at all but sapling sizes. Fire is more practicable under even-aged management.

Fire as a tool for understory control has been used for years by managers where game birds were the prime product. Historically, the longleaf Coastal Plains of the southeast were the proving grounds for this type of management. Stoddard and others used fire in operational management as early as the twenties. Fire under controlled conditions can be just as valuable in deer management in southern pine forests.

In general, prescribed burning in hardwoods is detrimental. Except for regeneration, fire should be used very sparingly in hardwoods. Stream bottoms supporting mast-producing hardwoods should be separated from adjacent pine stands by plowed lines, firebreaks, or backfires. When mast-producing hardwoods are a major component of upland forests, prescribed fires should not be used until they are of young pole stand size (Stransky and Halls 1967). Repeated burning, even though light, will eventually remove hardwoods from pine-hardwood stands. Unpublished findings from the ridge and valley province, pine-hardwood timber type in Virginia, indicate resprouting success with bear oak *(Quercus illicifolia)* in 1964 using prescribed burn (Shrauder 1964). Bear oak is an excellent perennial understory mast producer in shale soil. Additional research, especially in mountain hardwood types, is needed before widespread prescribed burning is recommended for management purposes.

Prescribed burning is an excellent forest management tool. It is fire applied in a skillful manner, under exacting conditions of weather, to fuels of the forest in a predetermined area for a specific purpose, to achieve certain results. A trained, experienced forester or resource manager can use it effectively with little risk. In addition to controlling understory vegetation and improving wildlife habitat, prescribed burning is widely used for reducing excessive fuel, controlling brown-spot disease in longleaf pine, and preparing seedbeds and planting sites. This paper concerns prescribed burn as it affects deer in southern forests.

Leopold (1950) mentions prescribed burn for deer as being the cheapest technique to increase deer carrying capacity on some ranges.

Fire in a forest environment has been used with marked success. In 1940, Bud Jenkins of the Michigan Conservation Department began a series of studies to determine the values of fire in controlling plant succession for grouse and deer. He found that to maintain desirable openings, they should be burned at 3- to 5-year intervals. The nonopen portions responded with increased browse, legumes, and fruit crops of shrubs.

Basically, there are two periods in the life of a pine stand when fire may be safely used without danger to pines—prior to regeneration to secure favorable conditions for germination, and after the trees are tall enough and bark thick enough to be above fire and withstand heat. Whether or not any benefits accrue to deer from the regeneration burn depends a lot on what vegetation was there previously and whether or not other site preparations, such as chopping and herbicides, were used. Under short rotation management, this may be the one and only time there is any opportunity for browse production—thus juxtaposition is so important. The second period, beginning in small diameter pole stands and continuing to maturity, encompasses a period from 40 to 60 years. Maturing stands provide major deer habitat and yields the maximum in benefits from prescribed burning. Here fire serves several purposes, (1) reduces undesirable woody growth, (2) brings palatable species down within reach of deer, (3) improves the nutrient quality of the browse, (4) generally provides increased herbaceous foods under semiopen overstory conditions, and (5) encourages understory fruit and berry production under sparse overstories.

While research is still needed on results of seasonal fires under various site, ground cover, and species conditions, properly timed and applied fires in pine stands are beneficial in southern timber and game habitat management (Stransky and Halls 1967).

Sweetgum, red maple, southern bayberry and several species of oaks occur in the understory and midstory of unburned pine stands. They contribute little, if any, to the food supply and suppress more desirable understory and ground species. Although oaks are desirable as a source of mast, under high stand densities they will never become large enough to provide acorns. Dwarf oaks, which respond readily to fire, are an exception.

Where hardwood-choked pine stands occur, one or more burns may be required to reduce undesirable species such as sweetgum for deer. These burns are usually executed in the summer, as the killing effect of fires is greater to growing tissue.

Research has shown that a series of consecutive annual summer burns will reduce sweetgum and oak about 50 percent. Under these burning conditions, deer habitat is on the upswing. As the hardwood understory thins out, such fire followers as greenbrier, panic grasses, legumes, and ragweed increase. Fires used under these hardwood-choked pine stand conditions are considered to be range reclamation fires as compared to the light periodic fires for understory management. They are hot and often kill desirable species and should be appraised as a calculated risk necessary to getting an otherwise mediocre range to usable condition for deer. Once the desired understory hardwood thinning on the deer range has been obtained, frequent, hot summer fires should be discontinued, lest the range become predominantly mixed grasses and low herbaceous species more suitable for quail.

Winter burning on a 3- to 5-year interval as a management method results in an excellent response of legumes, keeps browse plants low, and seldom kills plants, injures game or destroys nests. Vegetative response, however, varies with density of the overstory. In semishady areas, legumes such as partridge pea and beggar-ticks frequently follow fire, while in open areas, woody plants, hardwood sprouts, and grasses often come in after burning (Devet and Hopkins 1968). Plowing out selected areas such as old house sites, honeysuckle thickets, and othe fruit and berry patches provides immediate food supplie for deer. Where runner oak *(Quercus pumila)* occurs it bears vigorously for several years following fire. Fir greatly increases the protein and phosphorous conten of browse. These minerals are rarely adequate on southern deer ranges. In favor of 3- to 5-year burning intervals the maximum desirable browse conditions generall peak, and just begin to decline, at the close of the interval. These guides, of course, must be applied with knowledge of site conditions. Let's look at these conditions i more detail:

Nutrition

DeWitt and Derby (1955) compared nutrient conten of red maple *(Acer rubrum)*, white oak *(Quercus alba)*, flowering dogwood *(Cornus florida)*, and roundlea greenbrier *(Smilax rotundifolia)* following a low an high intensity fire at the Patuxent Research Refuge i 1947. Protein contents were significantly higher in th season following the low intensity fire, but no effect could be determined in the second year. The high intensity fire produced significant increases in protein contents of all four species and effects were still apparen at the end of 2 years. Protein increases from high intensity fires were more evident in samples from dry areas

The effects of burning on quality of browse are generally beneficial. Lay (1957) reports that increases in protein were the most enduring—about 29 percent mor protein the first winter after burning and 18 percen more protein the second winter after burning. The sam collection for these two burns likewise showed abou 17 percent and 10 percent more phosphoric acid. Nutrition benefits disappear within 2 years. Lay (1957) report that spring burns, range quality considered, are bette than fall or winter burns with summer burning probabl being equally good. Most of understory species, howeve was reduced 70 percent due to summer burn. Long tern results of repeated burning at short intervals is detrimental to the browse supply and mast for deer.

Composition

Out of 51 species reported in "Deer Browse Plants o Southern Forests" by Halls and Ripley (1961), 13 pin site species either resprouted prolifically, or resulted i increased nutrition following burning. The 13 specie are: French mulberry *(Callicarpa americana)*, Trumpe creeper *(Campsis radicans)*, Fringetree *(Chionanthus virginicus)*, Buckwheat tree *(Cliftonia)*, Dogwood *(Cornus)* Titi *(Cyrilla)*, Strawberry bush *(Euonymus)*, Yellov jessamine *(Gelsemium sempervirens)*, Yaupon *(Ilex vomitoria)*, Honeysuckle *(Lonicera)*, Blackgum *(Nyssa)* Greenbriers *(Smilax)*, and Sweetleaf *(Symplocos)*.

White-tail deer are known to consume a large variet of additional foods such as fleshy fruits, acorns, leaves grasses and other herbaceous plants and fungi (Stitele and Shrauder 1967). This was supported in more recen studies by the Southeastern Forest Experiment Statio and others (Lay 1967). Prescribed burn, in addition t woody browse, also improves yield and quality of fruits grasses and herbaceous plants (Lay 1956).

Fleshy fungi which fortunately occur without regar to stand density, respond well to fire. Nitrogen-toleran species fruit prolifically. Their ability to mature rapidly following stimulation—hours as compared to months for other food—offers the possibility of using fire to compensate for mast failures and other food emergencies. Several species are outstanding fire followers and at the same time are preferred deer food. They are: granulated bolete *(Suillus granulatus)*, little red russula *(Russula roseipes)*, swollen-stalked armillaria *(Armillaria ventricosa)*, Tennessee hygrophorus *(Hygrophorus tennesseensis)*, Clitocybe *(Clitocybe)*, and destroying angel *(Amanita verna)*. The ability of common species of mushrooms to withstand shade and respond to fire will become increasingly important to wildlife managers in the forest environment of the future.

Cover

In frequently burned pine forests, herbaceous plants usually form the dominant understory cover. Conversely, such plants are suppressed by the accumulation of litter when fire is excluded. In addition to herbaceous plants, certain woody species such as titi, trumpet creeper, and yaupon resprout prolifically and provide dense cover for deer. Periodic burning in patterns would provide increased nutritious foods on one area while dense cover for deer can be produced on adjacent areas. As plants resprout prolifically, hunter use generally declines on dense areas.

Soil

Soil studies mentioned by Suman and Carter (1954) indicate that the chemical characteristics of the relatively infertile sandy soils of the Coastal Plain region are not materially affected by burning. The Charleston Research Center (SEFES) found that a 10-year annual burning treatment in flat sandy soils increases the organic matter content of the top 2 inches of soil. They found no evidence of harmful effects to these soils by prescribed burning. The type and frequency of annual winter fire resulted in no detrimental effect on the physical properties of density, porosity, or percolation rate. However, when burning, the soil must be wet or damp not only to prevent fire from penetrating the soil and killing beneficial micro-organisms and consuming humus, but also to protect the layer of duff adjacent to the soil (Dixon 1965).

Costs

As mentioned, fire is an inexpensive method of setting plant succession back by providing not only abundant, but more nutritious deerfoods in a browse management program. Silker (1961) found that when using experienced personnel at wage levels of $1.00 per hour, burning costs may range from $0.30 to $0.50 per hour for backfires in normal pine-hardwood fuels and $0.12 to $0.50 per acre for strip headfire burning in light to moderate fuels. Night burning will probably result in decreased fire costs.

CONCLUSIONS

Fire in the wrong place under certain conditions can be one of the greatest enemies to mankind. It is one of nature's ways of setting back plant succession. It is an important technique in managing our wildlife resources.

Considering all data, there seems little chance for much damage to deer range in pine forests by prescribed fire. Benefits from fire increase as the understory begins to grow out of reach of deer. Large-scale burning should consider the pattern or distribution of the burns if maximum deer, quail, and turkey populations are desired. In general, the pattern that produces the most diversity of understory habitat will be the most beneficial.

In addition, the following considerations for deer management are important:

1. Prescribed burning is an excellent forest management tool that economically sets back plant succession to a more favorable game habitat.
2. A cool winter burn is preferred over a summer burn. Summer burns endanger late-nesting quail and turkey and decrease understory fruits and forage preferred by deer. An exception is a dense hardwood-choked-pine stand—a series of hot summer reclamation fires during the growing season may be needed first to eliminate hard-to-kill hardwood species.
3. A burning interval of about 4 years is ideal for deerfood and cover. This interval permits an excellent response for legumes, keeps most browse plants low, seldom kills plants, or injures game. Mast from vigorous runner oak is produced the second year. Food benefits produced, mostly sprouts, can last from 3 to 10 years depending on area and type of vegetation.
4. Palatable species of fleshy fungi occur abundantly following a fire.
5. Repeated annual summer fires produce a grassy habitat more suitable for quail than deer.
6. Protein and phosphorus contents of plants are increased by burning. Increased nutritional benefits are apparent for about 2 years.
7. Burning promotes prolific resprouting, thereby providing increased cover for deer.
8. Chemical characteristics of sandy soil in Coastal Plains are not affected by burning. Physical properties of sandy soil are not detrimentally affected by burning if soil is wet or damp.
9. Evaluate effectiveness of prescribed burn by: observing scorch on bole of tree (should be 18 inches or lower), no discoloration of crown foliage and complete blackening of the rough and undesirable hardwood understory. Bark cracks extending into the cambium at ground level indicate success of hardwood kill.
10. Additional research on prescribed burn in hardwood types with different soils, especially in the Mountain province, is needed. Under present knowledge, avoid burning in hardwood types for management of wildlife.
11. Fire is an excellent, inexpensive method of providing increased deerfood and cover in pine and

pine-hardwood types. While additional deerfood is produced in certain hardwood types, much research and evaluation remain to be done.

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The Goals of the Southern National Forests in White-Tailed Deer Management

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The white-tailed deer has been reestablished during the past 20 years as the most important and most numerous big-game species in the southern National forests. It is too numerous in many areas. Wildlife habitat management on these forests is now aimed to encourage species best suited for a particular area and habitat, as determined by a forest-wide survey of habitat needs. This survey will undoubtedly result in reduced emphasis on deer habitat in areas better suited to other wildlife species.

The white-tailed deer is the most important and most numerous big-game species on all the National forests in the Southern Region. Its popularity is very high with both the hunting and nonhunting public. It is scarce or absent in certain mountain areas of suitable habitat, however. Despite certain habitat preferences, its ability to adapt to various habitat conditions is an important factor in its management and popularity.

It is hard to realize that white-tailed deer were found only in remnant populations in the southeast as recently as 20 to 30 years ago. The success of reestablishing the white-tailed deer on the National forests was not accomplished without problems, however. In many areas deer populations have gone from a "famine to a feast" level and are seriously damaging not only their own habitat but also other forest resources. It is obvious that the number of animals has to be reduced to a reasonable level. However, public resistance to sound deer-hunting regulations remains as a continuing barrier to good management in many States.

MULTIPLE USE

The doctrine of multiple use is the cornerstone of land management decisions on the National forests, National grasslands, and land utilization projects. Unfortunately, it means many things to many people. However, the Multiple Use-Sustained Yield Act of June 12, 1960, states:

> Multiple use is the management of all the various renewable surface resources of the National forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

OBJECTIVES

The National forest objective in wildlife management is to manage habitat so that both game and nongame populations will be maintained at levels: (1) consistent with the requirements for other services of the land, and (2) in accordance with wildlife's recreational and related public uses and values. The Southern Region in supplementing this policy states: "Manage all National forest wildlife habitat to meet the requirements of the proper wildlife species, in numbers consistent with capacity."

GOALS

Population.—The Forest Service would like to see white-tailed deer established and managed in *all* suitable habitat. In addition to areas of unused range, there are examples where populations have exceeded the carrying capability of the habitat. Here the harvest should be liberalized.

White-tailed deer habitat.—In the past, quality habitat has been either a "feast or a famine," depending primarily upon timber cutting programs. Deer habitat must be produced on a sustained basis by manipulating food and cover over a period of time. Forest resources must be better coordinated, especially timber management.

Research.—Knowledge gained from habitat research on the white-tailed deer is the basis for its management on the National forests. More research is needed to manage deer habitat on a sustained basis. Therefore, it is a goal of the National forests to cooperate with all interested parties and agencies in furthering habitat research on the white-tailed deer.

Quality of experience.—Should wildlife management provide a quality experience with variety, or just as much hunting opportunity as possible? Forest Service policy is to "Provide, in cooperation with the States, hunting and fishing areas suitable to the varying needs, interests, and skills of the public; the intent being to retain some areas managed for quality of experience rather than numbers of participants."

The present deer program in the Southern Region encompasses both quantity and quality. To many people the Pioneer Weapons Hunting Area on the Daniel Boone National Forest in Kentucky is an example of quality hunting. A long history of an overpopulated deer range on the Pisgah Wildlife Management Area on the Pisgah National Forest in North Carolina has made people there demand quantity.

HABITAT SURVEY

Two years ago, the Southern Region started a program of having each forest survey its own wildlife habitat. Part of this program entails selecting wildlife species to favor in habitat management on established units for the next 10 years, based on existing habitat conditions. This does not preclude the management of all species found on the unit; however, each forest will give priority to those species for which the habitat conditions are best suited. Therefore, the forests will emphasize deer habitat management only where the habitat conditions warrant. And deer will not be favored on those units better suited to quail or other species of wildlife. In certain units, several species, such as deer, squirrel, and turkey, will receive the same priority in habitat management.

At present, habitat surveys are completed on the Kisatchie, Cherokee, and Jefferson National Forests and on the National forests in Georgia. Surveys are planned for the others. The rate of accomplishment will depend upon personnel ceilings and financing.

The habitat needs survey does not intend to deemphasize deer in the forests' wildlife programs. However, these surveys will probably show that deer have long been dominant in areas where the habitat is better suited to other species. This does not mean that habitat needs for deer will not be considered in these areas; rather, the needs of other species will have a higher priority.

IMPORTANCE OF DEER

How important are deer as a National forest resource? In 1967, there were an estimated 289,000 deer on the National forests in the Southern Region, and an estimated kill of 34,000. Widely varying dollar values have bee assigned by various States and areas for harvested deer Recent figures range from $300 to $1,200. If we us the minimal value of $300 per harvested deer, the 196 harvest of 34,000 deer had a monetary value of $10,200,000 on the National forests in the Southern Region.

What are the nonconsumptive values? Certainly th wildlife photographer, camper, and hiker value thei experience of observing deer in the National forests The opportunity of seeing deer, or other wildlife, is on of the important considerations in family outings an automobile trips through the National forests. Whereas other big-game species, such as the black bear, hav declined as a result of habitat changes and human in fluences, the white-tailed deer population has increase steadily for the past 20 years.

Since the white-tailed deer is so adaptable, its import ance will continue to increase on the southern Nationa forests. We are all aware of the activities and pressure from increased public use and demands on the Nationa forests. They will not have the same adverse effect upo white-tailed deer as on other big-game species. There fore, this deer should continue as a major big-game spe cies in the Southern Region of the Forest Service.

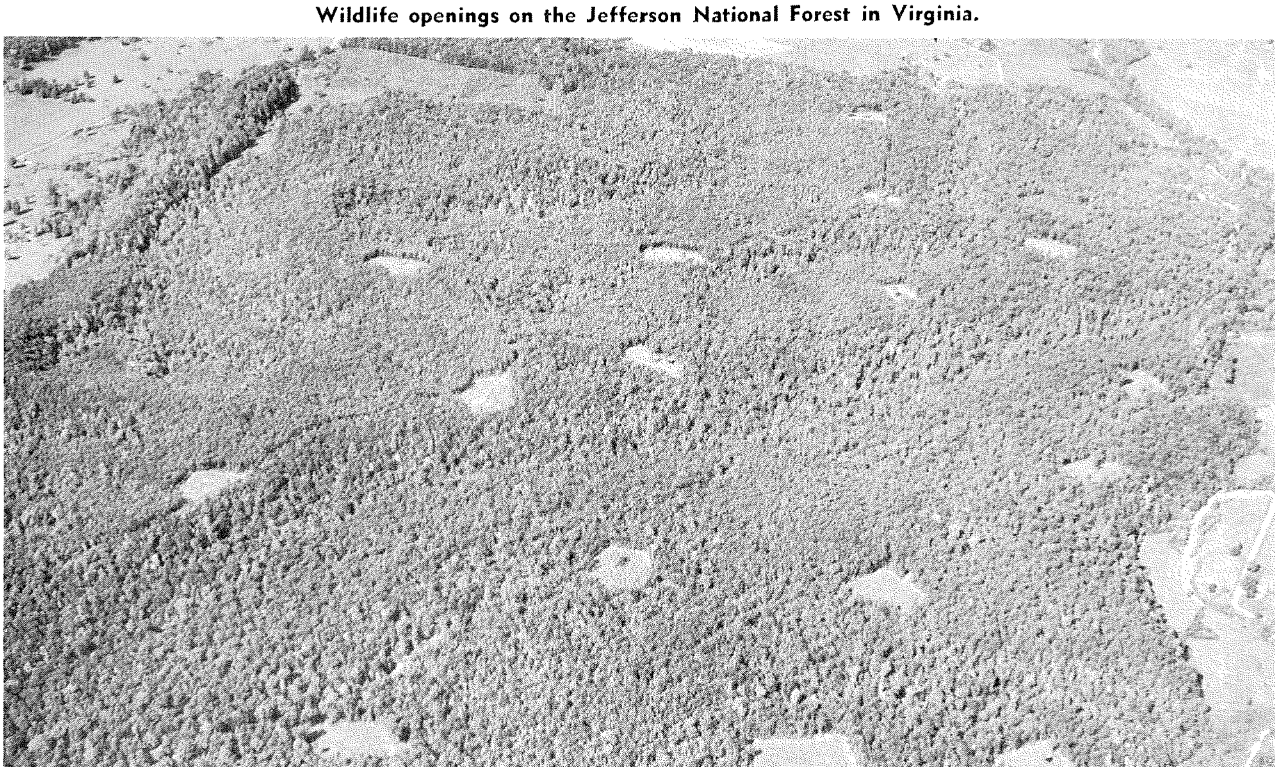
HABITAT MANAGEMENT

Habitat requirements and preferences for both foo and cover for the white-tailed deer are adequately cov ered in other sections of this symposium.

As a land management agency, the Forest Service i charged with management of wildlife habitat. There ar two ways to accomplish this responsibility. The first and by far the most important, is through resource coor dination, and second, direct habitat improvements.

Direct habitat improvements are more "glamorous, but the heart of the National forest deer habitat manage

Wildlife openings on the Jefferson National Forest in Virginia.



ment programs is coordination with all other resources, especially timber. Forest Service Handbook 2121.4 "Multiple Use Guide—Southern Region" provides the broad guidance in coordinating resources. Further guidance is provided by Forest and District supplements to the Regional Guide and in individual resource plans. These supplements are used to further clarify local situations and problems.

At the present time, direct habitat improvements for deer are limited. Where improvements have been established, they generally consist of openings, waterholes, food plantings, and release of food-producing species.

In addition to these direct habitat improvements, the Southern Region constructs hunter trails, parking areas, and hunter camps. Although these activities do not improve the deer habitat, they are important in facilitating the harvest and help provide a more enjoyable hunter experience.

The great importance of white-tailed deer in the South has encouraged a tendency to overemphasize deer habitat to the possible detriment of other important game and nongame species. This situation was partially responsible for the establishment of the "Habitat Needs Inventory Survey" presently under way in the Southern Region.

Habitat conditions do not remain static. Therefore, over a period of time, habitat emphasis will change on a given unit of land. Let's look at a unit of land in the southern Appalachian Mountains. Just after timber regeneration cuts, habitat management would emphasize deer. This same unit for the next 20 to 50 years will be best suited for grouse, and from 50 to 100 years for squirrel and turkey. Keep in mind there will be some deer in this unit throughout the 100-year period, but during this rotation there are periods when the habitat is best suited for the management of other species.

The future of the white-tailed deer in the southern National forests holds great promise. It is limited only by the potential of the habitat and the ability of the Forest Service and the respective State conservation departments to wisely manage this species and its range.

The Goals of State Conservation Agencies in Deerherd Management

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In this paper an attempt is made to extract from the directors of 16 southeastern State game and fish agencies some of their thoughts with regard to white-tailed deer and to present a composite picture of their general concepts on a regional basis. This species is highly important. It receives major attention in the game management program. It supports a significant portion of the total hunting program, both from the standpoint of economics and hunter effort. Most States expect an increase in deer density, distribution, and the accompanying problems involved in herd management. Some trepidation is evident among directors regarding an incipient trend toward fee hunting by industrial landowners.

In attempting to present the general picture of the role of white-tailed deer in overall game management programs being conducted by State conservation agencies in the southeast, a questionnaire was prepared and sent to the various directors. States included members of the Southeastern Association of Game and Fish Commissioners, and Texas and West Virginia. Emphasis was placed on the need for the directors' personal attention rather than their passing the form on to their deer biologist or someone else for completion. The directors responded admirably and in all but a few cases, presented their own views, and individual concepts and philosophies. Even in the exceptions, persons of administrative responsibility furnished the desired information. The thoughts, therefore, presented in this paper are more philosophical than technical, and reflect personal attitudes of the people who must treat the entire wildlife resource, rather than a single species such as that with which this symposium is most concerned.

Questions were designed to be thought provoking. Simple "Yes" and "No" answers were impossible without also elaborating. It was thought earlier that the answers would lend themselves to consolidation and permit formation of a typical southeastern situation—a stereotyped director, if you will. This proved to be rather clumsy, however, due to the wide range of conditions encountered in the region.

The following remarks are derived from the comments of the respective directors and also reflect, no doubt, the tempering by this writer of the conditions in his own State. Questions and analysis of answers follow the same order as were listed in the questionnaire.

1. What is your general aim in deer management? Is it to provide maximum hunting days? Or is the emphasis on quality?

Most respondents replied to the effect—"maximum deerherds consistent with range capability." Quality hunting (to include trophy heads, freedom from other hunters, and better than average hunter-success ratio) would, as suggested by two respondents, result as a by product of proper management. This writer's conclusio is that directors want maximum hunter days consisten with range capability and physical condition of herc without depletion of herd density. They would accom plish this by adjusting from year to year the areas oper the sex to be harvested, and the bag limit. They woul hope to produce some trophy antlered-deer but this i not essential, since any deer bagged is considered trophy in some areas. Trophy is a relative term.

2. To what extent do you expect deerherds to suppor your total hunting program? Will this change i the future?

The States which interpreted this as meaning to suppl a figure gave 30 to 50 percent of the total license sale as representing deer hunters. A different way of an swering relates to man-days effort in which three State gave 11.9, 15.0, and 25.0 percent of their total huntin effort being attributable to deer. The latter figure come from a State which probably places more value on th white-tail deer in its overall hunting program than d any of the other States interviewed.

In circumspect, it appears that white-tailed deer con stitute a significant portion of the surveyed States' tota resource and subsequent hunting programs. Respondent also indicated a continued expansion in distribution an densities, not only in those States which have supporte historic deerherds but also in border States where res toration efforts are proving to be effective. Some dee biologist may be shocked to learn that the white-taile deer is not necessarily the most important species a this time, although it is expected that deer hunting wil continue its rather rapid increase in popularity durin the next decade.

3. What are your planned limits of deer density? How will it be controlled? Are you concerned with cro damage? Range depletion?

There are no standards for density. It is the genera consensus among the respondents that density will, o necessity, be variable, due to the myriad environmenta conditions which exist in a given State and which exis from one State to another. The directors are cognizan of the need to expend more effort in management i areas of low carrying capacity as a means of improvin distribution, particularly, in conjunction with areas o high hunter density—centers of human population.

Crop damage is not a serious problem but occurs i localized areas. Range depletion is a little more serious generally, and there is expected to be an increasin alertness for this problem as herds develop in density and distribution. Control measures will involve adjustin hunter pressure through special seasons, special area and either sex harvesting.

One respondent pointed out the ambiguity of the term "range depletion" by stating—"Deer ranges can become depleted as a result of natural plant succession or as a result of population densities that are incompatible with the quantity and quality of food energy available to the deer population. The resource manager (be he wildlifer or forester) should be wise to recognize the fact that production of a *sustained stable* harvest of deer is a product of *sustained stable* source of energy."

4. Will future emphasis be on permit hunting?

This question was deliberately worded to evoke answers that might define permit hunting. At least, some of the respondents reacted by describing two kinds of permit hunting—a type of lottery wherein a predetermined number of people would be given the opportunity to participate in a special hunt; or requirement that any licensed hunter must buy an additional permit or stamp to hunt the designated species. Some of the others, in addition to the above precepts, mentioned fees being charged by landowners for the privilege of hunting their acres.

In a general way, most directors prefer to conduct their deer programs with a minimum of regulations. This entails merely setting a season and bag limit and not regulating number of hunters or their distribution. Some refinements are added from State-to-State but there is an avoidance of permits for any purpose, except permits for the purpose of additional revenue and for areas which require special harvest. Some have utilized lottery permits with satisfactory results. Some have experienced disappointment, especially in regard to public relations.

In summary, the opinion appears to favor an avoidance of permits, unless necessary to facilitate special harvest.

5. To what extent will out-of-State hunters be encouraged?

None of the polled States makes any great effort to attract nonresident hunters. On the other hand, all States treat the nonresident on a par with resident hunters except for increased license costs. Provision is made generally for trip-licenses.

Two respondents expressed a feeling that eventually public pressure may force a "favorite son" policy. One stated that nonresident fees may be raised to discourage this type hunter.

No one objects to the revenue generated by this source. It is expected that no great change in the status of nonresident hunters is forthcoming.

6. How do you rank deer among your other popular species? Do you think of deer in terms of a species which, with relatively little management, can produce a high return in recreational opportunity? Can any other species offer this comparative return for the same input?

Again, as in question No. 2, deer rank according to whatever criteria the respondent decided "rank" meant, from about the third most important species to the number one species.

Input/output ratio is considered to be highly favorable. Of the species which require management in the form of restocking, habitat improvement and harvest regulations, deer obviously produce a high degree of hunter opportunity expressed in man-days. Most respondents were quick to point out, however, that squirrels and rabbits support considerably more man-days of hunting, at practically no input except harvest management.

7. Do you detect a tendency on the part of commercial timber companies to charge a fee for hunting their lands? What is your reaction to this?

To the first part of the question, the northern border States replied in the negative. All other States replied in a positive way, ranging from slightly to definitely.

The rights and prerogatives of private landowners are clearly recognized, and supported and defended. Respondents did, however, express the feeling that revenues collected should be directed toward a sustaining game management program on these lands. Most of the States have entered cooperative agreements with commercial landowners for game management and public hunting. Hunting is generally offered without use fees. Leases to conservation departments are generally without payment. Two States have had leases on some free-leased lands terminated.

Comments from individual States indicated concern that the commercial landowners may become so engrossed in wildlife management that they might exert detrimental influence on the decision of the State administrative agency.

The average director is not particularly concerned over a fee charged by a landowner. He recognizes property rights and that fees collected could improve game management and subsequently hunter opportunity. He admonishes the landowner to accept responsibility for protection and proper game management procedures. He would rather have the lands under cooperative agreement, without payment for leasing, and without fee to the public user. He thinks that fee hunting will be accepted by a portion of the hunters and that public lands can support those who cannot or will not pay the use fee. He wonders if increasing costs of use fees will be detrimental to his efforts to obtain authorization for license increase or will affect his chance of establishing a big game stamp. He thinks that fee hunting on these lands is inevitable.

While this presentation obviously does not, precisely or comprehensively, treat all the ramifications of the status of the white-tailed deer in the southeast, some of the current thinking of administrators is amplified. Each State has its own problems, not only with deer, but with other game species. Some States place more value on deer than others. The directors' attitudes and concepts cannot be taken lightly. After all, these are the minds that determine where it is we are going, and influence the speed we are to maintain in getting there.

The Goals of Private Forest Holdings in Deer Management

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Farmers and miscellaneous individuals own the greatest portion of forest land in the South. Most of them like to have deer on their land. Their management goals have been vague and varied but the profit incentive is causing many to give greater emphasis to deer. The majority of forest industries welcome sportsmen on their land to hunt deer and other game. This improves public relations but if the industry is to provide improved facilities and quality deer hunting the deer program must be prepared to pay its own way.

Before discussing "The goals of private forest holdings in deer management," I think that at the very outset we should establish exactly what lands we are talking about.

As most of us know, the southern forests account for approximately 40 percent of our Nation's total forest acreage. Seventy-three percent of the South's forest lands is owned privately by farmers and other miscellaneous individuals; an additional 18 percent also is owned privately, but by the forest products industry; and the remaining 9 percent is owned by various governmental agencies. So, when we speak of private ownership, we are actually referring to two distinct groups—the individual landowner and the forest industry.

For clarity in this discussion, I have labeled that group composed of farmers and other individuals as "private ownership," and the forest industry group as "industrial forest land." It is necessary to make this differentiation because the goals each group of owners sets for its land are not necessarily the same. These goals are frequently determined by a number of influencing factors.

In private ownership, for instance, goals often have been determined by the size of the tracts; the purpose for which the land was originally purchased; and the land's actual capability to produce trees, agricultural crops, cattle or wildlife.

On the other hand, the forest industry generally had a predetermined goal for the land at the time of its acquisition—to grow as much timber as possible.

Over the years, however, the goals of each of these groups are subject to reevaluation and change—usually because of economics. Large acreages, once considered marginal farmland, for instance, have been returned to productive forests. Economics simply dictated that the owners could earn a greater profit growing trees on the land than they could cotton or corn. Likewise, with the increase in population and the growth of our cities, we have seen excellent forest lands become more valuable as sites for shopping centers and manufacturing complexes. Still other fertile lands have been cleared and planted in agricultural crops.

Therefore, in discussing the goals of landowners, we are dealing with a dynamic, changing condition. Yesterday's goal is not necessarily the same today, nor will it be the same tomorrow. This is why it is difficult to come to any single conclusion concerning the goals of these landowners in deer management.

Perhaps the private landowner, comprising the largest sector of landownership in the South, is the most difficult to evaluate. Their goals could possibly vary as widely as there are numbers of landowners; therefore, I hesitate to draw a definite conclusion. So far as I know, there has never been a study of the private landowner to really determine his goals in deer, or any other wildlife management on his lands.

Because of this lack of documented information, I must resort to personal observations.

In my field of work, I have had an opportunity to work with the private ownership sector for quite a number of years. From this experience, I believe it is safe to say that the vast majority of private landowners would like to have deer on their land, if for no other reason than the personal enjoyment and sportsmanship gained in deer hunting. Frequently, however, you will find that rare breed of private landowner who is a truly dedicated conservationist. He has practiced good deer management on his land for many years, and in addition to the pleasure of hunting, he is a man who enjoys the sheer beauty of the animals roaming his land. In some areas of the South, these early conservationists must be given at least partial credit for building up the deerherds that eventually moved on to other nearby lands.

A factor that has become much more important in deer management on private lands in recent years is economics. As the demand for more and better hunting has increased with our rising population, many private landowners have found it profitable to manage deer on their land in addition to farming, cattle and timber growing. The practice is becoming increasingly popular, and income from hunting permits and fees for leasing have in some cases surpassed that earned in cattle or farming.

This was borne out quite vividly last fall when I had an occasion to read a Sunday edition of the Houston Post. On this particular day, there were 34 ads concerning paid hunting. They went something like this: deer hunting lease on 340 acres for $1,100.00 . . . deer hunting $125.00 per gun per season or $20.00 a day with 3 day minimum . . . and yet another at $300.00 per gun on 4,600 acres. This is what I mean why I say economics is fast becoming a factor in improving deer management on private lands.

Another example of economics playing a major role in deer management on private lands that I ran across recently appeared in "Outdoors U.S.A." In case you are not familiar, this is a book published by the United States Department of Agriculture. One of the articles tells of a Texas rancher who capitalized on a deerherd that was becoming a definite detriment to his cattle range. He opened his ranch to hunters in 1961 and charged $10.00 a day. That first year produced 225 man-days of hunting with a kill of 100 bucks and 162 antlerless deer. Realizing he had a bonanza in the making, the rancher really began to practice deer management in earnest along with range improvement for his cattle. Now, this rancher charges $20.00 per day with a maximum limit of 20 hunters each day, and the 1965 season provided 250 man-days of hunting with a kill of 147 bucks and 163 antlerless deer. The practice of paid hunting is not new in Texas. In fact, for a number of years Texas has been the leading State in paid hunting.

These are only two examples where private landowners have found their goals of deer management changing as the economics became more attractive. In the good old American tradition, the return of a profit has caused many private landowners to readjust their thinking on the merits of deer management on their lands.

When you look at the private ownership sector as a whole, it is difficult to say that they have a common goal in deer management. As I see it, deer management goals on these lands depend largely upon the economics or the personal satisfaction derived from such a venture.

Forest industry lands, however, are another matter. It appears a general policy and goal is beginning to take shape. Of course, the first priority on these lands must be oriented toward growing timber, but other factors have emerged in recent years. Game management can definitely be considered as one facet of this new policy.

Prior to the emergence of this new thinking among the forest industry, I am afraid we must confess that very little, if any, consideration was given to deer management. But an increased outdoor oriented population with more leisure time brought out an entirely new aspect of industry-owned lands.

Originally, most of the industry's lands were opened to the public as an extension of our public relations and good neighbor policy. But, in reality, there was little improved hunting offered. This proved adequate for awhile and relations with our friends and neighbors went quite well. But we soon came to realize, as the number of visitors to industry lands increased, just opening the land for public use was not enough . . . they wanted more game to hunt.

It soon became obvious to the industry, if more game was to be provided, then some type of program had to be developed, and perhaps more important, some type of control had to be established if game management were to be successful.

Using the old "trial and error" method, we are now developing these programs and controls. Since this is a new venture for the industry, and there were no prior programs or case histories to follow, this method of implementation was necessary. We realize possibly some mistakes will be made, but we hope that as we feel our way through this period, the errors can be turned into building blocks for a bigger and better program that will benefit the most people.

The industry is now about 10 years into this new concept. It may appear to those people not familiar with the program that industry's role in deer management thus far has not been so spectacular. But this is certainly not a true picture. One only has to look back to the beginning of this program to realize the tremendous progress that has been made in game management on forest industry lands. Of course, deer are a product of land management. We manage the environment which in turn reflects the land's deer-carrying capacity. Some of the accomplishments are well worth reviewing.

Perhaps one of the most significant developments occurred when a number of companies sought out and employed highly skilled wildlife management personnel. These specialists have been able to advise and guide their companies in adopting timber management policies which are compatible with wildlife habitat.

In the South, International Paper Company has employed seven foresters who hold graduate degrees in wildlife management to administer the company's game management program. Our organization consists of the fish and wildlife director, who heads the program; a specialist who conducts research projects at the company's forest research center; and one man in each of our five woodlands regions who is responsible for activities in his particular area.

In actuality, many of the industry's forest management practices were excellent deer management practices also. Clearcutting is a prime example of a silvicultural practice that aids in improving browse for deer. Contrary to what most people believe, the overmature forest does not provide ideal game habitat. Clearcutting opens the forest floor to sunlight, thus encouraging the sprouting of hardwoods and forb production.

The trend today is to manage the southern forests on a much shorter rotation than has previously been the case. This, too, can have a good effect on deer management. As the blocks of even-aged timber are established, the browse and other food plants will tend to diminish as the stand matures, but nearby younger stands will continue to provide food and cover.

On some industry-owned land across the South food plots and food strips have been planted. Whether this practice adds to the carrying capacity of the land is questionable, but it does tend to concentrate game which in turn provides for a higher hunter success.

The trapping of deer is another program that has been carried out by at least one company to improve public deer hunting. In this case, deer have been trapped in high population areas and moved to areas of low populations in an effort to establish larger and more vigorous deerherds.

Since I am more familiar with specific programs being conducted by my company, let me take a moment to discuss them.

At International Paper, we have done considerable research in the area of fee hunting. Prior to launching a fee hunting program on company lands, experiments were conducted at our Southlands Experiment Forest near Bainbridge, Georgia. This research program, through questionnaires, surveys, and actual application of organized controlled public deerhunts, proved to us that the sportsman was willing to pay for hunting privileges.

Personally, I am opposed to fee hunting. I think it is necessary, however, if we are to exercise any type of control over hunting pressure on the land so that deer management practices can be successful. We will always have open land, I think, but more than likely these lands will not be highly populated with game. Also, I am sure we will continue to lease land to the various States for wildlife management programs.

Since our early work at Southlands, we have expanded our fee hunting system to some of our other lands in Georgia, South Carolina, and Alabama. We employ various methods of conducting the deer hunts, and fees charged may range from $2.00 per gun for a daily permit, to $25.00 per individual for a season permit.

We believe fee hunting is certainly one of the most promising advancements in deer management to date. A program such as this will enable us to control the hunting pressure and thereby carry out a more effective game management program. In addition, it will provide some economic return for the time, effort, and expense the company invests in carrying out an intensive deer management program.

Two other companies in the South with which I am familiar have also embarked on a fee hunting system. The Chesapeake Corporation of Virginia charges $2.00 for a permit to hunt on 190,000 acres of land. Their program is listed in the Directory of Private Hunting Lands in the Virginia Hunter's Guide, which is published by the Virginia Commission of Game and Inland Fisheries. In Alabama, Gulf States Paper Company also has gone to a fee hunting system on their lands with charges ranging from $1.00 to $10.00 for a season permit.

At this stage in the industry's developing deer management program, I believe the key to success depends on deer hunting becoming economically profitable. Of course, the extent to which landowners go in deer management may well depend upon State trespass laws. If an owner is to develop an effective deer management program on his land, he must have control of the hunting pressure. The States simply cannot afford sufficient law enforcement personnel; therefore, the individual landowners may be forced to employ game wardens.

Public pressures and demands have become too great for us to continue deer management simply as a public relations gesture. And, typical of all industry, a program is difficult to launch on a wide-scale basis, especially one that will cost considerable money until it has proven capable of paying its own way.

Of course, as the program begins to pay its own way, it becomes even more imperative that high quality hunting be provided. It's simply a case of when a sportsman pays money for hunting privileges he must have something to hunt. In order to provide such quality hunting, the landowner must be in a position to exercise control over the land, the deerherd, and the deer hunter . . . and fee hunting may be one of the solutions to this problem.

Another solution that in the long-run may be much simpler is for the landowner to lease parcels of land to various hunting clubs. Presently, this is quite common and prices of the lease may vary from 10 cents to $3.00 an acre, depending on the resident deer population and the demand for hunting. This type of arrangement has its advantages as well as its disadvantages, and in the future we may find providing certain areas for fee hunting and others for clubs to be the answer.

At the present time, we have approximately 8 percent of our lands in the South leased to private hunting clubs. Another 7 percent is in State game management areas, and only 3 percent is being utilized as public fee hunting areas.

Thus far, we have found that concessions to deer can be made in timber management practices, but it remains to be seen how far these concessions can go. Again, it's a matter of economics and control. As an example that may be of interest to you, at I-P we have a research project underway in cooperation with Auburn University and the Alabama Department of Conservation.

This project consists of clearcutting 1,000 acres of overflow bottom land with the objective of encouraging a massive hardwood regeneration program in the form of sprouts and seedlings. We anticipate this will provide an abundance of browse for an overstocked and, in some cases, starving deerherd. We believe that this study will go a long way in determining the effects of bottom land hardwood timber harvest on deer. Of course, we also hope to learn what effect the deer are going to have on hardwood reproduction.

In summary, the forest industry looks favorably on deer management. It is perhaps the most important game species on industry land and we desire to maintain a healthy herd on all sizable tracts in keeping with the primary objective of the land. For many years the majority of the forest industry has welcomed sportsmen on their lands to hunt deer and other game. This is part of the industry's basic philosophy of being a good neighbor and an accepted industrial citizen of the area. But if we are to provide *improved* facilities and *quality* deer hunting, the program must be prepared to pay its own way.

As I see it, the goals of private forest holdings in deer management cover a wide range of individual and corporate attitudes. The goals are influenced by a number of factors, ranging from personal desires . . . to public demand . . . to economics . . . to the ease of implementing the program. I do believe, however, we are on the right track and the future of deer management on private forest holdings indeed looks bright.

Prevention and Control of Damage to Trees

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The prevention and control of deer damage to cottonwood trees in the Delta area of Mississippi was tried through the use of the following: firecracker fences, odor and taste repellents, buffer zones, and physical barriers. The most promising of these techniques tested was a debris barrier constructed by windrowing tree debris around the area planted to cottonwood.

A great deal of work concerning the control of damage by deer to trees has been carried on in recent years in both the United States and Europe. Both chemical and mechanical means have been utilized in attempts to control deer damage. Some of the chemical repellents with certain European workers have tested and reported effective are:

1. Vaseline, oil (paraffin), and either pyridone or cresol in bentonite,
2. Anthropin (odor repellent),
3. Bone tar oil,
4. Sticky paint which repels by its texture,
5. Cow dung and lime.

Several of these repellents were tested by other workers, most of them in the United States, and were found in these instances to be ineffective.

The studies reported in this paper are concerned with the protection of cottonwood *(Populus deltoides)* plantations in the Mississippi Delta area from deer damage. Cottonwood, within the past few years, has become a very important pulpwood species and is now being grown by most of the larger paper and timber companies with lands located in the Mississippi Delta region.

Some of the greatest concentrations of white-tail deer *(Odocoileus virginianus)* in Mississippi live in the forest bordering the Mississippi River. During the early spring months, when the nutritious and palatable cottonwood cuttings begin to leaf out, deer browse extensively on the new cottonwood plantings. The terminal shoots are especially vulnerable, and very frequently the young cottonwood is deformed or killed by excessive browsing.

In 1964, cooperative research was initiated with the USDA Forest Service, Southern Hardwoods Laboratory at the Southern Forest Experiment Station, Stoneville, Mississippi, and the Department of Wildlife Management at Mississippi State University.

The techniques which were tried or investigated were firecracker fences, taste and odor chemical repellents, buffer zones, and barrier devices. The results and evaluation of this investigation are as follows:

FIRECRACKER FENCES

A firecracker fence, which followed the design of a fence used in Maryland by Flyger and Thoerig (1961), was experimented with in 1964 on the Crown Zellerbach lands near Rolling Fork, Mississippi. The fence was constructed with wooden stakes 4 feet long, 2 inches wide, and 1 inch thick. These stakes were driven into the ground to a depth of about 1 foot and spaced at intervals of 20 feet. Wire staples were driven into the stakes approximately 6 inches from the top. One M-80 firecracker was attached to each stake, on which was taped a detonator firecracker. A nylon string was strung from each firecracker and made just tight enough so that when a deer walked into the string, the firecracker would explode. The firecrackers were waterproofed with household paraffin. The total cost of construction of 1 mile of fence was $87.83.

However, this fence proved unsuccessful due to several factors. First, it was difficult to waterproof the firecrackers. Second, even though the firecrackers were waterproofed, the strings of the boobytrap type detonators were found unreliable. In three out of five cases in laboratory tests, the strings broke before enough pressure could be applied to detonate the main firecracker. Even if a reliable firecracker could have been made, the single strand fence would not have been effective for an extended period of time. Observations made on a 12-acre field surrounded by the firecracker fence revealed that deer continued to enter the field by either leaping the fence or sliding under it. In order to prevent deer from sliding under or leaping over the fence, a more elaborate modified version of the fence was constructed around a 1 acre portion of cottonwood plantation. This fence was made from the same type of material as the first one. However, this fence was constructed by driving two rows of stakes, each stake spaced 20 feet apart, with the second row of stakes spaced 10 feet behind the first row of stakes. Two strings of firecrackers were attached to the front row of stakes nearest the plot, one string at the top of the stake, and the other string at the bottom of the stake. The back row of stakes (those farthest from the plot) had only one string of firecrackers at the top. Firecrackers were also strung between the rows in a zigzag fashion from each stake. This structure was observed to be successful in repelling three deer. However, this success might have been due to the formidable aspect of the structure, and not the firecrackers, since it was observed that the deer stopped short of the fence and did not attempt to enter the enclosed area. This structure was abandoned due to its impracticality.

CHEMICAL REPELLENTS

Seven different taste repellents and one odor repellent were field tested on cottonwood cuttings in a small block design. The repellents tested were:

Pennsalt thiram S-42
Pennsalt thiram 75

[1] Mr. Hodil is now on the staff of the Maryland Game and Inland Fish Commission.

Pennsalt thiram 80
Pennsalt thiram Animal Repellent
Pennsalt OMPA Systemic Repellent
Du Pont Arasan 42-S
Morton Chemical Company ZIP
Bone tar oil odor repellent (Magic Circle)

These repellents were applied so that nine treatments were arranged in two latin square designs. Each chemical appeared once in each row and once in each column in order to allow for nonrandom movement of deer. The method of application was by compression sprayer, except for the systemic repellent, which was applied by soil injector.

Of the eight repellents tested in this experiment, two showed promise as a possible effective deer browse deterrent. Those were the systemic repellent (OMPA) and the odor repellent (Magic Circle bone tar oil). On the basis of the percentage of plants browsed and unbrowsed, there was a significant difference between the percentage of plants browsed on the untreated plots and the plants browsed on the treated plots. However, there was no significant difference between repellents.

The taste repellents were found to be ineffective in controlling deer damage due to the rapid growth of the cottonwood seedlings, which will grow from 6 to 10 feet in a single growing season.

On the basis of the results obtained from the small plot study, the bone tar odor repellent and the OMPA systemic repellent were selected for further testing in large field blocks.

Systemic Repellent

In 1965, Dennis Jordan, a graduate student in wildlife management at Mississippi State University, completed further experimentation with odor and systemic repellents. The deer repellents were applied to six experimental plots located in a cottonwood plantation which had been planted the previous winter. On plot 1, the systemic repellent OMPA was applied to approximately 2½ acres of cottonwood cuttings. A soil injector was used to apply 2 ml. of repellent to each cutting. The injection into the ground was made approximately 2 inches from each cutting. Only one treatment was made, and it was applied in early March, 1965, when the cuttings first began to leaf out. Total cost per acre for this treatment was $14.15. Deer browse damage was reduced 20.7 percent.

On plot 2, approximately 2½ acres of cottonwood cuttings were treated with two applications of OMPA made at 1 month intervals. The method, time of application, and amount of injection were the same as in plot 1. The second application was made in early April. The cost per acre was $27.20. Deer damage was reduced by 27.0 percent.

Odor Repellents

On plot 3, the bone tar oil odor repellent was applied on the ground around the periphery of approximately 5 acres of cottonwood cuttings. Two applications were made monthly for a total of four applications, commencing in early March, 1964. A 4:1 mixture in water was applied to the ground with a garden type pressure sprayer. Total cost per acre was $12.16. Deer damag with this treatment was reduced 13.8 percent.

On plot 4, strips of burlap were soaked in bone ta oil odor repellent and attached to stakes spaced 12 fee apart surrounding approximately 5 acres of cottonwoo cuttings. The burlap was treated twice at 1 month intervals. A 4:1 dilution with water was used and treatmen commenced in early March. The total cost per acre wa $4.15. Deer damage was reduced 24.4 percent.

In 1967, the same technique was used, but treate stakes were scattered throughout the field as well a on the periphery. This study revealed no significant difference between the treated and untreated plots.

On plot 5, a ¼ inch cotton rope was soaked in bon tar oil odor repellent and attached to stakes surroundin the periphery of approximately 5 acres of cottonwoo cuttings. At intervals of 15 feet, soaked burlap strip were attached to the rope. The burlap strips were treate twice at a 1-month interval, commencing in early March A 4:1 dilution with water was used. The total cost pe acre was $15.92. Deer damage was reduced 40.9 percent

In another experiment conducted in the same are during 1967, a two strand fence of heavy twine was constructed around the perimeter of a 4-acre field of cottonwood seedlings. The two strands were placed 18 and 48 inches above the ground. Burlap rags soaked in odo repellent were tied at 3-yard intervals along the fence The rags were treated a total of 3 times at monthly intervals beginning in mid-March. Total cost of fence rags, repellents, and labor was $12.50 per acre. Browse damage reduction ranged from 12 to 53 percent during the 4-month testing period (table 1). One big advantage to this type of fencing is that trees and bushes around the edge of the field can serve as fence posts. Cost of the fence could be reduced by using less expensive rags and by diluting the repellent to half strength.

Table 1.—*A comparison of deer damage to cottonwood cuttings in a rope fence plot treated with odor repeller and a control area*

Treatment date	Examination date	Trees damaged by deer	
		Rope fence plot	Control plo
		Percent	*Percent*
March 10, 1966	March 24, 1966	11	51
March 15, 1967	April 1, 1967	11	44
April 1, 1967	April 23, 1967	40	52
April 23, 1967	June 17, 1967	33	86

On plot 6 bone tar oil odor repellent was placed in a small circle around each cottonwood seedling on an area of approximately 5 acres. The pressure sprayer was used to apply the 4:1 dilution twice at 1-month intervals, commencing in early March. Total cost per acre was $3.92. Deer damage was reduced 20.4 percent.

Approximately 5 acres of cottonwood cuttings were used as a check plot so that the intensity of deer browse on the treated areas could be compared to a norm.

A second type of odor repellent tested in 1967 was animal tankage. Tankage is a residue of animal tissue (50 percent protein, 5 percent fat, and 8 percent crude fiber and unknown material) and is used in some parts of the country as a feed supplement for hogs. Tankage was placed in small bags on posts spaced approximately 15 feet apart. Approximately 4 acres of cottonwood were encircled by posts containing bags of animal tankage.

Deer damage was noted in 34 percent of the cottonwood trees within the treated plot, and 44 percent of the trees in the control plot were damaged by deer. This small reduction in deer damage did not justify the expense involved in this technique.

From these experiments it was concluded that bone tar oil odor repellent applied to rope fence device was effective and more economical in reducing deer damage than OMPA or animal tankage. OMPA was costly for the results obtained, and was also discouraging because of its extreme toxicity.

AERIAL APPLICATION OF REPELLENTS

In the spring of 1966 a new technique was tested. Because of the apparent effectiveness of bone tar oil odor repellent as a deer browse deterrent, it was decided that further tests with this chemical were warranted. However, due to the rising costs of labor and the difficulties involved in hand treatment of large cottonwood plantations, it was thought that airplane spraying of the repellent might offer a more efficient and economical means of application. A 27-acre field of cottonwood seedlings located on Diamond Point Island near Vicksburg was selected for the experiment. Thirteen acres were treated by agricultural spray plane, and the remaining portion of the field was reserved as a control. Applications were made from an altitude of 100 feet. One part bone tar oil odor repellent was mixed with seven parts of water by volume and applied at the rate of 8 quarts mixture per acre. The repellent was first applied in late February, before the young cottonwoods began to leaf out. Four more applications followed at varying intervals, depending on the degree of browse damage. The dates of application were: February 26, March 19, April 9, May 16, and May 29, 1966. The total cost of repellent and aerial application was $2.40 per acre per application. This method of treatment resulted in an average browse reduction of 11 percent for each 3-week interval during the testing period. Survival of the seedlings on the treated plot was 20 percent greater than on the control plot.

BUFFER ZONES

Linder *et al.* in Germany (1956) believe that browsing and bark peeling by red and roe deer are largely due to their physiological need for trace minerals and nutrients which they are unable to obtain from the native foods growing in the acid forest soils which are low in potash and phosphorus. These men have tried winter feeding with hay and fodder fortified with trace minerals. They claim that peeling and browsing damage was reduced within tolerable limits in an area with 8.5 deer per 100 hectares.

The browsing of the terminal shoot of forest crop trees was reported by Hauer (1953) in Hungary as a sign of green fodder shortage. He suggested the raising of frost-hardy greens on game pastures as one possible solution to reduce damage. Chemical analysis of the leaves from cottonwoods browsed extensively by deer and those leaves from cottonwoods showing relatively little browsing damage was made, along with analysis of soil samples taken from around the browsed and unbrowsed cottonwoods. The results showed no difference in the chemical analysis of the soil between the browsed and unbrowsed plants. No significant differences were found in the chemical analysis of the leaves, with the exception of mineral content. The mineral content was higher in the leaves of the browsed plants than in those of the unbrowsed plants during both years that these analyses were made.

In the spring of 1967, a field test was devised to determine if deer damage to cottonwood plantations could be reduced by aerial application of odor repellent when supplemented by fertilized feeding areas. A large cottonwood plantation near Fitler, Mississippi, was the location for this experiment. Four 10-acre fields, located ¾ mile apart, were treated by spray plane with odor repellent from a height of 20 feet. Four adjacent 10-acre fields served as control plots. A total of three treatments were made at approximately monthly intervals beginning in mid-April. Two parts by volume of bone tar oil odor repellent were mixed with six parts water. This mixture was applied at the rate of 2 gallons per acre. Two 1-acre fertilized buffer zones planted to winter wheat and clover were established approximately 150 yards from two of the treated fields. One-acre buffer zones of fertilized native vegetation were established approximately 150 yards from the two remaining treated fields.

The two buffer zones of native vegetations, which consisted largely of blackberry (*Rubus* spp.), Ladies-eardrops (*Brunnichia cirrhosa*), trumpet creeper (*Campsis radicans*), and greenbrier (*Smilax* sp.), were fertilized with 1,000 pounds of basic slag, 200 pounds of nitrate of soda, and 200 pounds of ammonia nitrate, along with ES Min El trace mineral group (per acre basis).

One hundred seedlings on each of the treated and control plots were tagged for deer browse evaluation. In addition, 25 trees on each of the four aerially treated plots were tagged and received four hand sprayer applied treatments of bone tar oil odor repellent at 3-week intervals.

A check area consisting of 130 cottonwood trees, located ½ mile distant from any buffer zone or treated area, was examined periodically for deer damage.

Periodic examination of the planted buffer zones showed that deer utilization of these two wheat and clover plots was heavy during late winter and early spring. The two buffer zones of fertilized native vegetation were used by deer as soon as the plants began to leaf out in early spring. Heavy deer utilization of these two plots continued into the spring months.

Deer damage to the cottonwood seedlings involved in the experiment was evaluated on April 1, 1967. This evaluation was conducted before any repellent was applied. It was found that deer damage to seedlings planted in fields located near buffer zones was only 2 percent less than to those located ½ mile distant from any buffer zone. This small reduction in deer damage to the young cottonwoods did not justify the expense involved in establishing these supplemental feeding areas.

Evaluation of deer damage on the treated and control areas at 3-week intervals through the spring and early summer months showed that deer damage was reduced an average of 18 percent on the four aerially treated plots.

Hand treatment with odor repellent of 125 selected trees on the aerially treated plots afforded no additional protection against browsing deer. Height measurements on a total of 800 cottonwood seedlings located on the treated and control plots showed that there was no appreciable difference in height growth. These measurements were made near the end of the first growing season.

In general, the results of this experiment indicate that 1-acre supplemental food plots are of little value in reducing deer damage on cottonwood plantations. When the food plots were tested in combination with the aerially applied odor repellent, an average browse reduction of 18 percent occurred for each 3-week period during the spring and early summer months. Total cost for treating 1-acre of cottonwood seedlings with an aerial application of Magic Circle odor repellent was $4.05 per application ($2.80 for repellent and $1.25 for spray plane application).

PHYSICAL BARRIERS

Wire Guards

Wire exclosures constructed around individual trees were also tested as a possible technique for protecting cottonwood seedlings from browsing deer. Five foot tall wire exclosures were constructed from 2-inch mesh chicken wire. These exclosures were cylinder shaped with diameters varying from 12 to 18 inches. The wire exclosures were placed around individual trees and staked to the ground. This control technique was 100 percent effective, but the high cost ($80.00 per acre) makes it impractical for use on large cottonwood plantations.

Fence

One of the most effective types of control tested was a temporary fence. The fence was constructed of wooden stakes, 2-inch mesh chicken wire, binder twine, staples, nails, and bone tar oil. Stakes 6 feet long, 1 inch wide, and 1 inch thick were driven into the ground to a depth of about 1 foot at 10-foot intervals around a 4-acre cottonwood plantation. Five foot tall 2-inch mesh chicken wire was stretched by hand as tightly as possible and stapled to each post with a high compression staple gun. Alternate 6-foot stakes were braced on opposite sides with binder twine, and 1½-foot stakes driven 12 inches into the ground. A 2-foot long, 1-inch wide, and 1-inch thick stake was nailed to the top of each 6-foot post. These stakes pointed toward the outside of the fence and upward at a 45° angle. These stakes served as an outrigger type device and supported three strands of binder twine spaced 6 inches apart. Four feet from the fence on the side away from the field, 5-foot stakes were driven 6 inches into the ground at 50-foot intervals. Binder twine soaked in bone tar oil repellent was stretched tight and stapled to the top of each of the 5-foot stakes. The total cost of materials and construction of this fence was 6 cents per foot. Two man-hours of labor was required for maintenance of the 1,800-foot fence during the 4 month testing period. Data based on a sample of 1,000 trees showed that 6 percent of the cottonwoods inside the fenced plot were damaged by deer, while 70 percent of the cottonwood seedlings on an adjacent control plot were damaged by browsing deer. The chief advantages in this type of fencing appear to be its comparatively low cost and high degree of protection. Much of the material, such as the chicken wire, can be used for several years. This would greatly reduce costs over a period of several years.

Debris Barriers

J. S. McKnight of the Southern Forest Experiment Station at Stoneville, Mississippi, L. C. White of Chicago Mill & Lumber Company, and W. W. Dannenburg of the U. S. Gypsum Company, experimented with a barrier constructed of the accumulated debris resulting from clearing operations in the area. The debris was pushed into windrows, completely encircled the area with the exception of an opening large enough to permit the entrance of tractors and cultivating equipment. The windrows were at least 20 feet wide at the base, and 10 feet high. The entrance to the field was covered with a hanging screen of burlap. The areas protected by barrier fences, which were constructed with felled timber and treetops piled flush with the ground, were not penetrated by deer. Some deer were able to enter where a great deal of earth was mounded up with the felled timber debris. The technique where the debris was piled flush with the ground shows excellent promise, and additional field studies are needed with this barrier type fence.

OTHER TECHNIQUES

Foresters for the R. F. Learned & Sons Company of Natchez, Mississippi, utilized cottonwood switches grown in a nursery for 1 year for planting stock. These cottonwood switches averaged 12 feet in height and were at least ¾ inch in diameter. A tractor with a posthole digger was used to dig holes about 12 inches in diameter and 4 feet deep. A posthole digger can dig about 500 holes per day. The cost involved in digging the holes and planting averaged $51.53 per acre. This technique was very effective in reducing deer damage, but the cost is excessive.

SUMMARY AND CONCLUSIONS

The results of field testing a number of repellents and devices for controlling deer damage to cottonwood plantations in the Mississippi Delta area revealed the following:

(1) Firecrackers were difficult to waterproof and were not dependable. (2) Taste repellents proved economically ineffective due largely to the rapid growth of the cottonwood. (3) Bone tar oil odor repellent applied on burlap strips, which were hung from a rope fence, proved to be the most effective method of the chemical repellents. (4) Bone tar oil applied by airplane was ineffective. (5) The establishment of buffer zones of highly fertilized native vegetation, as well as clover plots, proved ineffective in controlling deer damage. (6) The most economically effective technique tested was the temporary type fence. (7) The windrowing of debris appears to have significantly reduced deer damage in the Delta area.

The variance of the results obtained with the same technique from 1 year to another year, or from one area to another area, very probably was the result of differences in deer population. Some years does would be harvested, and a significant reduction in the deer population would result. It is the belief of the writers that no chemical repellent will provide effective protection from deer damage to such palatable species as cottonwood when the deer population exceeds the carrying capacity of the range. As of this date, the windrow technique and the temporary fence appear to be the most economically effective technique to control deer damage to cottonwoods in the Delta area.

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Measuring Habitat Productivity

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This paper describes possible approaches to estimating habitat productivity in the South based on qualitative and quantitative measurements. Methods are suggested for determining quality of forages using modifications of current forage evaluation techniques for estimating nutritive value. Also discussed are methods and difficulties of measuring forage yields where all facets of the understory habitat are considered potential deer food.

Numerous methods have been devised to evaluate white-tailed deer habitat, but no particular technique appears adequate to estimate habitat productivity in the South. Highly diverse habitats, ranging from the Coastal Plain to the southern Appalachians, exhibit vastly different levels of productivity, depending on such factors as weather, soils, and plant species combinations. And there is only a limited understanding of nutritional requirements and food preferences of deer in the various physiographic regions. Also, the highly variable form, distribution, and seasonal availability of food items within habitats present complex sampling problems.

Objectives in measuring habitat include relating quality and quantity of forage to the productivity of a habitat. Measurements of forage quantity and quality are necessary prerequisites to determination of habitat productivity.

This paper describes habitat analysis techniques (both qualitative and quantitative) used in the past and suggests some realistic approaches that may be used in the future.

QUALITATIVE MEASUREMENTS

Evaluation of Forage Quality

The limiting factor affecting nutritive value of forages is normally the content of the digestible or apparently available energy. Forage consumed by animals can meet their growth requirements only if forage quality provides the necessary nutrients in adequate amounts; therefore, a knowledge of forage quality is desirable. Factors determining nutritive value of forages usually include energy, protein, phosphorus, and Vitamin A. Animal requirements for these and other nutrients may change when meeting the demands for growth, fattening, breeding, or general maintenance.

A knowledge of the nutritional requirements of deer is basic to evaluating forage quality in terms of meeting the animal's daily requirements. Information on the daily nutritional requirements of deer is limited (French *et al.* 1955; McEwen *et al.* 1957; Murphy and Coates 1966; Silver 1968; Wetzel 1968; Cowan, personal communication.[1]

[1] Dr. R. L. Cowan, Prof. Animal Nutrition, Penn. State Univ., University Park, Penn. 1969.

Following is a discussion of several techniques fc evaluating forage quality:

Animal production.—Animal growth and reproductio permit an estimate of the gross nutritive quality c natural forages. However, as pointed out by Reid (1962 animal production provides only a subjective measur of forage quality. But in conjunction with forage prc duction and utilization measurements it has been suc cessfully used by researchers working with domesti range stock (Frischknecht and Harris 1968) and wit deer (Gill 1956; Adams 1960).

Chemical composition.—A method of forage evaluatio which has received considerable attention is the deteı mination of chemical (nutrient) constituents of forag and their relation to nutritive value. The traditionа laboratory technique for determining the chemical cor stituents of forages is the Weende system of proximat analysis, described by Maynard and Loosli (1962). Tw of the fractions obtained by this procedure, nitroger free-extract (NFE) and crude fiber (CF), are subjec to considerable error. Although the NFE is relativel digestible, it contains highly undigestible component like lignin. The CF is considered to be relatively undi gestible; however, it includes cellulose which rume microbes digest readily.

Forages often vary widely in their chemical compc sition (Hagen 1953; Harlow and Jones 1965; Wilson 1969 These variations, which occur even between plants o the same species (Short *et al.* 1966), result from man factors, including season, growth-stage, soil type, physi ographic and climatic differences, soil moisture, and lan management practices (Lay 1957).

In South Carolina, areas which had the highest value for crude protein and phosphorus in certain brows plants also had the highest values for average bod weight of deer (Thorsland 1967). Conversely, two area which had the lowest values for these two plant nutrient had lower average body weights for deer.

Using data obtained from digestion trials with domes tic animals, Schneider *et al.* (1952) developed regressio equations for estimating total digestible nutrients o digestibility of any specific nutrient from chemical cor position of forages. Baumgardt *et al.* (1962) mentione that the correlations associated with those regression have not been satisfactory because the wide variation in amounts and proportions of several nutrients in foı ages affect their digestibility and in turn their nutritiv value. Other studies (Hart *et al.* 1932; Hellmers 194(Swift 1948; Weir and Torell 1959; Short *et al.* 1966) ir dicate that considerable variation in chemical compos tion occurs between plant species growing on the sam range. Some of these investigators have suggested thа deer select the most nutritious forages; there appeaı to be ample evidence supporting this hypothesis. Thus, it seems doubtful whether an investigator could select range forage having approximately the same nutritive composition as that which a deer might select.

Edlefsen *et al.* (1960) compared the nutrient composition of hand-plucked range plants to that of similar plants obtained from esophageal fistulae on sheep. Although significant differences were found between samples, the relative magnitude was not great.

It might be possible to select manually range forages which closely resemble, in chemical composition, those eaten by deer. By following a tame deer fitted with a harness and leash, one could observe its feeding habits and select similar forages from the same location. Healy (1967) conducted a forage preference study using deer on leashes; however, forages were not chemically analyzed. Van Dyne (1968) made such a comparison in developing a technique for predicting relative chemical composition of dietary botanical components obtained from esophageal fistulae of grazing livestock. Validity of the predicted values was tested by comparing them to values obtained for hand-clipped samples from the same range. The predicted chemical composition of grazed plants was found to be reasonably close to that of hand-clipped plants. This approach, using nonlinear programming and matrix methods of analysis, also provides a reasonable estimate of the digestibility of cellulose. It offers a means whereby a great amount of information on botanical and chemical composition of the diet can be obtained with a reasonable degree of accuracy in a relatively short time.

A promising technique was developed by Van Soest (1963) and Van Soest and Wine (1967) to simplify feed evaluations. The rationale for the method is that cell contents of plants are digested almost completely (98 percent) by ruminants but plant cell walls are only slightly digested. This method involves treating (digesting) a feed sample with neutral detergents and yields two fractions—the cell contents composed of readily digestible compounds, and the cell-wall components consisting of fiber insoluble in neutral detergent, called neutral detergent fiber (NDF). However, a portion of the cell-wall constituents, represented by the hemicelluloses and fiber-bound protein, is soluble in acid detergent; the remaining insoluble residue is called acid detergent fiber (ADF). The ADF is composed primarily of lignin and cellulose (lignocellulose). A value for total digestibility of forage based on the Van Soest technique probably provides a better estimate of true forage quality than the proximate analysis value. Shore and Harrell (1969) compared the standard proximate analysis and the detergent solution analysis of two southern browse species. Significant differences between the methods were evident, as indicated by the different values obtained for various components in current twigs and old twigs.

Another new technique of chemical evaluation of forages was developed by Gaillard (1968) and is based on composition of cell-wall constituents of plants. Laboratory digestibility of roughage samples was compared to known *in vivo* digestibility of the roughages. He concluded that lignin and uronic acid concentrations from cell walls influenced the digestibility of organic matter more than concentrations of cellulose or hemicellulose in the cell walls. A regression equation to predict the digestibility of organic matter was developed using lignin, neutral detergent residue, and uronic acid as independent variables.

In vitro digestibility of forage.—The energy value of a forage has been shown to be closely related to the digestibility of its dry matter or organic matter (Baumgardt *et al.* 1962). In addition, Baumgardt *et al.* (1962) mentioned that although the digestible dry matter (highly correlated with digestible energy) is normally the limiting nutritive factor, it is also important to know the digestibility of the forage protein. Fortunately, these researchers have shown that forage crude protein is highly correlated with digestible crude protein. For routine analyses the prediction of digestibility of forage dry matter, using laboratory techniques, is a valuable and time-saving procedure for evaluating forage quality.

Johnson and Dehority (1968) compared several chemical and *in vitro* techniques used to predict digestibility and intake of forages. The *in vitro* and chemical data were compared to *in vivo* dry matter and energy digestibility, relative intake, and nutritive value index (Crampton *et al.* 1960). These workers found that the two-stage digestion procedure of Tilley and Terry (1963) was the best method for estimating dry matter digestibility (DMD), which agrees with comparisons conducted by Oh *et al.* (1966). Van Soest *et al.* (1966) suggested that the two-stage method could be improved by replacing the second stage (acid pepsin digestion) with a determination for cell-wall constituents using the neutral detergent procedure, which shortens the unmodified two-stage method by nearly 2 days.

Grimes (1968) was the first to compare the relative digestive capabilities of rumen-fistulated deer and sheep and an *in vivo* nylon bag microdigestion technique developed by Lusk *et al.* (1962). He concluded that sheep could be used for determining quality of forages utilized by deer. Cowan *et al.* (1969) discussed the applicability of the techniques used by Grimes.

Rumen analyses.—Short (1963) compared VFA production in white-tailed deer and a fistulated steer. He found that mean concentrations of VFA in rumen liquor samples were similar for deer and cattle when both were fed a concentrate ration. When both were fed aspen and white cedar, deer maintained a higher level of VFA production. Ullrey *et al.* (1964, 1967, 1968) found VFA production in deer fed white cedar exceeded that for deer fed aspen, jack pine, and balsam fir.

Rumen contents collected during the summer from Sitka deer were analyzed by Klein (1962) to provide an index to the nutritive quality of forage on two Alaskan islands. Positive correlations were indicated between percentage nitrogen and percentage volume of microorganisms ($r = +0.67$) and percentage nitrogen and light transmittancy of the clear fraction ($r = +0.75$). Comparisons of rumen samples from the two islands revealed that differences were significant for most chemical analyses. Klein's study also suggested that fiber content of fecal samples might be used as an indicator of forage quality.

Kirkpatrick *et al.* (1969) studied seasonal changes in proximate composition of rumen as related to forages consumed by white-tailed deer in the southeast. They found that mean crude protein levels of rumen contents varied from 26 percent in spring and summer to 14 percent in the fall.

Another technique which would provide a good index to forage quality measures the relationship between the nitrogen (crude protein) in forages and the extent of its conversion into rumen microbial nitrogen. Weller *et al.* (1958, 1962) studied digestion in sheep and found that the largest loss of plant nitrogen within the rumen was attributed to its conversion into microbial nitrogen. Unfortunately, the relatively long and detailed analyses required preclude use of this procedure as a routine analysis for determining forage quality.

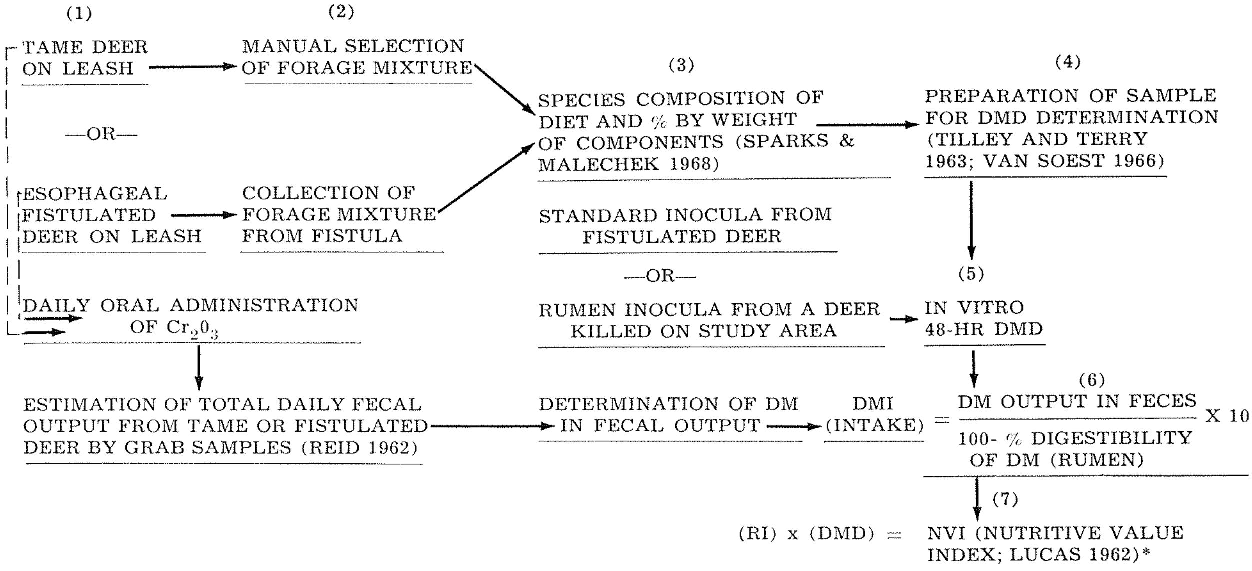
Forage intake.—Forage intake is of maximum importance when evaluating qualitative habitat productivity. Therefore, the chemical and botanical composition of the diet must be sampled carefully to prevent error in evaluations. Sampling may be done with both animals and plants.

Estimating amount of forage consumed includes the ratio technique which involves the measurement of an undigestible indicator like lignin in the forage and the feces (Cook 1956), and the fecal nitrogen index method (Lancaster 1949; Arnold and Dudzinski 1967). Merits of these methods are discussed by Van Dyne and Meyer (1964), who developed a promising new method for estimating forage intake of grazing livestock by using microdigestion techniques. Van Dyne's system can only be used, however, if adequate facilities are available for maintaining relatively large numbers of deer fitted with esophageal and rumen fistulae.

In vitro fermentation trials have shown promise f evaluating forage intake (Crampton 1957; Crampton *al.* 1960; Donefer *et al.* 1960; Barnes 1966). The hyp thesis is that the speed at which a particular forage digested in short periods (6 to 12 hours) determines ar mal intake of that forage. Confirmation of this theo for determining intake would be especially beneficial wildlife studies.

Possible approaches to determining forage quality.- Figures 1, 2, and 3 outline possible approaches to dete mining forage quality. These are only suggestions bas on modifications of current techniques, some of whic have already been discussed. Caution is needed in inte preting data; the methods should be used with reserv tion.

In the first approach, figure 1, an index to nutriti value is derived from an expression of dry matter inta and dry matter digestibility in relation to metabolic si of the animal. This approach to estimating the nutriti value of forages was developed by Crampton *et a* (1960). The nutritive value index (NVI) indicates t effective feed value of forages by combining a measu of the quantity of forage dry matter voluntarily co sumed per day and the percentage of digestible energ in the forage into its calculation. It is necessary to rela the quantity of forage consumed daily to the daily co sumption of a standard or reference forage; thus obtai ing a measure of relative intake (RI). This standa value is derived from feeding a standard forage and d termining the average dry matter consumption per un of metabolic size (body weight in kilograms raised to t



* Modification of Nutritive Value Index (Crampton *et al.* 1960), assuming a high correlation between DMD and digestible energ

Legend: DMD = Dry Matter Digestibility; DMI = Dry Matter Intake; DM = Dry Matter; RI = $\frac{\text{DMI/day (sample forage)}}{(\text{Wt}_{kg}{}^{.75})\ (\text{DMI/day of std. forage}/{}_{kg}{}^{.75})}$ 1(

Figure 1.—*Estimation of nutritive value for a mixed-forage diet of deer using percentage fecal DM and daily output of feces to predict forage intake.*

¾ power). In determining the standard or reference forage to be used for white-tailed deer which—in their natural habitats—exist on a mixed-forage diet, it would be necessary to select a forage or forage mixture which provides the quantities of nutrients for meeting nutritional requirements when fed *ad libitum*.

After obtaining a value for RI of a forage or mixture of forages, a value for its digestible energy is determined; multiplying these two values gives the NVI. Since Baumgardt *et al.* (1962) have shown that digestibility of forage dry matter is highly correlated with digestible energy, dry matter digestibility could be substituted for digestible energy in calculating the NVI. The theory, methods of calculation, and application of the NVI for forages is discussed by Crampton and Harris (1969).

As illustrated in steps 1 and 2, the botanical and chemical composition of forages collected by esophageal fistulae and by manual selection should be compared. If significant differences occur, this will necessitate using the more accurate method. An estimate of dry matter in total daily fecal output will be obtained using the chromic oxide ratio method combined with fecal grab samples.

In steps 4 and 5, a representative sample of the diet, obtained in step 3, is prepared for *in vitro* dry matter digestibility determination by grinding.

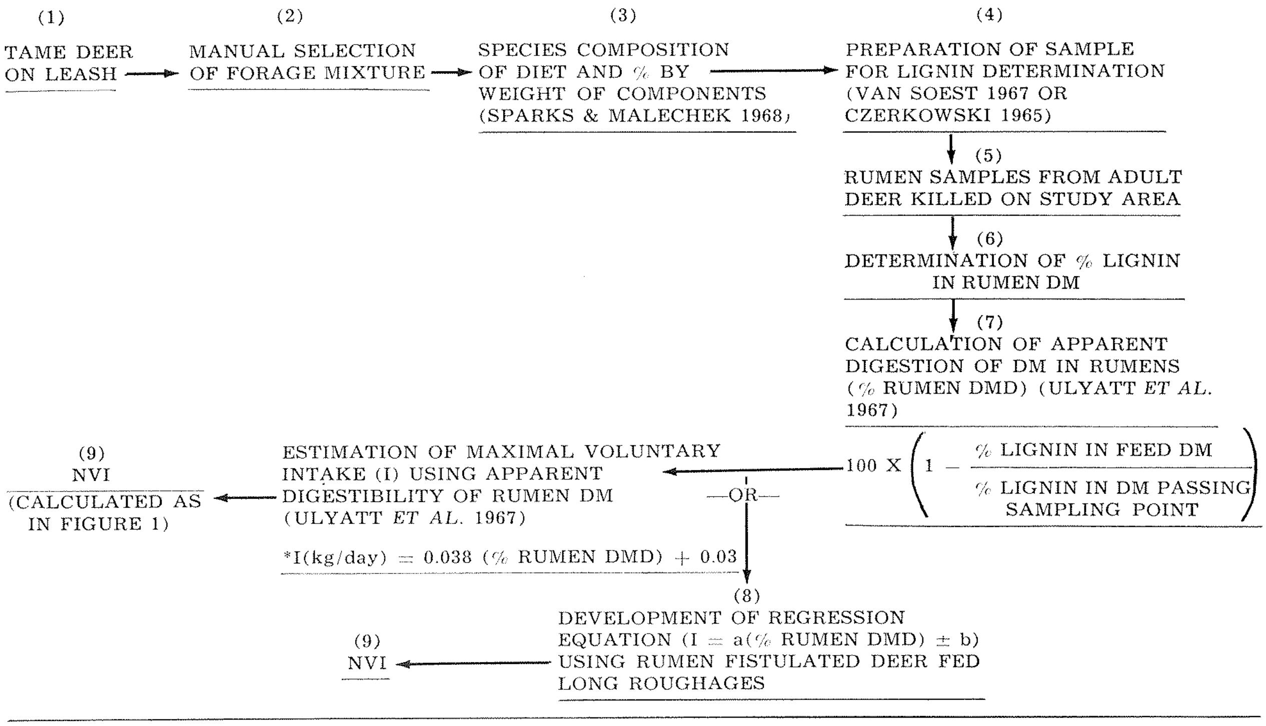
In lieu of using rumen inocula from deer killed on the study area for determining dry matter digestibility, a rumen fistulated deer calibrated to the study area could serve as the source of inoculant. This would standardize the inocula used for all *in vitro* trials and would provide a sound basis for comparing dry matter digestibility of forages collected from several areas. Another possibility for standardizing inocula for *in vitro* trials would be to use rumen fluid from a fistulated deer, or possibly a fistulated sheep, which was fed a standard ration. During each *in vitro* trial, a sample of the standard ration also should be included for microdigestion to permit adjustment (correction) of digestibility values of range forages in relation to possible changes in digestibility of the standard ration.

An estimate of daily dry matter intake can be obtained from the ratio of daily dry matter output in feces to indigestibility of rumen dry matter, as shown in step 6.

A modified nutritive value index (NVI) may be calculated by multiplying dry matter intake (relative intake) × dry matter digestibility (step 7).

This procedure might be useful in estimating nutritive value of range forages which greatly influence habitat productivity.

The method used in the second approach for estimating nutritive value of forages (figure 2) provides an estimate of dry matter intake. This method is based on apparent digestibility of rumen dry matter to calculate a nutritive value index as in the first approach. Steps 1 through 3 of figure 2 are the same as in figure 1, except that it might be possible for the investigator to



* I = Dry matter intake.
Legend: DMD = Dry Matter Digestibility; DMI = Dry Matter Intake; DM = Dry Matter.

Figure 2.—*Estimation of nutritive value for a mixed-forage diet of deer using apparent digestion of ruminal DM to predict forage intake.*

obtain forage samples manually by observing a tame deer on a leash.

Rumen samples are obtained from several adult deer on the study area and percentage lignin of the rumen dry matter is determined (steps 5 and 6). Collection time for the rumen samples must be standardized. Late in the afternoon seems to be most desirable.

In step 7, apparent digestion of rumen dry matter is determined by the ratio of percentage lignin in dry matter of the forage sample to percentage lignin in rumen dry matter.

In step 8, maximum voluntary intake may be estimated from the regression of voluntary dry matter intake on percentage rumen dry matter digestibility. This estimate may be calculated from an equation developed specifically for deer by feeding long roughages, such as hay, to rumen-fistulated deer. However, an equation developed for sheep fed long roughages may be used.

In step 9, using the estimated dry matter intake and apparent digestibility of rumen dry matter, NVI may be calculated as in figure 1.

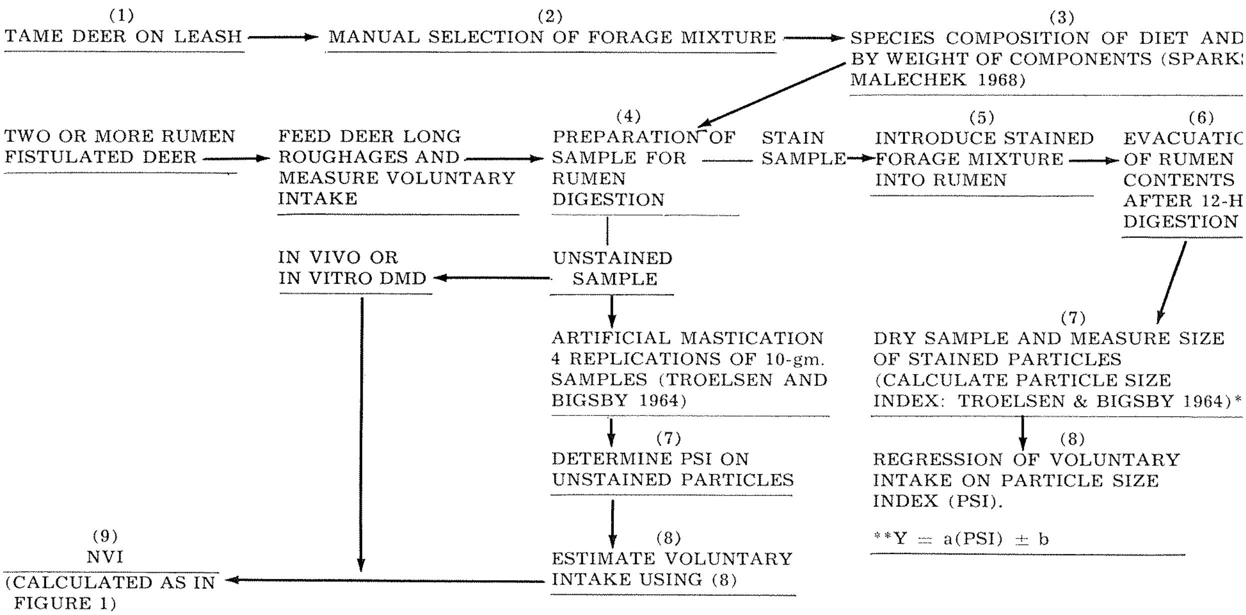
The third approach (figure 3) for estimating nutritive value of forages is based on the assumption that rate of passage of digesta from the rumen is regulated by the size of particles present and voluntary intake is related to the rate of passage. This approach employs an artificial mastication technique that reduces forage to a certain particle size. Particle size determined in this manner was found to be highly correlated to a particle size index (PSI) and voluntary dry matter intake (DMI) determined during *in vivo* digestion trials (Troelsen a Bigsby 1964). The equation for the regression of volu tary DMI on PSI, as determined *in vivo*, can be used estimate voluntary DMI from PSI obtained on forag subjected to artificial mastication. A nutritive val index can be calculated as described previously, usi estimated DMI, *in vivo* or *in vitro* DMD, and the met bolic size of experimental deer. In figure 3, steps through 3 are the same as in the first two approache

In step 4, rumen-fistulated deer are used to obtain measure of voluntary intake of long roughages. Als one portion of the forage sample obtained in step 3 stained and introduced into the rumen through the fistu for a 12-hour digestion period. This is illustrated in ste 4, 5, and 6.

The unstained portion of the forage sample is subject to artificial mastication with an apparatus developed l Troelsen and Bigsby (1964). Using another unstain forage sample, dry matter digestibility is determined l either the *in vivo* nylon bag technique or by the *in vit* method of Tilley and Terry (1963). The rumen-fist lated deer serve as a source of inoculant for *in vitro* c gestibility trials. A sample of a standard ration fed the fistulated deer should be included in each *in vit* digestibility trial to permit adjustment of digestibili values, as explained in the discussion of figure 1.

Following digestion, a sample of rumen contents obtained, dried, and a PSI computed (step 7).

In step 8, an estimate of voluntary intake may be o tained by calculating the regression of known voluntai intake on PSI.



* PSI: Mean sum of percentage stained or unstained dried samples which passed through a series of sieves, divided by 100 and the coe cient of variation.

** Y = Dry matter intake.

Legend: DMD = Dry Matter Digestibility; DMI = Dry Matter Intake; DM = Dry Matter.

Figure 3.—*Estimation of nutritive value for a mixed-forage diet of deer using an artificial mastication technique to predict forage intake.*

A PSI is determined on the portion of unstained sample, and an estimate of voluntary intake is calculated from the regression equation developed in step 8.

In step 9, NVI is calculated (as in figure 1) using the value for estimated voluntary intake and dry matter digestibility.

Any one of these three approaches may help to determine what percentage of the total available forage in a habitat can be considered as usable and useful.

QUANTITATIVE MEASUREMENTS

Sampling Considerations

If forage surveys are to be useful in the South, all facets of the understory available as deer food should be measured seasonally by weight or other descriptive parameter common to all foods. More than one measurement technique may be necessary to survey all foods adequately. In the past we have used techniques developed in the North, where fewer species of plants are important in deep snow zones.

Plot size.—Guthrie (1964) found that in measuring woody browse, a 1-milacre plot was most efficient when comparing plots 1, 2, 4, 9, 25, and 29 milacres in size; yet in double sampling, the optimum was 4 milacres. Conkle (1963) reported that optimum plot size was obtained by selecting sizes that were most effective in reducing the coefficient of variation. Mesavage and Grosenbaugh (1956) found that precision of estimates of equal intensity increased as plots were made smaller and more numerous.

Whelan (1962), in determining minimum size for woody understory sampling units, found that 1/100-acre units were adequate. For sampling grasses and forbs on southern cattle ranges, Campbell and Cassady (1955) recommended a 3.1-foot-square plot because of its convenient size and ease of conversion to pounds per acre.

Plot shape.—Ursic and McClurkin (1959) found rectangular plots gave better representation of local variation in the vegetation than square or circular plots of equal size. Distribution of species largely determines which shape plot is best. Johnson and Nixon (1952) found that cruising time is less on a compact rectangular plot than on a long, narrow one. Bormann (1953) states that "Variance decreases as plots are increased in length provided the longest axes of the rectangular plots cross observed contours and vegetational or soil bandings."

Number of plots.—The number of plots needed to obtain a reliable sample from any area is not primarily a function of the size of the area, but rather of the variation from place to place within it. The number of sample plots for any degree of accuracy can be determined by statistical methods once the normal distribution around the mean has been established (Bruce and Schumacher 1935; Snedecor 1946). Mesavage and Grosenbaugh (1956), using a systematic survey, suggested that the number of sample plots should be calculated as though the plots were located at random. Grosenbaugh (1952) prepared two tables that are helpful in deciding the number of samples to take. In one table it is necessary to have an estimate of the population's coefficient of variation; the other table provides a rough estimate of the coefficient of variation for different conditions.

Horton *et al.* (1964) describes how the nomograph can be used to plan and execute the major job of vegetation surveying in one stage. The model they used is based on line intercepts to measure cover density, but it can also be used to predetermine the number of samples needed to measure yield. It is based on selecting several plots to sample the extremes of vegetative conditions occurring within a type.

The difficulty of measuring highly variable plant populations is demonstrated by Lyon (1968), who compared 19 different variations of quadrant and plotless sampling techniques in a known population density of bitter-brush. He found that "(1) Many methods would not produce a correct answer with any sample size, (2) all methods required unreasonably large samples to attain acceptable precision, (3) several methods required more effort than counting all plants on 1 to 2 acres."

Sampling Procedures

Woody plants, forbs, and grasses.—The following five steps will result in useful habitat productivity surveys:

1. Start surveys randomly.
2. Consider using different sized sample plots, such as concentric circles or transects of variable length or width.
3. Obtain an adequate sized sample.
4. Equate food items by weight.
5. Conduct seasonal surveys.

A 100-percent clipping method, described by Campbell and Cassady (1955), provides the most accurate measure of forage yield, but is sometimes impractical because of the time it consumes. The double-sampling technique (Wilm *et al.* 1944), which weighs and estimates weight of vegetation on a number of plots, as modified by application of the Dry Weight Prediction Method (Blair 1958) should avoid the undesirable features of the 100-percent clipping method. Another modification of the 100-percent clipping method is the Ranked Set Sampling Method, first described by McIntyre (1952). This procedure establishes sets of three closely-grouped quadrants which are visually ranked within sets as to highest, intermediate, or lowest in forage weight. Only one quadrant of each set is clipped and weighed.

For purposes of comparison, it is necessary to standardize terms describing what plant parts deer consume and to what height they feed. General terms, such as "browse," should be discarded and replaced by more specific terms, such as evergreen leaves, woody twigs, etc.

Fruit.—The value of acorns as food for deer has been documented by Goodrum (1959), Harlow and Tyson (1959), and Duvendeck (1962). The contribution of understory fruits other than acorns, in east Texas, has been reported by Lay (1961).

Methods of determining annual acorn mast and other fruit abundances have been described by several workers (Downs and McQuilkin 1944; Uhlig and Wilson 1952; Edwards and Evans 1955; Gysel 1957; Crawford 1958; Sharp 1958; Lay 1961; Thompson 1962).

Difficulties encountered in measuring fruit abundance and establishing its importance to deer include: (1)

fruits may be eaten by all wildlife, not just deer; (2) their distribution is neither random nor uniform; (3) fruiting is cyclic as well as species specific and differs greatly between trees of the same species; (4) fruiting success is influenced by such factors as climate, heredity, soil, and stand conditions; (5) traps are necessarily small for convenience in handling.

Burns *et al.* (1954) placed four randomly located traps per tree crown in one area and one trap per crown under trees of the same species in another area. The standard error of the mean ranged from 40 to 50 percent when sampled with four traps and 14 to 60 percent when sampled with one trap. Gysel (1956) found little difference in number of acorns between traps when more than one trap was placed under the same tree. Gysel (1956) and Thompson (1962) found no significant difference in number of acorns in traps and adjacent ground plots when counts were made weekly.

Thompson (1962) compared circular and square plots 0.0001-, 0.0040-, 0.0010-, and 0.0023-acre in size and found that none followed the conventional species-area curve. He did find that a polyethylene film cone (3.00 mil) was less influenced by wind, had better drainage, was not easily damaged by falling sticks, and had the greatest efficiency in retaining acorns.

Efficient but inexpensive and disposable oak seed traps have been described by Klawitter and Stubbs (1961) and Thompson and McGinnes (1963). Fifty-five gallon, open-top barrels make good permanent seed traps (Crawford and Leonard 1965; Segelquist and Green 1968). Bushel baskets have been used and found satisfactory by Minckler and McDermott (1960), Merz and Brakkage (1964), and Liscinsky (1966). Openings for small traps ranged from 1.5 square feet for bushel baskets to 2.6 square feet for steel drums. Downs and McQuilkin (1944) developed a wooden-wire trap with an opening of 10.89 square feet. Their design has been a popular one.

The necessity for using a large number of small traps to obtain statistical reliability was demonstrated by Thompson (1962). Based on 18 traps 0.0001 acre in size located in each of six study areas, he found that the standard error of the mean for number of acorns per mast trap indicated he would need from 53 to 1,228 traps to obtain the required sampling intensity.

The following recommendations for measuring tree fruit production are based on a review of current literature:

1. To establish fruit production potential—
   a. Determine percentage of canopy cover by forest type for entire area.
   b. Determine extent of canopy cover in mast-producing trees.
   c. Convert extent of canopy cover of mast-producing trees to square feet, and
   d. Determine the square-foot coverage of mast-producing trees by species.
2. To determine fruit production—
   a. Randomly select sampling points, and
   b. Sample a sufficient number of trees each year to obtain square-foot production of fruit for each species.

In the scrub oak and scrub palmetto areas of the Coa al Plain regions, total fruit counts per scrub can be co veniently taken at randomly-located plots. Adequa size counts are comparatively easy to obtain (Harlo and Tyson 1959).

Fallen leaves.—The importance of evergreen folia as food for deer in the South during the winter h been documented. But the possible importance of fall deciduous leaves has not, until recently, been given mu attention. Studies relating to the importance of this fo to deer have been reported by Watts (1964) and Die (1965).

The uniformity of hardwood leaf production over mo of the southern Appalachians lends itself to easy sam ling. Olson (1967) randomly placed 10 plastic garba cans (opening 1.89 square feet) on each 0.25-acre pl to sample all litter. Leaf fall probably could be measur with sufficient reliability with acorn mast traps or in forage survey.

Mushrooms.—The ephemeral nature and wide dispe sion of fleshy mushrooms make it difficult to obta reliable data on this important deer food. Prelimina data required prior to conducting an adequate surv must include: when they occur, their growth patte how long they remain available, and what affects the distribution.

In telemetric deer studies conducted at the Universi of Georgia,[2] workers demonstrated the ability of de to detect the presence of fungi obscured from hum sight. This indicates litter removal may be necessa to sample mushrooms when using any sampling metho Perennial mushrooms (fruiting bodies which displ annual growth rings) become abundant in cut-over are and are found primarily on dead wood; they may be ce sused by using regular field plots.

Sampling by photography.—Brown and Worley (196 described the use of wide-angle photography to measu crown canopy and to determine aerial coverage, slo and aspect, tree heights and distances, basal area stoc ing, identification of plant species, and to count trees.

Photography is a quick method of measuring featur difficult to ascertain by other field methods. Many a pects can be photographed on a single entry for a poi location. The worker should, however, recognize t limitations in using photography—its inability to mea ure the inconspicuous or seasonally available food iter such as fruit, mushrooms, and fallen leaves.

The influence of canopy cover on understory densi has been illustrated by Shaw and Ripley (1965), Schu ter (1967), and Young *et al.* (1967). Jameson (196 presents a mathematical equation which fits overstor understory data better than previously-used equatio

CONCLUSION

Before valid estimates of habitat productivity are po sible, it will be necessary to ascertain the quality a quantity of available food on a seasonal basis and rela these factors to the nutritional requirements of whi tailed deer.

[2] Personal communication with R. L. Marchinton, School Forest Resources, Univ. of Georgia, Athens, Ga. March 19

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Evaluating Food Use–New Methods and Techniques

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To evaluate true deer foods it is necessary to determine objectively: (1) the plants and plant parts ingested, (2) the nutrient content of ingested material, (3) the digestible portion of the ingested material, and (4) the ability of digested nutrients to meet animal requirements.

To evaluate trends in the condition of deer habitat, we must keep a running balance of the true food value of the habitat. Much of the deer's food comes from parts of plants that are present in the habitat for short periods and show little evidence of utilization. New techniques must be developed that adequately sample plant production and utilization of each plant or plant part in the mixed diet of deer.

Changes in the supply of food which support a deer herd have been evaluated by examinations of the biological characteristics of the deer and by examination of the habitat. Sampling deer and relating gross changes in animal physical condition and fecundity to food supply is an approach used by many wildlife management agencies. The wildlife literature abounds with reports on many animal measurements. Animal measurement systems are usually relatively simple and inexpensive because data are easily collected during hunting seasons. However, animal changes lag behind habitat changes. By the time habitat deterioration is reflected by apparent changes in the deerherd, it is usually too late to reverse the trend in habitat. A deteriorated habitat recovers slowly, even with complete protection (Halls and Crawford 1960). Even if animal changes were apparent prior to habitat changes, the land manager would be handicapped because he lacks detailed information needed to apply proper habitat modification measures.

Measuring the food available and food consumed in the habitat requires (1) knowledge of the plants and plant parts which make up the deer's food supply, and (2) suitable techniques to measure food availability and utilization. If habitat changes can be detected before they noticeably affect animals, management can offset impending habitat deterioration. Measuring available deer food and its utilization is more difficult and expensive than measuring the resultant changes in the deer. If we desire to manage deer rather than have them manage themselves, however, we must maintain and improve their habitat. Allowing deer to manipulate their habitat has resulted in widespread habitat deterioration.

My assignment for this conference was to report on new techniques for evaluating food use. Rather than describe new techniques, I will discuss the general methods of evaluating food use. Techniques mentioned are not necessarily new but are not as yet used to any extent by the wildlife profession.

EVALUATING DEER FOOD

Webster's New Collegiate Dictionary (2nd edition) defines food as "Nutritive material taken into an organism for growth, work, or repair and for maintaining the vital processes." Certainly the entire volume of vegetation within reach of a deer is not food, as has been recognized by biologists for years. To evaluate deer food in the environment we must measure: (1) quantities of plant parts ingested, (2) quality of the ingested material—its chemical composition and caloric value, (3) digestion of plant nutrients, and (4) ability of digested nutrients to meet animal requirements.

Once the nutritional requirements of deer are well established, food may be equated to potential animal numbers. All necessary steps for determining food have seldom been followed in past investigations. We have been weak even in objectively determining what plants or plant parts were ingested.

FOODS INGESTED

Dunkeson (1955) questioned existing methods of determining deer food ingestion when he alluded to a "woody-twig bias." He observed plant materials eaten by a semitame deer in a large enclosure in the Missouri Ozarks and found that forbs, mushrooms, and fruits were frequently consumed. Korschgen (1962) made stomach analyses of several hundred deer. His work showed the great variety of plants eaten and the minor importance of woody twigs. Harlow (1961) in Florida and Lay (1967) in Texas have reported similar results. Current studies in the southeast are showing little use of hardened woody twigs and heavy use of a variety of other plant parts.[1] There is now little basis for retaining a woody twig bias in the South. Lay in this symposium reports on foods of deer in greater detail.

Discounting unusual items, such as old inner tubes, the great variety of plant parts ingested by deer in the South can be separated into general categories:

1. Dormant woody twigs, hardened—minor importance.

2. Photosynthesizing woody twigs—green stems of dogwood, blueberry, greenbrier, sassafras, and other plants are consumed while leafless, probably when stems are photosynthetically active.

3. Succulent buds, twigs, and leaves of woody plants—eaten while actively growing, mostly in spring.

4. Evergreen leaves—a major winter food which includes leaves of woody and herbaceous plants.

5. Fruit—a major autumn and winter food when available, and also consumed in other seasons.

[1] Data on file at Southeastern Forest Experiment Station, Blacksburg, Va.

6. Grasses—particularly cool-season grasses which are eaten when actively growing during fall and spring.

7. Seasonal forbs—heavy use of many species, primarily during their period of active growth, but also after growth is completed.

8. Fungi—many species are consumed heavily when available during several seasons.

9. Dried leaves—little is known about their importance, but they are often ingested.

Several monographs and symposia have dealt with the many methods used to determine kinds and amounts of plants ingested. Brown (1954) devoted four chapters to measurements of plant utilization in open grasslands, shrub lands, and dense pastures of humid regions. A "Symposium on Forage Evaluation" was reported in 1959 in Volume 51 of the Agronomy Journal. A chapter was devoted to methods of measuring forage utilization in "Basic Problems and Techniques in Range Research" (National Academy of Sciences-National Research Council, 1962). Several symposia held by the Forest Service have dealt in part with measuring ruminant utilization of plants (USDA Forest Service 1959, 1963). *Wildlife Investigational Techniques* (Mosby 1963) contains a chapter dealing primarily with stomach content analysis. A Forest Service Range and Wildlife Habitat Evaluation Research Workshop, held in May 1968, included several papers on determining forage quality and animal consumption. (The transactions will be printed as USDA Miscellaneous Publication 1147.) Additionally, many separate papers present techniques for determining ingestion of plants by deer. Methods discussed in these works vary from a visual estimate of plants removed based on plant appearance and direct observations with binoculars of feeding animals in the wild state to more sophisticated studies of tame lead deer and animals equipped with rumen or esophageal fistulae.

The criterion of a satisfactory method for measuring food ingestion is how well it measures all categories of ingested plants or plant parts—not just their occurrence, but the amounts consumed. The major shortcomings of past techniques are that they were not quantitative, unbiased, or adequately replicated.

The use of a tame deer fitted with an esophageal fistula appears promising for obtaining sound quantitative samples. Studying tame deer without a fistula provides information on kinds of food eaten but not amounts (Wallmo and Neff, in press). Proper replication requires that an adequate number of tame, fistulated deer be available. Providing facilities, personnel, and feed to maintain a herd of captive deer will be expensive, but if we intend to get sound data we must be ready to pay for it. Unfortunately, no data exist on how many deer will be needed to sample the various habitats adequately. It may not be necessary to examine the entire sample taken through a fistula. Sparks and Malechek (1968) describe a method to determine botanical composition by weight based on 100 microscopic examinations of each sample.

Some plant species and plant parts are ingested and others are not. Plant material readily ingested or sought out by the animal is considered palatable. If we knew the basis of palatability, we could objectively evalu potential ingestion of all plants, both those present the environment and those that might be introduc Dunkeson (1955) indicated that deer selected plants smell. New work by Longhurst *et al.* (1968) indica that plant selection by deer is first determined by sm then taste; and after the plant is found acceptable, is selected by visual recognition. Efforts are being ma by Longhurst and his coworkers to isolate plant co ponents that contribute to aroma. If this can be acco plished, a new area of research will be opened..

It should be possible to develop techniques of obj tively determining palatability and use them in habi evaluation. It would then be possible to distingu plants or plant parts that would be consumed—assumi certain animal densities—and base habitat evaluati on only these plants or plant parts.

The subjective palatability ratings used in the p necessarily had to be related to certain environme and could not be considered absolute throughout t range of the deer. Plants or plant parts desirable deer in one area may not have been desirable in a simi environment nearby. For instance, flowering dogwo (*Cornus florida* L.) was eaten in the Arkansas Ozar (Halls and Crawford 1960; Crawford and Leonard 196 but not on nearby areas in Missouri (Korschgen 19 Dunkeson 1955). This was probably caused by a de irruption in Arkansas, which was serious enough eliminate more desirable deer foods from the plant co munity. Deer die-offs were noted (Alexander 1954; R. Leonard, personal correspondence) during years of acc shortage. Dogwood eaten in the Arkansas habitats pro ably would not have been consumed if more desiral foods had been available. An objective palatability rati system would have placed dogwood in its proper p spective as an alternate food, while a browse surv system would have rated it very desirable simply becau it was browsed.

Standard survey methods can rate desirable foods unimportant either because they are not abundant because utilization cannot be measured. Some who stu deer recommend a low ranking for palatable foods wh plants are not abundant because management bas on "ice cream" species dictates acceptance of fewer de However, we should objectively rank these plants palatability alone and, through research, learn to mod the environment and increase palatable species. Bas on subjective survey ratings, it is conceivable that reco mended habitat management measures could be inc rectly directed toward increasing unpalatable food the expense of palatable food.

Food Quality

Food quality in deer habitats has been determined fr an arbitrarily assigned component of vegetation, usua the current season's total growth of certain woody plar The same practice has been used in sheep and cat studies, but the assigned vegetation component w usually the season's total growth of certain grasses a forbs. Weir *et al.* (1959) compared the difference chemical content of fistula samples and clipped sampl They concluded " . . . the selective grazing practic by animals . . . makes it essential that our research evaluate the nutritive value of forages be based on methods which represent the forage actually consumed rather than forage available." Because of the great variety of plants consumed by deer, this conclusion applies even more in deer habitat evaluation.

Proper use of esophageal fistulae should accurately determine the components of ingested forage. This technique can also be used to provide samples for nutrient analysis if certain problems are recognized. Chemical composition of samples collected by esophageal fistulae are biased by contamination from saliva, and this bias changes with the animal's diet (Rice 1968). Samples are also affected by the method of handling—failing to freeze the sample soon after collection, draining samples, ovendrying, or rinsing with tap water (Bowman and Lesperance 1967; Rice, in press).

Cook (1964) corrected for saliva contamination by determining the nutrient content of saliva from each animal and then saturating a dried sample of ingested forage to determine total moisture held by the dry material. Field moisture content determined from hand-plucked samples of the forage was subtracted, and nutrient values of the vegetation were differentiated from saliva values. Fistula collections were made in bags with screen bottoms which let excess saliva drain, creating the possibility of leaching loss.

The following untested modification of Cook's procedure is suggested for further study when using fistulated deer:

1. Calibrate by allowing the animal to feed normally on the study area for a few days before sampling. This should allow a relatively constant chemical composition of the saliva and some time for the rumen population to adjust. Length of the proper adjustment period is unknown and should be studied.

2. Take a saliva sample through the fistula immediately before the animal begins to feed. Freeze the sample for subsequent chemical analysis to determine weights of various nutritional components.

3. Collect vegetation through the fistula in an air-tight, water-tight container placed within an insulating container of dry ice. Determine weight of wet sample. Keep the sample cold until it can be freeze-dried. The length of time that the sample can be collected is limited to the time of active feeding and by the size of the collection bag. Sampling should be terminated before the animal starts to ruminate because regurgitation contaminates the sample.

4. Observe the vegetation being collected through the fistula and hand-pluck vegetation similar to that eaten by the animal. Determine moisture content of the hand-plucked vegetation. (Hand-plucking may be deferred until after the samples are examined in the laboratory so the composition can be more accurately determined.)

5. Determine weight of saliva in the wet sample. It is the total weight less the sum of the dry weight of vegetation and the weight of plant moisture determined from the plucked sample.

6. Determine, by chemical analysis, proportions of various nutritional components of the sample collected in step 3. Sample dry weight multiplied by the appropriate proportion gives the weight of various nutritional components in the sample.

7. Determine the weight of nutritional components of the vegetation. It is the total weight in step 6 adjusted for the weight of similar nutrients from the saliva contaminant.

Van Dyne and Torell (1964) criticized Cook's procedure because of assumptions (1) that hand-plucked samples are similar to grazed forage, (2) that saliva composition or secretion rate does not change throughout the sampling period, and (3) that fistula samples are completely saturated with plant or salivary moisture.

Use of a water-tight container in the modified procedure ensures that samples are completely saturated. Contamination is assured, but can be quantified. Collecting the sample over a short time—perhaps 1½ hours—and immediately placing it on dry ice would limit bias resulting from chemical changes in plant tissues.

Calibrating the animal to the range and sampling over a short period should limit changes in composition of the saliva. Saliva composition changes can be checked by analyzing saliva samples taken during and following vegetation collections.

The modified technique also assumes that hand-plucked samples are similar in moisture content to grazed forage. This assumption could be checked with the isotope-dilution technique (Van Dyne and Torell 1964), wherein the animal is dosed with an isotope, and moisture contributed by animal saliva can be distinguished from plant moisture. Isotope-dilution was recommended as a means of measuring salivary contamination of fistula samples and its use should be considered. Because of restrictions on use of radioactive isotopes, this technique could serve as a check for other, more general methods of determining contamination.

Van Dyne and Heady (1965) studied variability in measuring dietary constituents from a range when sampled by esophageal fistulae in cattle and sheep. They reported that six animals would be adequate to sample most dietary constituents within 10 percent of the mean at the 95-percent confidence level. Habitat and feeding habits of deer are probably more variable than those of cattle or sheep, and more animals may be required. Maintaining control over several lead deer requires considerable manpower. Marchinton and Baker (1967) describe the use of a free-ranging tame deer carrying a radio transmitter to aid in locating the animal for observation. Radio transmitters could be placed on free-ranging fistulated animals if some means of automatic fistula closure were developed. It might then be possible for a few men to collect samples from several tame, fistulated deer.

Short (1967) discusses several precautions to take when collecting plant samples for chemical analysis. Plants may have to be collected at comparable times of the day, because chemical composition of the protoplasm will be different after a day of photosynthesis than after a night of respiration. During periods of rapid growth, chemical properties of plants will differ in a shorter time than during less active periods. Thus, sampling frequency should be related to phenological stage, the importance of which has often been overlooked in habitat evaluation. Short also stresses the importance of immediately stopping respiratory processes in the sample by quick-freezing and drying in a cold, low-pressure system.

Arguments about which nutrients are important to the animal and the validity or accuracy of methods for measuring these nutrients are beyond the scope of this paper, and in themselves would provide substance for several symposia. It is important to note that new methods are evolving in these areas. Dietz's paper (in press) is recommended for recent information on food quality.

Digestibility

Even though plants with high nutrient values are ingested, it does not follow that the total value goes to the animal. Plants or plant parts may not be equally digested. Nagy (in press) points out " . . . that we are really feeding billions of micro-organisms whose digestive activities in turn provide most of the nutritional needs of the ruminant animal." He stresses the need for an adequate understanding of the rumen micro-organisms. We should be concerned with foods that will maintain a proper rumen population, and not necessarily with all foods ingested by deer. If a plant part is heavily eaten, but poorly digested, it cannot be considered a valuable component of the diet unless it supplies an essential dietary element needed only in small quantities.

Some plants contain substances which reduce the activity of rumen organisms (Nagy *et al.* 1964; Oh *et al.* 1967, 1968). An excess of these substances reduces the number of rumen organisms, digestion is slowed, plant material accumulates in the stomach, and plant intake is reduced (Nagy, in press). An animal may die with its stomach full of undigested plant material of a single species which is digestible when eaten in a mixed diet.

Digestibility of plants from a given environment must be measured using deer which come from the same kind of environment and which have fed on a variety of plants found in that environment. For instance, Oh *et al.* (1967) found with *in vitro* trials that digestion of Douglas-fir was higher in rumen fluid from deer adapted to an area containing Douglas-fir than from deer adapted to an environment without Douglas-fir. Rumen organisms are specific for plants from specific habitats.

Digestion of plants also differs by animal species. For instance, sheep are better able to digest some plants than are deer, while deer are superior at digesting others (Longhurst *et al.* 1968; Short 1963, in press). Digestion may also be influenced by animal age, sex, activity, and health.

Several methods of determining digestibility were discussed in the recent Range and Wildlife Habitat Evaluation Research Workshop (Pearson, in press; Short, in press). Samples for digestibility trails in cattle and sheep have been collected from esophageal fistula samples (Van Dyne and Torell 1964) to ensure that digestibility is related to the plants and plant parts consumed.

I could find no published reference to the use of esophageal fistulae on deer. The difficulty of the technique and the difficulty in taming animals for fistulization have probably held back its development as a tool in wildlife management, although it has been used by range and livestock workers for years. Difficulties using the technique are probably not insurmounta and in the next few years it should become a us tool for deer management research. Captivity, handl by humans, and fistulization may alter normal feed patterns of deer. Feeding patterns of experimental a mals will have to be compared with those of wild d

Animal Response to Digested Nutrients

The response of an animal to the nutrients diges from its food is the final evaluation of a food. Ani response may be measured by several criteria—its abi to gain weight, produce offspring, grow antlers, or c binations of these or other criteria. Equating digesti nutrients with animal performance ties food ingest food quality, and food digestion to management g which select the important criteria.

Determining animal nutrient requirements is proba the most important need in deer management at t time. Nutrient requirements of game were discussed the recent Forest Service Range and Wildlife Hab Evaluation Research Workshop (Halls, in press).

EVALUATING FEEDING PRESSURE IN THE HABITA

Predicting habitat trends by studying the effect deer on vegetation depends on measuring abunda and utilization of plants or plant parts which are portant deer foods. Observing signs of browsing woody plants tells little about utilization of the t food supply, except that if signs of browsing are plent in any season except spring the supply of quality fo likely is too low. This does not solve the problem determining trends before the habitat has deteriora to a point where the trend cannot be reversed eas

Much of the deer's food comes from plants or pl parts present in the habitat for short periods and can be measured by surveys made once or twice a y Mushrooms sprout and disappear within a short peri Fruits of many species ripen and fall from spring thro late autumn. Herbaceous plants grow, mature, and appear throughout the year.

To compound the difficulty, signs of utilization are obvious—mushrooms, blades of grass, basal leaves, a small forbs often are plucked at ground level, with li sign of use. I observed several deer nuzzling thro leaf litter of an Arkansas upland hardwood stand over an hour. Using 7-power binoculars at a dista of 20 to 30 yards, I could not discern what they w eating. Immediately after they left, I looked for si of utilization. By crawling on hands and knees a searching diligently, I found signs where they pulled small blades of grass sprouting under 2 to 3 inc of litter.

Little work has been done to establish techniques t adequately sample each type of plant and plant p which occurs in a mixed diet. Measures to detect vironmental trends must be made on frequently-inv toried plots where each plant part is measured or coun Plant changes due to animal consumption must be s arated from changes due to seasonal progression. closures paired with open plots would provide this c parison. The proper number, size, and distribution plots or plot pairs needed to sample each vegetative category depends on variability in each category and the accuracy desired. Additionally, consumption must be related to plant production because the same degree of utilization considered moderate during good growth years becomes excessive during years of poor growth. Time and effort required for adequate sampling will probably be considerable. Intensive management may have to be restricted to areas which sustain heavy hunting pressure.

The degree of utilization that food plants can withstand and still maintain their position in the plant community must be determined. When plants decrease after over-utilization, the food value of the plants which replace them must be compared to food value of the original population so habitat change can be evaluated. We should strive to reach a state of knowledge that allows us to keep a running balance of the habitat's true food value. At present, this is more information than managers can use because they cannot readily improve the habitat or decrease the deer population. However, detailed habitat information will be necessary for intensive management needs of the future.

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Problems in Censusing the White-Tailed Deer

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Comparisons are made between drives, strip flushing, pellet group counts, track counts, conventional aerial photography, trap-retrap methods, kill data, and infrared line scanning. The latter equipment is now available at considerable cost but it has not been adequately tested. Although not a census technique, radio telemetry helps to refine basic census methods. Infrared and microwave radiometry may well be fertile fields for biological research.

The lot of the deer biologist has been hard and frustrating and will continue to be until more reliable and convincing censusing techniques are developed. Sportsmen continue to openly disbelieve the biologists' "population estimates" and although it may be heresy to suggest, there is often some justification for this. We shall attempt to discuss the advantages, disadvantages, and validity of eight methods that have been used with a few peeks into the future with the newer technology now becoming available. We shall attempt to show the role of deer movement and home range as a problem facet of censusing. All States with adequate protection and a buck law have developed overbrowsing ranges, die-off or stagnation problems, underharvest and in general wasteful and inefficient resource management. In general these conditions stem from inadequate and unconvincing census figures. This can be particularly acute in areas of low carrying capacity such as the southern Appalachians. One of us particularly remembers going on a sportsman "show-me" trip 20 years ago in north Georgia. The carrying capacity was undoubtedly around 15 to 20 deer per square mile and the population estimate by several methods was around 25 to 30 per square mile. The unbrowsed vegetation in the small fenced enclosures (40 by 40 feet) was impressive and could be seen, standing out, over 100 yards away in the bleak October woods. Dead *Smilax* reinforced the conviction of the field men that a doe season was long overdue. Unfortunately, the most impressive thing about the 200-mile trip through the heart of the deer country to a few of us who considered ourselves professional wildlife managers was that *no one* actually saw a deer all day long. The sportsmen representatives were reasonably understanding and the relaxed seasons were grudgingly approved. Many State conservation departments stay in "hot water" simply because they are trying to do a good job of conscientious deer management. Many of us have given up on scientific management of a deerherd until our methods catch up with our ideals. That this whole field is still in an unhealthy state is attested to by some fairly recent titles in the literature: Lewis and Safley (1967), "A comparison of some deer census methods in Tennessee," five methods discussed; Dasmann and Taber (1955), "A comparison of four deer census methods;" and Eberhardt (1960), "Estimation of vital characteristics of Michigan deerherds," in which at least three independent methods were used in estimating population levels.

Allen (1962) has pointed out that he feels that the main reason that the fishery biologist has made more progress in putting fisheries management on a scientific basis in the past 30 years is because basic censusing is easier. A farm pond researcher can drain a pond and count and weigh his fish. The deer biologist has no such easy way out as yet. Adequate harvesting of deer is often delayed until long after the carrying capacity has been exceeded. Lewis and Safley (1967), in discussing the "Peninsula deerherd" in upper Norris Lake, an area of modest carrying capacity for deer and cattle, point out that deer by the "best" census estimates must have reached the incredible population level of around 129 per square mile in 1957 before declining around 70 percent. It is obvious that deer are a valuable resource and it behooves us to devote more effort and expense to developing better census methods.

CENSUS METHODS

Drive census.—This method was widely used back in the Civilian Conservation Corps days when manpower was available for the drives and for clearing firebreaks around selected areas, often 1 square mile in reasonably level country. With experience these drives give good population estimates and may be very accurate. Sometimes in enclosures where conditions are unnatural freak counts result because the deer simply won't flush, but in the field with disciplined drivers backed by skillful horsemen, good flushing and counting can be achieved. The main disadvantage to this method, assuming that typical areas can be picked, is that the sample size is so tiny due to the labor of setting up areas and carrying out the work. The need for relatively level terrain, roads, firebreaks, and 30 to 50 people severely limits this useful but exhausting method. In rugged mountainous or dissected terrain often devoted to wildlife, since no other uses are apparent, the method is often hopeless.

Strip flushing census.—Erickson (1940) has described a one-man strip flushing count method similar to the cruising method used for grouse earlier. One simply calculates the average flushing distance, no mean feat, and the number of miles walked. Lines are run at ½-mile intervals on at least 4-square-mile samples by "stalking" at daylight and in the evening.

The advantages are that one or a few men can obtain a rough estimate of population cheaply and quickly. On

[1] Research on which many of these conclusions are based is supported by the College Experiment Station of the University of Georgia College of Agriculture Experiment Stations, McIntire-Stennis Projects, and the Georgia Forest Research Council.

the other hand, it depends on "jumping" deer and assumes that beds are randomly distributed which they are not. The method breaks down completely in the "laurel thicks" so common in the Appalachians. The method is best for relatively level open lands and has been used fairly successfully in Minnesota and Oklahoma.

Pellet group counts.—This method has been described by Bennett *et al.* (1940). It is based on the assumption that periodic accumulation of deer droppings bear a direct relationship to population density. A defecation rate of 12.7 pellet groups per deer per day is generally used. This same figure has been used previously by range managers for sheep. A line varying from 6 to 11 feet wide and 1,000 or 2,000 feet long has been used with an accumulation period of 1 month. It has been used with fair efficiency from January through March in the Appalachians. It is possible to use triangular-shaped transects and painted lines. Mathematical computations can be worked out in order that the number of pellet groups per line can be converted directly to deer per square mile.

The method is cheap and interesting. If approached right, refuge managers often enjoy making these counts and a large amount of data can be obtained quickly and easily. Unfortunately greenery developing on the forest floor and falling leaves limits the method to late winter. Dung beetles interfere particularly in the Piedmont and Coastal Plain. This census technique is almost confined to late winter and in many ways this is the wrong time to census deer, so this limits the usefulness of this method. In hot areas or heavy rainfall areas it has little value.

Track counts.—This method has been used extensively in west Florida. Grid-like roads were driven on the morning following an afternoon rain. Home ranges of the deer were determined to be about 1 square mile. Counts were compared to drive censuses. It was concluded that the number of deer crossing the roads per linear mile approximated the number of deer per square mile (Tyson 1959). Counts can be made by game rangers from vehicles, and in flat country with a stable climate, consistent data gathering is feasible. More recent work in the mountains and Piedmont by at least two game departments indicated wide variation and some groups have given up on this method.

This method has the advantages of being cheap and easy to carry out on a large scale. However in some ecological situations it appears of little value. Harlow and Downing (1968) have shown that due to variability it often takes an impractically exhaustive amount of data to be statistically valid. This is particularly true at the lower population densities.

Complete census by airplane.—This method has been used in the West and in deer "yards" and in east Africa for a variety of plains antelope. Counts are made visually or with aerial camera equipment. This method has been of no value in the southeast.

Lincoln index.—This estimate is calculated by marking trapped deer and checking their recovery on managed hunts. Lewis and Safley (1967) attempted this but hunting and trapping must be representative of the population. The amount of effort needed soon becomes impractical. Such a method works well for cotton rats where a high percent of the population can be marked but, at best, deer trapping is hard work and under m conditions simply impossible. In general, this met shows little practicability except where trapping is be done anyway as for restocking.

Kill figures.—This method requires data on the and numbers of animals killed by hunters and the str ture of the wild population. In general, many stu have shown that under heavy legal buck hunting aro 10 to 12 percent of the population will be taken. Un either sex hunting, the kill may vary depending u many factors. Lewis and Safley (1967) found that percent of the herd could be removed under heavy hu ing pressure. They concluded that this method was most practical for use on typical management areas Tennessee.

This method, if it can be called a census method easy to apply since kill and age data are often availa and requires little extra work, but it is not applica to parks or in areas of closed seasons. At best it remain a rough approximation and assumes that n hunting mortality is minimal.

Infrared line scanning.—There has been considera interest in the possibilities along these lines for over 10 years. Biologists have been intrigued by progress being made on forest fire detection using he detecting crystals. The line scanners produce ima which resemble photographs but are built up a line a time like television. Infrared film simply will photographically pick up animal body heat but the l scanners will. Progress on fire detection, which is mu simpler than deer detection, has been summarized Hirsch *et al.* (1968). Croon, *et al.* (1968) discuss t whole subject in relation to big game censusing. method was tested on the George Reserve near A Arbor at midday on January 4, 1967. They knew population of deer on this 2 square mile enclosure be about 101 animals. They also put out some deer pens. The imagery resulting from the overflight in cated 98 animals. However there was little evergre coniferous canopy and where it was present the pen deer could not be discerned. For open country or ha wood areas after leaf fall the advantages are obvic You simply overfly, observe, and count the anim. It is possible to get a large sample and, under some c ditions at least, excellent accuracy can be obtain Infrared Thermal Mapping equipment (Blythe and I rath 1968) is available from Bendix Aerospace Syste Division. It weighs only 55 pounds and can be used almost any small aircraft. It covers a range of emiss from 0.7 to 14 microns wavelength. This goes well ab that visible to the eye or to photographic film but d include the wavelengths emitted by mammals (aroun to 14 microns). The usual flights are made at 1,000 f and objects over 3 feet in diameter with one-half deg centigrade temperature differences can be detected. equipment at this time seems well adapted to detern ing river water temperature differences and for detection. Bendix put on a demonstration in Februa 1969, at Tampa which one of us attended. We have been shown imagery of cattle and deer. The equipm costs around $40,000 and perhaps more for the up range where deer detection may be best. We discus this whole subject with McCullough (personal commu cation) and he concluded that the method has all too many disadvantages at this time: (1) equipment is difficult to keep operating; (2) it is expensive; (3) it won't punch through conifers; and (4) in open or hardwood country after leaf fall it has few advantages over conventional aerial photography which is far cheaper and easily available.

From an overall standpoint this method has good potential in open lands if animals are out at night and not in the daytime, and in deciduous areas after leaf fall. It would appear to be of limited value in the southeast with its extensive conifer overstory. It will not record through clouds either.

RADIO TELEMETRY

Although radio telemetry is not used to census deer populations directly, the data obtained from this technique are often necessary to refine basic census methods sufficiently to obtain accurate population estimates. Tester and Heezen (1965), studying the responses of three radio-equipped deer in relation to a drive census, pointed out that censuses of animal populations are usually predicted upon a knowledge of the animals' behavior. They further stated that the technique of radio-tracking provides an excellent opportunity for adding to our knowledge of animal behavior and for observing the natural responses of individual animals to census methods. Many of the previously discussed census techniques necessitate knowledge of such variables as activity cycles, diel movement patterns and the influence of meteorological factors on them. Any census technique, for example, which necessitates direct observation, photography or the other forms of remote sensing presently available, requires that the animals be in a relatively open area for accurate detection. Movement pattern and activity cycle information which allows the investigator to predict the likelihood of deer being in such areas or the percentage of the populations to be exposed at a particular time becomes important. The value of circadian movement patterns for use in calibrating track count census methods is also clear inasmuch as distance traveled per unit of time is directly related to the number of tracks made. It is important that wildlife biologists be able to predict the movement and activity parameters for the "average" deer in the population under study during the unit of time tracks are being accumulated. This is influenced by a great many variables ranging from meteorological conditions to population density.

The location of deer in time and space also has important implications in estimating their number in relation to their primary substrate, i. e., ecological density. Since much of the value of census information is related to estimation of carrying capacity measured in numbers per unit area, it becomes important to know the size of the land resource base which supports the individuals comprising the population. The latter is sometimes rather complex since deer may use certain portions of their annual range only on rare occasions, but these seldom used areas may nevertheless be of considerable importance in the maintenance of the animals. An example of this is exhibited by deer in agricultural areas that travel to and feed on agricultural crops considerably out of their normal home range. It is important to know that these areas although used only for a brief period during the year may contribute substantially to the support of the deer population. Therefore, for population estimates to be meaningful, a deer biologist must have information concerning how large an area is actually being censused.

The development of transistorized radios for use on animals opened new doors for studies of movement-ecology beginning in the late 1950's. Progress, however, did not proceed at the rate which was expected or in proportion to the number of researchers which became involved. Until very recently the preponderence of technical papers on telemetry in ecological studies concerned themselves with the technique and presented relatively little new ecological information.

This we think can be attributed to several factors. First, the development of good telemetry equipment was slow due to lack of the large amounts of capital needed for basic development and technical research. A related problem was the lack of communication between scientists and technicians in the widely separated disciplines of communications engineering and ecology. It is very difficult for a single individual to have sufficient expertise in both disciplines to develop equipment for his specialized needs and to apply this equipment to ecological problems efficiently. This problem is beginning to dissolve as more technicians are becoming available with experience in meeting the special construction requirements of biotelemetry systems.

A second basic problem is that researchers tend to expect the equipment to take the physical work out of field investigations. This may be true to some extent in the case of automatic systems such as those described by Heezen and Tester (1967), and Cochran *et al.* (1965). These systems cannot be efficiently used to answer some of the questions which we are seeking answers to because of their high cost, relative immobility, and certain technical problems discussed in the above papers.

Portable equipment is now available and can be obtained at reasonable costs. To have maximum utilization of portable equipment, however, requires a great deal of physical effort. It necessitates, at least when studying species such as deer which have variable activity cycles, working throughout the night as well as the daylight hours. Relatively few people are willing to give the kind of effort required to utilize the potential that the portable systems now available have. A final problem is that researchers expect too much from the equipment in terms of dependability and performance and as a result quickly become discouraged. A "rule of thumb" which we have found useful in setting up telemetry projects is to establish a goal for equipment performance which meets the *minimum* performance criteria which can be established and still obtain some useful information.

Fortunately for those of us who wish to obtain detailed information of deer movement-ecology, whether this information is for refining census techniques or for other purposes, wildlife telemetry has "come of age." We feel that it is now possible to obtain excellent and dependable telemetry systems at reasonable costs and within reasonable lengths of time. We presently have a number of very satisfactory telemetry systems functioning on deer in the southeast and during the past several years have telemetrically analyzed the movement-ecology of more than 60 deer in various areas of Alabama, Florida, Georgia, and South Carolina (Marchinton and Jeter, 1967; Marchinton, 1968; Marshall and Whittington, 1969). These animals have been located in a wide variety of habitat types and a wide range of deer population densities. It is not the purpose of this paper to go into a detailed discussion of the movement-ecology of deer. However, it should be pointed out that there is an increasing fund of telemetrically obtained information concerning the movement-ecology of deer in a variety of habitats in the southeast and this information should be of considerable value for censusing deer in the areas where these studies have been made.

Research needs.—All of the census methods leave much to be desired. We are by no means in a hopeless situation but newer approaches would be welcome. Zimmerman (1969), in discussing forest fire detection, states, "Although microwave radiometry has the potential for operation under conditions of complete cloud cover, and infrared does not, the current state of technology dictates the choice of infrared in spite of this one major drawback." Both infrared and microwave devices are sensitive to heat where visual systems have no sensitivity. Considerable effort has gone into research to detect man-sized animals for counter insurgency efforts. Small radar units open up new possibilities on the ground. Scent detecting devices have been developed and capacitance sensors are available which can detect deer simply by their presence in a detector zone. We will need to carry out further radio telemetry studies in a variety of habitats and seasons because most census methods depend in one way or another on the basic nature of the animal movements, range, and responses.

Deer census methods have come a long way since the deer drives of the Civilian Conservation Corps days in the thirties, but it would appear that newer technologies may make more valid and accurate methods available, hopefully in the near future.

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The Use of Models in Resource Management

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The terms "models" and "systems analysis" are new in wildlife management but the basic concepts are old. A model is an idea of how something works. A systems analysis is accomplished for a complex process by breaking it down into parts or subsystems, the functioning of which can be studied separately. The functioning of the whole process may, under fortunate circumstances, be understood as the combined functioning of the parts and their interactions. Computer simulation of the system may be useful.

A possible systems analysis of the deer problem of the southeastern States is described in general features. It is suggested that a computer simulation of the entire system is probably impossible in the present state of knowledge, but that no doubt portions can be simulated well enough to expand our comprehension and ability to manage rationally.

This is a discussion of models and systems analysis with special reference to deer. It is written for those who may be uncertain as to what a model is or what a systems analysis is supposed to do.

The terms "models" and "systems analysis" have been heard increasingly of late in wildlife management. These terms have been in fairly general use for perhaps 10 years, and were in technical use well before that. My first point is that biologists have used the same ideas for a long time.

A model may be defined as "your idea of how things work." Anyone who has worked in deer management "operates from a model," as the phrase goes these days. In other words, he has put together in his mind a concept of how the many interrelated factors operate, and has directed this analysis toward logical management of the resource. If he chooses to use the modern verbiage, he has every right to refer to his intuitive appreciation of, say, deer population dynamics, as his model. To write it out as a mathematical formula does not make it any more or less of a model. It does make it easier for others to understand.

Historically, ecologists have long struggled with the quantitative aspects of complex situations and the idea that the world of nature is many-factored and highly complicated is built into their training. It is second nature for them to at least mentally abstract the important factors and to attempt to understand their meaning. Equally, they learn early that nature is variable. It has been a little difficult for biologists and statisticians to understand what all the fuss is about in engineering and business administration, from which most of the recent emphasis on model building and systems analysis have come. But it is easy to become too complacent about this. While ecologists have been trying to progress on the basis of a more or less intuitive understanding of a complex situation, workers in these other fields have made real progress in scientific method. We must study what they have done.

First, I believe there is a basic difference in the kind of objective. The newer view sees a model as a direct means to an end, which is prediction (and perhaps control). The older view, though not really contradictory, was much less specific. It held that if we come to know enough we will eventually learn to predict and control. In this view, the model is seen as part of the accumulation of knowledge, and this accumulation can easily become the main objective of research.

The different steps in building, testing and using a model may be listed as follows (Churchman *et al.* 1957; Watt 1966, 1968).

A. Description
  1. Formulating the problem
  2. Constructing a mathematical model

B. Analysis
  3. Deriving a solution from the model

C. Prediction
  4. Testing the model and the solution

D. Optimization
  5. Establishing controls over the solution
  6. Putting the solution to work: implementation

E. Data acquisition.

The steps are not always taken in sequence. A certain amount of data acquisition is required before a problem can be formulated, and obviously some data are required for testing the model. On the other hand, a successful model dictates the kind of data required in the future.

To formulate an ecological problem and describe a model requires selection of the important factors from the infinite number which operate in any biological situation. Then some specification of how these operate is required, preferably in a quantitative form. Thus simplification and abstraction is required at the start. Model description may be *deterministic,* meaning that it will always have the same outcome if it starts at the same point, or it may be *stochastic,* meaning that operation of chance is allowed for. It is quite fashionable to claim that one will first develop the deterministic model and then add the stochastic element. The latter step rarely seems to follow. Further, it appears probably that the differences involved may be relatively minor if fairly large populations are involved.

After each process and relationship has been stated in a quantitative or mathematical way, then a solution must be obtained for the whole model before we can use the model, or even test it to see if it is realistic. Since all the pieces of the whole are stated in mathematics, it would seem that a mathematical or analytic solution would be the answer. Occasionally, this may be possible, but often the assumptions required to allow a mathematical solution for the whole model are so restrictive and unrealistic that the resulting analytic solution is not trustworthy biologically. Even our intuitive understanding of ecology involves such complexities as to exceed the capabilities of mathematics.

One difficulty is that biologists are rarely even fair mathematicians. One solution to this problem may be for them to learn more and more mathematics. This is a good answer for those who can push deeper and deeper into mathematics, and do original work to solve biological problems. But this is rarely a practical solution for an applied problem.

A second method of seeking an analysis of a model is by simulation using computers. Usually this exploits the tremendous bookkeeping capability of computers which can be instructed to look at the status of a large number of factors and according to instruction to calculate the effect of each of these factors on the variable being followed, say the population and then report the resulting change in the population over a short interval. This same process repeated many times allows many factors to be included for their effect on the biological process and does not require that some known mathematical function be found which describes the whole progress of the population in time. As an oversimplified example, a computer would be ideally suited to keep account of your personal money resources, your bank account, and your household cash, adding and subtracting as you earn and spend, and capable of calling up a balance at any moment. Similarly, it is able to consider the progress of a biological process and providing it is properly instructed, to add or subtract over many time units.

There has been a tendency to feel that this capability of the computer will free biologists from the need to know advanced mathematics, and provide a simple manageable tool which can do just as well. Experts in the field tell us that this is not true. They warn that study of the operational characteristics of computers has in itself become an advanced and exacting branch of mathematics. For example, the common approach to biological processes mentioned above, that of dividing time into short units and considering what happens from one unit of time to the next, is particularly susceptible to the progression of errors. That is, an error which might be minor in one calculation is repeated with each calculation and because there are so many calculations the error may grow to important magnitude.

In spite of these cautions, the only path open for many problems seems to be through computer simulation. The test will be how useful the method may be in the long run.

After building a model we must test it against reality. One way is to vary the inputs to the model and observe whether the results conform to nature. A better way is to make a prediction based on the model and confirm this with an experiment, or by gathering information on the particular point. A good model is one which makes reliable predictions.

Population models, while only part of a resource n agement problem, are often of greatest interest to bi gists. A population model is primarily concerned \ the balance between mortality and reproduction, tal account of the factors which affect these two proce: Watt (1968) has listed four categories, according to de of complication of the model.

1. Models which explain change on the basis of relation between the number of reproducing mals and the number of offspring. This kin model requires less information than the o and may be used where there is less informat but the capabilities are limited.

2. Models which use information on the age struc of the population relating present number those of past time. More information is used the model is still limited. The population m used by Davis (1967) in his application of dyna programming to deer management, comes ur this category.

3. Models that consider many factors intrinsic to population but assume extrinsic factors to ren constant. Watt refers to these as "complic steady-state models." Intrinsic factors are, h ever, allowed to include the character of the vesting agency, the exploitation rate, and nat mortality.

4. These models are more complex and thus n flexible. Both intrinsic and extrinsic factors be included, with as many environmental fac being included as may be desired. These are steady-state models. They tend to have high mands for information, being in principle limited as to complexity.

A system, to quote Watt (1966) is "an interlocl complex of processes characterized by many recipr cause-effect pathways." A systems analysis is an atte to understand a system well enough to manipulat as a whole. A systems analysis starts with the const tion of a large and complex model to describe the sys

The rest of this paper discusses systems analysi the form of a proposal for a regional analysis of the problem of the southeastern States, say those for w administration of Federal Aid funds is carried through the Atlanta office. At present there is no p pect of initiating such a study. But in the contex this conference, a discussion of systems analysis best follow this proposal.

Accompanying growth of its deerherd, each State felt the need for added biological information and carried on investigations at varying levels, supporte State and Federal Aid funds. In some States, the am of information compiled over the years has rea major proportions. Most of the biological investigat which would seem appropriate have been carried at least once. Now is the time to consider what is re needed for management, and what opportunities exist for cooperation.

Regional aspects are important. Ecological similar occur over several States and social and economic fa are superficially similar, yet some management prob are more acute in some States than in others. A regional analysis could explore these differences.

The management of the white-tailed deer is indeed an extremely complex activity made up of many interlocking processes with multiple cause-and-effect pathways. The whole problem is too large and complicated to be mentally grasped as a whole, even though smaller parts are being handled very well on an intuitive basis. There is great need to organize the available information into an understanding of the problem as a whole. The methods of systems analysis seem to be an appropriate basis for such an organization.

The basic concept of systems analysis, old to biologists, is that a process of great complexity can be attacked by breaking it into separate component units, each of which can be studied and understood at least as to the relation between inputs and outputs, whether or not all the inner workings are completely known. To this has been added an emphasis on the quantitative, a certain systematic organization of the problem, and the conviction that any complex process can be computer-simulated if useful approximations can be set up for the functional relationships. Further, for management processes there is emphasis upon a clear definition of the desired outcome (or "output of the system"), a point of obvious relevance to management of natural resources. Application of this method may be discussed under the four elements of Description, Analysis, Prediction, and Data Acquisition. A fifth element, Optimization, completes the analysis.

I. *Description.* The primary phase of this study would be a description of the system of deer management in each State. This would be carried out by a full-time specialist who would be what has aptly been described as a "circuit-riding brain-picker." He would visit the individual States and discuss deer management with technicians and administrators, developing from their concepts and practices a statement of the whole problem in that State in the form of a system. He could start discussions with a simplified version of a management system and elicit suggestions and changes to develop a better model of the local system. Eventually these State models would be combined into a generalized description of a State management system, with features left unique to a State where necessary. This process of description can be classified under five headings.

I.1. Definition of all the objectives of deer management will be needed to produce a clear statement of what deer management is expected to accomplish. The complexity of the deer problem is apparent when one attempts to state the outcome expected of successful management. Even if one accepts some one of the different measures of hunting success, then what weight is to be given, for example, to tourists viewing the animals or to reduction of forest and crop damage? It may prove impossible to set up a single objective or a set of alternative single objectives, and the desired outcome may have to be stated as a compromise among several somewhat contradictory aims, expressed as a weighting of the several objectives. But a specification of management objectives will be necessary. In fact, it scarcely seems necessary to invoke the term "systems analysis." to point out the necessity of defining the objective of deer management.

I.2. Identification of the major subsystems making up the whole system, and the component parts making up these subsystems will be required. For example, the deerherd, its biology and population dynamics, comprise the best known subsystem, and the sex-age subgroups may be viewed as components of this subsystem. There are other subsystems, well known though less clearly differentiated, which include, for example, the interaction of the public with the wildlife department, which occurs on the one hand through educational activities and on the other through pressures from interest groups and through the legislature. Others are the regulation-producing system, the data acquisition systems (concerned with biological information and hunter statistics), and the system of laws and enforcement. This part of the investigation may be developed partly through study of the literature but mostly in discussions with State personnel. A model is needed for each subsystem.

I.3. Interactions and relationships among subsystems and components must be specified. An output of one component becomes an input of another (unless it is an output of the whole system). For example, what is the effect of increasing enforcement effort on the biology of the deerherd? Identification of the important pathways of influence will be critical, and must be developed through study of the system and in discussions.

I.4. There must be an identification of the decision points for deer management and the criteria for making decisions, including the influences bearing on the decisions. These points must be explored in discussion with State administrators.

I.5. The important inputs into the whole system from outside, and the outputs of managed deer hunting must be identified. This step also includes defining the boundaries of the whole system. Inputs from outside will include, for example, the influences of weather on deer and hunters and the effects of changing land use practices.

II. *Analysis.*

II.1. This implies systematic study of each component of the system, concerning what is now known of the relationships between inputs and outputs, how its functioning can be quantified, and what more needs to be known of its nature in order to build it into a simulation model. Depending upon the component being studied, this step of analysis may lie anywhere between a desk study of literature and data, at the one extreme, and at the other, gross speculation in discussion with informed persons. With some of the components, we might be able to do no better than point out the need for competent study. For example, what is really known of the quantitative relationship between enforcement effort and illegal hunting?

II.2. A quantitative model of deer population dynamics would be one of the principal objectives of the study. There is much information already available on this subject, but no specific model general enough to include the features found in all States. One of the most important questions to be answered here is what kinds of data must be obtained on a continuing basis to actually use a model of population dynamics in management.

III. *Prediction.*

III.1. A graphical representation or chart of the system of deer management in each State should be drawn up, based on discussions with the biologists and administrators. This would be a first approach to simulation and could serve as a model for further discussion of details. Such a chart would indicate the kinds of effects to be expected from changing a component and would thus facilitate at least qualitative prediction.

III.2. Although computer simulation of the entire system of deer management for a State must be the eventual objective of a successful systems analysis, it is doubtful that at the present time all factors can successfully be quantified well enough to permit such complete simulation. But a minimum objective would be to discover what factors we need to know more about in order to attain this ultimate objective, and to set up a simulation for any subsystem whenever enough is known.

III.3. A model of deer biology could probably be programmed for computer simulation in a fashion general enough to be adaptable to the particular needs of each State. Enough is known to allow reasonably successful simulation of the biology of a herd under management. This could allow use of the computer in "experimental" investigation of the effect of varying the different factors affecting the population dynamics, and investigation of the outcome for different management plans.

IV. *Data acquisition.*

IV.1. One objective of the study would be to assemble a list of what information now exists in the region. This could be carried out during visits to the States, when detailed notes could be made on the condition, accessibility, and technical coverage of the stores of data previously gathered and now in the file, as well as those now being gathered. Such a listing of information should be made available to all the States.

IV.2. A check list of all reports on deer management and biology could be assembled, showing whether published or not, and whether available.

IV.3. An important objective of the study would be to decide what further information will be needed to understand both deer biology and the other factors of management, and also what data should be gathered in the future as routine information to support man ment decisions.

IV.4. Cooperation among those States with sin problems, climates and habitats promises to proı efficiency, both in sharing the conduct of investigat and in some of the routine data gathering. Explora of this possibility should be a principal aim of the st

In summary, the process of systems analysis aim set up a model for such a complex entity as deer r agement, by breaking it up into a number of sm units which can be individually studied. After a q titative model has been set up for each of these sm units, and the relationship between inputs and out specified for each, then the whole can be reassem from the parts.

A computer simulation may be set up if enoug known about all the parts. Then the simulated sy may be tested to determine how well the predict match the real world. If the goal is management, the objective will be to manipulate the system to pro the optimum output.

Even if there cannot be a successful simulation of whole system of deer management, the careful const tion of models for subsystems and the attempt to q tify their interpretation will yield worthwhile divid in the form of increased understanding.

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Sociological and Economic Considerations in Management of White-Tailed Deer

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Many problems in deer management will develop as human populations increase and social patterns change. Some aspects of three problem areas are discussed: the implications of urbanization, quality in recreational hunting, and the economics of resource use including conflicts of interest. Precise, objective studies of the value of deer and other wildlife resources are needed. Administrators and managers are urged to take a broader view of the deer resource and its relevance to the needs of society and to diversify their management objectives to maximize benefits and minimize conflicts with other resource interests.

In considering how to treat the socioeconomic aspects of deer management in the Southern States, we have determined to limit our discussion to three broad problem areas. We doubt that any one State would claim it had the answers to any more than a small fraction of the multiple questions rearing their heads in each area, and we resisted the temptation to launch a "questionnaire" to find who had the answers. As a matter of fact, we have concluded that for the purpose of this panel, and for this assigned subject, we can perhaps be of greatest service by questioning the validity and utility of some of the conventional interpretations of economic data on deer hunting and carcass values, and pointing up some sociological questions surrounding deer management, answers to which are sorely needed by wildlife management agencies if their programs are to be more effective in the future.

The areas we have selected for discussion are:

1. The implications of a rapidly urbanizing America to modern deer management.
2. The challenge of achieving quality in recreational hunting.
3. Economics and resolving conflicts of interest with regard to resource use.

DEER MANAGEMENT AND URBAN SOCIETY

There is probably no experienced wildlife manager employed in a State or Federal regulatory agency who will not agree that his major problem in implementing technically sound deer management programs is in winning public acceptance. It is a "people problem" and thus a political one. He must operate in the context of traditional and strongly entrenched attitudes, and any victory he achieves is likely to be a compromise.

There is ample evidence to support the thesis that the accelerating urbanization of our society will have profound effects on policies and their implementing regulations in future deer management. Attitudes of the urban population will increasingly dominate legislative decisions and the policies and programs promulgated by wildlife management agencies. Greater involvement in resource issues by the urban-oriented populace will result in a broader base of interest in wildlife for its esthetic and cultural values and an increase in antihunter sentiment in general.

The patterns being planned for interspersion of open space, green belts or parks for recreation to accommodate the burgeoning urban and suburban communities will accelerate the loss of wildlife habitat on which any form of firearms hunting will be tolerated.

Scrublands, forest lands, and low grade agricultural lands reverting to wild herbaceous and forest covers will command the deer manager's major attention. Here he will continue to be most closely involved with rural hunters and landowners. However, even here the desires and needs of the urban populace will be influential, and the manager will have to learn to work with them also.

The wildlife agency that continues to depend almost entirely on revenue from the sale of licenses to finance its programs of acquisition, habitat management, law enforcement, and education finds itself on the defensive when recreational hunting is threatened. An increasing problem in the cities will be one of convincing the urbanite of the value of hunting. In the United States, only 3.4 percent of the population living in large cities are hunters (U. S. Department of the Interior 1966). Many of the nonhunters see no great relevance to wildlife generally and regard hunting as cruel and even atavistic. The bulk of agitation for stricter gun control legislation comes from the urban centers where the distinction between the criminal with a gun and a legitimate hunter becomes fuzzy.

Resource issues are being settled increasingly on social, ethical, and moralistic bases. We must be able to show that the sport of hunting has broad social values as important for the nonhunter to understand as for the hunter. The economic importance of controlling deer populations through regulated hunting seldom occurs to the urbanite. He may view the wildlife agencies' special deer seasons as "gimmicks to sell more licenses and provide an outlet to a sadistic lust for killing." Are we doing a good job in answering this kind of charge or preventing its gaining credibility? In our information and education programs, it is necessary to emphasize that an important part of the wildlife agencies' responsibility is to control excess populations. Hunting is a management tool to this end, and the recreational values may be only secondary. We should level with the public on this fact.

Man is by nature a hunter. Anthropological evidence indicates that man evolved from an apparently unique group of predatory apes. Indeed, it appears that his predatory, aggressive nature was primarily responsible for the development of the brain, the use of tools and fire, and the general evolutionary success of the human species. Physiologically, man as a species is still equipped for life as a hunter. However, in the urban environment, the hunting instinct may be expressed and adequately satisfied by most in their pursuits of making a living. In others the hunting instinct is satisfied by ritualization in the form of sport hunting. Some hold that this contributes to the mental and physical well-being of the participants. Furthermore, codes of ethics, traditions, and restraints have definite character-building influences. These character-building qualities must be preserved and nurtured if hunting is to survive as a sport.

In an increasingly violence-conscious, urban-oriented society, we may be sure that antihunter sentiment and demands for rigid gun control will increase. Is it possible for game managers and hunters to convince the public that hunting has broad social values, that to some it is essential to mental and physical well-being, that it has character-building influences that pay off in reduced crimes of violence and fewer social problems? There is need for sound statistical data to support these claims if the antihunting public is to be convinced of their validity.

QUALITY IN RECREATIONAL HUNTING

As the pressures of mass use increase, the problem of maintaining standards of quality in outdoor recreation will become more critical. Most of us will agree that the greatest social values of the white-tailed deer are recreational, cultural, and aesthetic. To many, the greatest realization of these intangible values is through the quality hunting experience.

What is quality hunting? For purposes of this paper, we accept the statement of the Mississippi Flyway Planning Committee (1961) that quality hunting is "characterized by reasonable solitude, primitive surroundings, rugged exercise, suspense, excitement, and a chance to pit the skill of the hunter against the innate cunning of the prey, resulting in a hunt to remember with satisfaction whether or not a full legal bag is taken."

Beyond a point, quality of the hunting experience clines as the number of hunters increases. The ultir in low-quality hunting has already been reached some of our public hunting areas. Excessive deve ment has resulted in an atmosphere of artificia Hunting pressure is so great that hunters can finc refuge from other hunters. There is no opportunit apply knowledge of woodcraft and stalking skills. F mentation of hunters, assigned stands, numbers, perr and badges add to the artificial atmosphere.

Disgusted, many an experienced sportsman hang his gun unless he has hunting privileges on private la He is replaced by the novice who accepts such condit as part of the sport because he has never known anytl better.

Aldo Leopold (1949, 1953) eloquently appealed consideration of quality in game management and what he called "split-rail values." He appealed for g departments to take the lead in fostering "the distin American traditions of self-reliance, hardihood, w craft, and marksmanship."

There are steps that State wildlife agencies can should take to achieve greater quality in recreati hunting. They should begin placing as much emph on providing pleasant hunting experiences as they now placing on harvest. Through their public relat programs game departments should conduct educati efforts emphasizing sportsmanship and tradition placing less emphasis on the kill.

General tax funds are needed to supplement fu provided by hunters to eliminate the necessity of pending upon numbers of licenses sold to provide enue.

Seasons should be as long as possible to avoid con trating hunting effort in a short period of time. Pu hunting areas should be diversified with some a developed to accommodate maximum use and some a undeveloped and with limited access and contro numbers of hunters (e. g., primitive weapons are Regimentation should be held to the minimum neces to preserve other values. Habitat on such areas sh be managed in such a way as to preserve as nearl possible a natural appearance with a diversity of spe and a minimum of artificiality.

Administrators and biologists should give more sideration to local hunting traditions in recommen regulations concerning seasons and hunting meth Local traditions and codes enrich the sport of hun and provide charm and color and diversity of hun opportunities. Unless there are sound biological administrative objections, local traditions should be tured.

More attention should be given to trophy values. M agement on a maximum sustained yield basis does allow animals to reach maximum size and develop tro antlers. Research is needed to determine method controlling deer numbers while allowing some bu to reach trophy size.

Also, it is generally recognized that prey species h a genetic need for predation. In the South, hunters h largely replaced natural predators of deer, but the u regulations and harvest methods select against tro animals. American wildlife biologists have generally not been impressed by genetic factors in game management. But European game managers place great importance on selective harvest and culling deerherds. Fundamental studies are needed to evaluate genetic effects of harvest practices.

Private lands probably provide the best opportunities for quality hunting. It is axiomatic that "mass use impairs quality" (Leopold 1949, 1953). Private property, functioning as a form of territoriality restricting use, averts destruction of quality values (Hardin 1968), and 75 percent of the forest lands in the South are in private ownership. Game departments should investigate means of providing technical advice for private landowners wishing to form game pools or cooperatives or clubs wherein quality hunting opportunities would be increased.

ECONOMICS AND CONFLICTS OF INTEREST

Deer populations in many of the Southern States are now expanding rapidly and interest in hunting them is growing. Studies on the economic impact of this situation are interesting, and they demonstrate that deer hunting can make a very significant economic contribution to an area. For example, a small six-county area in Georgia receives an injection of more than ½ million dollars into its economy each deer season, three-fourths of this coming from hunters not residing in the area (Almand 1968). Phillips (1965) reported that three parishes in northeastern Louisiana receive an influx of more than $158,000 during each 5-day deer season.

Ramsey (1965), in making an economic comparison of deer to domestic livestock in the Edwards Plateau region of Texas, said: "Records from the Kerr Wildlife Management Area indicate that the net return per animal unit of deer can exceed that from livestock if the deerherd is adequately harvested." From Llano County, Texas, in the same region, Teer *et al.* (1965) collected data which show that in 1961, 25 ranches consisting of 47,217 acres received a combined income of $57,395 or $1.22 per acre from deer hunters.

Emerson (1968) reported hunters in the Tennessee Valley area to spend approximately $20 million each year enjoying their sport.

The Uwharrie Deer Restoration Project, which was merely an idea in North Carolina in 1944, now enriches the local economy by more than $100,000 each year (Wilson and Thompson 1964).

Deer hunters in Virginia harvested 24,934 deer during the 1966-67 season (Cross, personal communication). If the figure of $400 per animal (Almand 1968) is applied, deer hunting in the State contributed almost $10 million to the economy during that year.

Watson and Whitehead (1967) wrote: "Wildlife management in our town of Crossville (Tennessee) is a prominent business." Dr. Watson is Mayor of Crossville.

Many northern areas have for years enjoyed the sizable income produced by wild deer populations. In New Hampshire, 1962 hunting values were assessed at over $12 million, of which deer accounted for at least 90 percent (Silver 1968). She stated: "The importance of deer hunting as a factor in the economy of the nonindustrial 'North Country' was emphasized in 1963 . . . . A spokesman for the New Hampshire Motel Owners Association, appearing before a legislative committee in opposition to proposed deer legislation, estimated that a 10-day shortening of the season would result in a minimum loss of $100,000-$200,000 to members of his organization. Another motel operator estimated his loss to be $500 per day in addition to the layoff of nine employees. A restaurant owner at Colebrook estimated his income from hunters to be $40-50 per day."

Mangold (1965) stated: "Official reports indicate that deerhunters in New Jersey legally harvested 8,049 deer in 1964 with an average expenditure of $736.50 per deer. We have an estimated deer range of approximately 4,830 square miles or a little over 3 million acres, which averages $2 per acre spent hunting deer."

There are many other similar reports which show that deer are economic assets to the community. Of all the benefits, however, how much is cancelled by crop damage, tree damage, fence damage, vehicle damage, personal injury, and disruption of other forms of hunting and outdoor recreation in general? Even though many people may think of deer as a priceless game resource, others at the same time may view them entirely as pests. If deer management is to successfully contend with these varying attitudes, it may be necessary for management personnel to become more familiar with these attitudes and the people expressing them. The result may be that deer should be considered as more than just a hunter's quarry or a photographer's subject with positive aspects, but also that they have negative inferences in certain situations.

Surveys of hunters in five Southern States (Alabama, Georgia, Kentucky, Tennessee, and Texas) indicate that a majority of license holders never hunt deer and less than 20 percent of the total hunting effort is for deer (Durell 1965, 1968; Kelly 1967; Legler [n.d.]; Marshall and Payne 1968; Wilke 1962). Most hunters, therefore, are not directly benefited by the South's growing deer populations. How then are these nondeer hunters affected by expanding deerherds?

The multitudes which hunt rabbit, fox, and raccoon generally require dogs for best enjoyment of their sport. There are few hunting dogs which will not run deer. This creates conflict, therefore, which is quite prevalent in many areas where hunters spend great amounts of time trying to recall their dogs from a deer chase. These people undoubtedly are left with a bad taste when they realize that a disproportionate amount of their money may be spent on managing an animal which they consider a pest.

Much has been said concerning possible detrimental effects of hunting dogs on deer populations, yet little hope is offered the hunters who utilize hounds and are increasingly plagued by what they consider to be encroaching deerherds. Other land management conflicts occur between deer and crop, timber, orchard, and flower garden interests. The critical attitudes of these groups should provoke serious consideration of whether a high population of deer is desirable for all areas.

Would the exclusion of deer from selected areas help resolve some conflicts? Are game management programs building a white-tailed deer monoculture in the South? Are many game biologists criticizing forestry for pine plantations while at the same time establishing "deer plantations?"

It is good for deer managers to recognize these conflicts and to expect that occasions will arise when they will be asked, "Why have deer at all?" McNeil (1962) stated: "Until we learn to make better assessment of nonmarket values of deer, we will run the danger of allowing deer populations to become so large that costs will exceed benefits."

It may be beneficial for deer managers to more critically evaluate their economic data and better understand its full meaning. If a deer in area A, for example, costs the hunter $100 to harvest while a deer in area B costs $200, what conclusion is to be drawn? Are deer from area B actually bringing more money into the community than those from area A and thus are greater economic assets? Are the hunters in area B paying more for their sport?

In efforts to justify the costs of management, a game manager may be tempted to use the cost figure for harvesting a deer in his State for calculating the economic worth of the deerherd. This is a treacherous course to take.

The cost, for example, of harvesting a deer from low density populations may be extremely high, whereas the worth of the overall herd may be low. Conversely, as deer numbers increase, per capita harvest costs could decrease, yet the value of the herd would become much higher.

To further assure correct evaluation, meat value, which is a rarely considered economic factor, must not be overlooked. Almand (1968) stated that solely from a food standpoint, the meat from one deer represents at least $75 compared to an equal amount of meat bought at a butcher's shop. Although most deer hunters may view venison as being secondary to recreational benefits, the same venison is a primary stimulus for legal and illegal harvest in many underdeveloped areas. Deermeat can be an important quality protein source for people in such areas who survive on a subsistence diet. Furthermore, this meat is produced on lands generally unsuitable for agriculture and domestic livestock production.

It is evident that a comprehensive economic assessment of white-tailed deer must be derived by utilizing both positive and negative values. Future success in deer management will be dependent upon a broad viewpoint in which deer are considered in relation to all other forms of land use and the overall social outlook.

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Regulatory Legislation and Public Attitude on White-Tailed Deer Management

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Today, as in the past, economics and politics largely influence the shaping of game management policies. Often, the sound recommendations of biologists have been overruled by political pressure. Traditions, land-use competition, recreational needs, crop damage, fee hunting and political payoffs are among the many factors that influence regulatory legislation and game commission policy. Better communication and education are needed to get a public understanding and support of programs that best meet the needs of the people.

In the evolution of game management as a science, some are inclined to view the growing involvement of socioeconomic and political factors as recent developments. And with it we look back a couple of decades to the good old days when biological facts seem to be the main consideration in shaping the destiny of wild things. But if affairs seem more complicated today—and they probably are—it is mainly in retrospect. In the game management equation, people have always been prominent, and the frustrations they add through economic and political pressures have always been with us.

In wildlife management, no other segment of this resource—unless it is waterfowl—has felt the byplays, the economic hauling and political pulling that have come to our deerherds. And I say "deerherds" in a sweeping context because no State has been free of management considerations far removed from good biology alone.

Let me begin in Wisconsin—not because it is unique in having more or bigger problems, but mainly because it has done an unusual job in documenting its history of deer management. We can see well enough that political factors were present in Year One of beginning management.

Consider for a moment the attitudes of the first settlers, and of the succeeding generations that followed for at least 100 years. This was a new country then and nature had endowed it abundantly. Game was for the taking—not for sporting purposes—but as part of the economic underpinning of a rural life of limited means. There was nothing wrong with that so long as a seemingly bottomless supply could meet the demand of a sparse human population.

But the relationship didn't hold. Game supplies dwindled, and society stepped in with the doctrine that ownership of resident wildlife rests in the State and the State had responsibility for managing game in accordance with the supply. In Wisconsin, attempts at management began in the late 1800's. It was social and political in nature, aimed at parceling out remaining populations, *not* at development of herds. It's easy enough to imagine the political pressures that faced the early enforcement staff in the face of long-held traditions that game was for the taking.

Since those bleak days enlightened management—and circumstance—has restored deer over much of their original range, even adding thriving herds where none existed before. But political involvements have accompanied the transition and are with us today in even greater variety and complexity. In fact, I think it is a fair statement to say that modern game management seems less a matter of biology and more a matter of allocating resources among competing demands. This process of decision-making places deer management fully in the political arena.

I will refer again to Wisconsin, and the Lake States area generally, to illustrate a point. Following logging and fire suppression in the late 1800's, the deerherds expanded rapidly. The era coincided with a return by city dwellers to the out-of-doors. The backwoods became a place to get away from it all. Old timber trails afforded access to deserted logging camps, and hunters and fishermen moved in.

The next generation of sportsmen were accompanied by their wives and kids. The crude camps and shacks were replaced by "civilized" housing; waterways became scenic spots for a profusion of motels, hotels, and lodges. The summer resort industry had arrived. For the deer, and for those who would manage them, it brought problems—political problems.

More than being just venison, deer had esthetic values. For a child of the pavement, the sight of a doe with her fawn is recompense enough to assure a successful vacation. (The same could be said for most city-bound adults.) Resort owners were quick to see the dollar values in a flourishing deerherd. They wanted deer around—in quantity—and naturally enough they took to the stump and to the legislative halls to "save" the deer. In pursuing their cause, they had the enthusiastic support of tavern keepers, restaurateurs, gas merchants, and others who benefit from a flourishing tourist trade. Eventually there came the day when they had the immeasurable support of the late Walt Disney's movie about Bambi.

Saving the deer meant restrictive regulations and, above all, no doe hunting—this at a time when the animals were in plague numbers and starving by the tens of thousands every winter. Good biology dictated sweeping reduction of the herds if remnants of the range were to be saved, but more often than not politics ruled and a bad problem grew worse.

In groping for a solution—one that would compromise between deer aplenty and winter starvation—a number of States have tried winter feeding. That simply adds politics to politics to produce a sum of less than zero.

Wisconsin tried it as far back as 1935, but it was not until the winter of 1942-1943 that they went all out.

It was one of those "shakedown" winters, long and cold. The snow was deep, browse was in short supply, and deer were everywhere. When the snow melted, the carcasses were everywhere, too. No one knows how many starved, but estimates of the total loss ranged from 50,000 to 200,000. One thing sure, more deer died that winter than had been taken in any previous season by the hunters.

The next meeting of the legislature earmarked 50 cents from each deer license for use in artificial feeding and the purchase of deeryards. In the 1950-1952 biennium, Wisconsin spent $154,000 from this fund to feed starving deer. And over an 11-year period (1943-1953) they put a total of nearly $580,000 in the grand experiment.

While substantial, such an outlay of sportsmen's funds would not be objectionable if favorable results could be claimed. But deer feeding programs have been tried around the country and the unanimous feeling of trained wildlifers is that, in general, feeding aggravates the problem.

The complexities don't end with the resort trade. Other interests have other reasons for managing deer in a different fashion. There's the forester whose stands of seedlings are browsed to the ground by the ravenous hordes. This can add to a substantial loss; in some areas, deer are taking off 1 out of 5 acres of forest reproduction. Then there's the orchardist whose fruit trees are chewed back to misshapened snags. And farmers everywhere bemoan the loss of soybeans, corn, melons, tomatoes, peppers, alfalfa, winter pasture, and other crops too numerous to mention.

It matters little if—as often happens—that the orchard or patch farm was grubbed from a cutover forest and so had a full blown depredations potential built in. The fact is that for these people there are indeed too many deer and, hunter interests aside, the animals are little more than vermin to be eliminated en masse.

In the West the dilemma takes a new form. Here the cattlemen and woolgrowers want deer off—more livestock on. Sportsmen, as expected, argue for reduced grazing pressure to put more forage in the bellies of big game. I hasten to emphasize that I am not painting either as the bad guy. A cattleman or a woolgrower can also be a sportsman. I suppose this illustrates the political implications of modern deer oratory.

In most areas the conflict between deer and agriculture grows worse as the adaptable white-tail learns to relish the products of the farm. Would-be solutions have come not from biologists, but from legislative halls. The results, as you know, have been less than satisfactory.

One of the early palliatives was Pennsylvania's Deer-Proof Fence Law of 1923. Through this expedient, distressed farmers were furnished 8-foot wire fencing to hold back the hungry herds, providing they would meet half the cost of construction. Small landowners most in need of help couldn't afford it—and fortunately so for the game department. Because fencing out deer "here" simply puts more of them "there;" and when followed to its logical end the scheme would bankrupt any game fund.

Wisconsin's Legislature tried to hush complai farmers by appropriating $40,000 annually to pay damage complaints. In one biennium, they shelled close to $60,000 in payment of 613 deer-damage cla If such schemes were merely useless, it would be tr enough, but they encourage dishonesty among the zenry as well. I am not singling out Wisconsin farm mind you. Any County Commissioner anywhere can you that in the damage claims filed before his Co Board, the wild dogs always seem to kill only the ribbon livestock.

Politics in Maryland are probably no worse than where—except when it comes to managing the deerh Then the professional's hands are tied. In some counties of the State a burgeoning herd has all but some orchardists out of business. As you might exp a few operators have acted on their own by shoo deer on sight, or hiring it done, in season and out. orchardist, without apology, stated he counted in ex of 75 dead deer in his orchard 1 year. Since he shooting them with a .22, the odds are the total was above that figure.

Reporting to the Sixteenth Annual Conference Southeastern Association of Game and Fish Commiss ers, Maryland biologists Flyger and Thoerig, said t

> "Feelings run high between orchardists and hun ers in this region. The orchardist wants deer numl ers reduced and together with the Game and Inlar Fish Commission have tried to establish antlerle seasons. The more vociferous hunters in this are have been able to prevent all but one small ineffe tual antlerless season. On one occasion the Gam Commission, wishing to control the killing of de and keep it out of the hands of the public, assigne wardens to shoot deer in the orchards. This did n please the hunters and within a week a large o storage building in one of the orchards mysterious caught fire and burned to the ground, just as one the hunters earlier had predicted would happen

They went on to say:

> "The deer situation in western Maryland is n only unpleasant and wasteful but needless. Effe tive management of the herd is obstructed by a sma but influential portion of local hunters. The Gam and Inland Fish Commission is caught in the midd of this situation with its hands tied by legislatic and public opinion. On the one hand farmers d mand action threatening to take matters into the own hands. If the Commission permits such actio open lawlessness is encouraged with loss of respe for hunting laws. However, if a farmer is prosecute for shooting deer in defense of his property the cou is likely to favor the farmer, thereby setting a prec dent for other landowners and farmers to follow On the other hand, hunters want more deerhuntir but refuse to permit an antlerless season believir that they can build up their herd."

While I have delved into the past and into probl of faraway States in the course of exemplifying poli considerations that have entered into deer managem it should not be inferred that these problems have s been solved. To the contrary, these and more are much with us and some tend to be aggravated by still another relatively new development on the scene. I refer to the trend away from free hunting as we have known it and towards commercialized gunning and private preserves.

Over much of our northern country the number 9 wire has come to identify the private deer club. In Michigan's better deer range one can now drive for miles and see on both sides of the road the single strand of wire with signs hanging at measured intervals that caution the unattached hunter to stay out. It started in the Lake States area, but has since spread to many parts of the country, including the South. Today deer clubs are prevalent throughout the range of the white-tail. And in the course of reserving hunting rights for a relative few, the membership has opened up a new area of political maneuvering.

I can speak firsthand of situations that have appeared in Louisiana.

In Louisiana a few clubs prevail upon prominent political figures to take membership. This gives them a certain amount of prestige and a lot of political leverage. During years when permits are issued for the taking of extra deer, those clubs having the most influential political leaders exert the most pressure and receive the most permits. However, many progressive clubs leased land having a low deer population, protected it at their own expense and harvested deer as recommended by State game biologists. Because of good management, they harvest many more deer annually per unit of area than is taken on surrounding lands that are open to public hunting. Since most club members invite friends to hunt, they spread the kill among a large number of people.

A few tax assessors have been influential in deer management by threatening to raise taxes when forest landowners demanded a reduction in deer numbers because no forest reproduction could be obtained.

Wherever deer come in contact with soybeans, there is no escape from damage. Tensas Parish, Louisiana, has many acres of beans and a high deer population; therefore, farmers suffer crop depredations. For the past 2 years farmers have killed many deer in bean fields during the crop growing season. They were left to rot or given to farm employees. Wildlife agents filed many charges against these farmers, but they were not brought to trial. The police jury, sheriff, and the district attorney maintained a list of people who would not be prosecuted. The Wild Life and Fisheries Commission contended that the deerherd should be reduced by licensed hunters during the regular season to a level that damage could be tolerated by the farmer.

In Louisiana, legislators often exert heavy pressure on the Wild Life Commission to employ a particular person as a local agent. He then becomes "my" agent and may be requested to give special protection to favored lands during the nonhunting period and to look "the other way" during the deerhunting season. He often condones violations by local hunters and harasses outside hunters. In some instances he may be used as a guide, driving a State vehicle to take hunters into the woods and to carry deer out. He may even be requested to serve as the camp cook. The solution—no agent should be permitted to work in his home parish.

A few elected public officials fail to take action against deer poachers or go very light on them with the expectation that the offenders will round up several votes during the next election. Some feel sorry for the violator because he may be poor and have a large family. But in this day and age no one need be dependent on game for a meat supply. It should be pointed out that most sheriffs, district attorneys, and judges are more enlightened today than ever before and that they assume their rightful responsibility by taking proper action and imposing stiff fines. To most of them, game laws are no longer a joke.

In Louisiana, the parish governing body in 37 parishes supposedly has the authority to veto doe seasons in their parish. There have been many instances in which these police juries have not permitted the Wild Life Commission to have an any sex deer season when it was badly needed. These same governing bodies have enacted restrictive camping ordinances and trespass laws designed especially to harass out-of-parish deer hunters.

Some Wild Life Commission members are politically motivated and insist on a politically oriented program. They still believe in the "spoils system" in which employees are rewarded for their political activity. These political employees have no knowledge of deer problems and have no interest in them. Some are complete "deadheads" and some spend most of their time in political activities. Under these conditions, management of our deer reaches its lowest point. This form of wildlife administration is not only the least productive but it is also the most costly.

We know well enough what happens to biological management when dollar values appear for any entity of the outdoors. I have already alluded to the power play of summer resort operators who, in part, are capitalizing on the assured prospect of their clientele seeing deer. In other areas (particularly the West) similar commercial interests are catering to free-spending, nonresident hunters. These interests seek more liberal seasons and bags and, above all, a "fair and reasonable" nonresident license fee that will encourage a good influx of outside hunters. Again, it pits dollar interests with local hunters, and management decisions often involve a little biology and a lot of politics.

And there's more. Few people outside the South can appreciate fully the intensity of feelings engendered by devotees of the fox chase. Some fox hunters hold deer in genuine disdain. To a man with a pack, Heaven is a township crawling with red foxes but free of grays and white-tails and in which dogs can be run every night of the year. And they make themselves heard, but not without a great clamor from deer hunters who seek laws permitting the shooting of "free-running hounds."

If that's not enough, you can add archers versus gun hunters, riflemen versus the advocates of slugs and buckshot, doe hunters versus buck-only supporters, quail hunters who want no deer gunners out during the fall and winter. And I will add the far-out instance of a Michigan Commissioner (there are probably others from other States) who wanted an earlier deer season so it would not conflict with his Florida vacation. All of them are being heard—and far too many being heeded—in caucus rooms well removed from the laboratory and checking station.

In retrospect, we have not always managed our deerherds along sound biological lines. This most popular and abundant of our big game animals has a way of touching the lives of many people of diverse interests.

A majority of our landowners in the range of the white-tail are aggrieved by its presence. Foresters, grazers, truck crop producers, diversified farmers, orchardists, and others all bemoan their presence as they see their livelihood penalized by this omnivorous beast.

The conflict occurs to some extent even when herds are maintained within the carrying capacity of the natural range. And the strife increases when populations are allowed to expand beyond the capability of the natural habitat to support them. On the other side of the ledger are still other interests who see economic gain, and sporting satisfaction in seeing the herds at saturation level. It often adds up to a wasted resource through starvation and impaired reproduction in the herds.

Too often solutions have been sought in trying to fence the animals out, payments for damages, artificial feeding, trapping and removal and other expedients that wasted funds and accomplished no good. A solution to the problem—if indeed it has one—will have to fol on sound biology.

We have the facts but not the following. No ma how valid the basis for biological management, i useless in the face of public resistance. And, so, a commonly the case, our job now is one of communica and education. Not to be entirely pessimistic, we h witnessed good progress in some States, but it's not lil to stay that way unless we keep on with our educatic efforts. As has been remarked, in conservation educa we are not addressing ourselves to an audience bu a passing parade. Each new generation brings its (doubters and self-styled experts and so we must p for public understanding and support for a long tim come.

As of now, the name of the game is still politic most areas, and in terms of maximum sustained y it's not the best way. But by other measurements may approach "the greatest good for the greatest num for the longest period of time." And as profession we live by that credo too. In the meantime, the consu audience, which adds to 6 million, gains 40 million re ation days from the sport while decorating 2 mil fenders with this greatest of game, or worst of verr depending on how you view it.

And that's not bad.