EVALUATION OF WILDLIFE FORAGE CLEARINGS FOR WHITE-TAILED DEER HABITAT MANAGEMENT IN A 600-ACRE ARKANSAS OZARK ENCLOSURE

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OZARK ENCLOSURE

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PREFACE

The purpose of this study is to evaluate the usefulness of wildlife forage clearings as a habitat management technique for white-tailed deer in a 600-acre wooded enclosure in the Arkansas Ozarks. This is accomplished by comparing the quantity and quality of cultivated forages produced on forage clearings to the yield and quality of native species growing in the undisturbed forest. The impact that cultivated forages have on deer feeding habits, physical condition, and population changes are evaluated also.

The Arkansas Game and Fish Commission, the Federal Aid Division of the U. S. Fish and Wildlife Service, the Southern Forest Experiment Station of the U. S. Forest Service, the Cooperative Wildlife Research Unit and the Department of Animal Science and Industry at Oklahoma State University, and the Southeastern Cooperative Wildlife Disease Study at the University of Georgia all furnished financial and technical assistance for this study.

I wish to express my appreciation for the advice and assistance provided by Dr. John Morrison, my major adviser, and Mr. Lowell Halls, Project Leader of the Wildlife Habitat Project of the Southern Forest Experiment Station. I wish to thank the other members of my committee, Dr. Ronald Johnson, Dr. Bryan Glass, Dr. Jerry Crockett, and Mr. Theodore Silker. Thanks are also extended to Dr. Jack

McCroskey, who served on my committee and supervised chemical analyses of forages prior to accepting a position at the University of Idaho.

Mr. Robert Leonard, Mr. Fred Ward, and Mr. Mitch Rogers, wildlife biologists with the Arkansas Game and Fish Commission, were responsible for that agency's participation in this research effort. Dr. Frank Hayes, Director of the Southeastern Wildlife Disease Study, and his associates necropsied several deer removed from the enclosure.

Mr. Walt Green and Mr. Ed Mitchell, technicians with the U. S. Forest Service and Arkansas Game and Fish Commission, respectively, performed many essential tasks during this study. Many biologists and wardens with the Arkansas Game and Fish Commission, personnel from the Sylamore Ranger District of the Ozark National Forest, and students from Arkansas Polytechnic College, Mountain View High School, and the Job Corps assisted with the many deer drives.

Finally, I wish to dedicate this thesis to my wife Suzanne, who quite frankly is often confused as to what I am actually doing running around in the woods, but nevertheless tolerates my frequent absences and cares for our three children Bo, Kim, and Mike.

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CHAPTER I

INTRODUCTION

This study was initiated in 1967 to determine the feasibility of using small cultivated forest clearings to improve the habitat of white-tailed deer (*Odocoileus virginianus* (Boddaert)) in a densely wooded 600-acre enclosure located in the Arkansas Ozarks. Specifically, it was designed to compare the quantity and quality of forages produced on cultivated forest clearings to the yield and quality of native forages growing in the adjacent undisturbed forest. Additional information was also obtained on how well this source of forage was eaten by deer and how it affected deer feeding habits and changes in population levels within the enclosure. Clearings were designed especially to produce winter forages for deer, but yield and utilization estimates were taken biannually and forage quality was estimated seasonally to determine year-round importance.

The enclosure was suited for measuring habitat changes and variations in deer populations because investigations conducted prior to the construction of cultivated forage clearings had established the basic productivity of the area for native deer foods (Segelquist and Green 1968) as well as its approximate carrying capacity for deer (Segelquist *et al*. 1969). These studies indicated that the enclosure was capable of supporting a population of only one deer per 40 to 60 acres and that the scarcity of winter forage was one of the major factors limiting deer numbers.

Definitions

Wildlife forage clearings are openings in the forest habitat, either natural or man made, that are maintained in natural or planted agricultural forage crop species (Larson 1967). Wildlife food plots are special areas created specifically to grow food for wildlife. Food plots can be constructed in any habitat type. Depending upon the species of wildlife to be emphasized, food plots may be designed to produce grain or other fruit, forage, roots, tubers, bulbs, or a combination of several of these items. Thus, wildlife forage clearings are merely special kinds of food plots. Throughout this report, the term "forage clearings" will be used in reference to cultivated forest openings of the kind created in the study enclosure. The term "food plot" will be used when it is possible that forage is not the only crop produced or that the food-producing area is not located in a forested habitat.

History of the Development and Use of Wildlife Food Plots and Forage Clearings

The first recorded use of food plots, presumably forage clearings, in the United States was on public refuges in Pennsylvania in 1917 (Leopold 1933). By 1963 an additional 21 states were using or had used forage clearings for forest game management (Larson 1966). Since 1963 at least one more state has joined the group. Nevertheless, despite their long and extensive history of use, the role that forage clearings play in the management of habitat for deer is poorly understood. Larson (1966) reviewed the status of wildlife forage clearings and found that few wildlife biologists agreed on their importance to deer management because of the dearth of research studies designed to answer specific questions about their usefulness to deer. While many states have cleared and maintained thousands of acres of openings for deer at an estimated cost of 8 million dollars (Larson 1969), almost no effort has been expended to determine the effects of these practices on the quality of deer habitat or their ultimate influence on deer population levels. It seems strange that so much effort has been expended on an unproved practice, but a brief look at the factors leading to the development and use of forage clearings in deer management helps to understand the reason for this dilemma.

The white-tailed deer is primarily a product of the forest edge or of the secondary phases of vegetative succession rather than of the climax. White-tailed deer ranged broadly over the North American continent at the time of discovery by Columbus, but they were probably present in relatively small numbers in extensive areas dominated by uniform climax forests or grasslands (Severinghaus and Cheatum 1956). Highest populations probably occurred in areas of greatest vegetative diversity where two or more types of vegetation adjoined, such as wooded stream valleys in the grasslands or in forested areas disrupted by natural openings created by wind, fire, excessive moisture, or drought. The eastern climax forests of North America, especially the northern and central deciduous forests where the canopy cover was complete and understory vegetation was sparse, probably sustained relatively small populations of deer.

The creation of openings in the climax forests introduced an element of habitat diversity favorable to deer. This was evidenced by the rapid expansion of deer numbers in North America concurrent with settlement of the continent. Leopold (1936a), in comparing deer management programs in Germany and the United States, emphasized this point when he noted that the period of maximum wildlife abundance in America came just after the ecological disturbances resulting from settlement.

Early settlers must have noted the attraction of deer to forest clearings and their fondness for cultivated crops. The list of foods eaten by deer includes almost every crop cultivated in the United States (Hosley 1956). This observation is substantiated by the results of a detailed study by Korschgen (1954) which showed that agricultural crops made up from 3 to 25 percent of all foods eaten by Missouri deer over a 5-yr period. Agricultural crops must have influenced the expansion of deer numbers in some areas of the U. S. during early settlement.

As long as deer populations were high, as they were until the end of the 19th century throughout most of the country, little thought was given to deer management. However, as demands for venison and deer skins increased, professional hunters virtually exterminated deer over large parts of the country. Settlers also killed many deer to protect crops and to obtain food and skins. As human populations increased, pressure on deer increased resulting in drastic declines in deer numbers. With declining deer numbers came increasing concern for their conservation. The first measures for conserving deer numbers consisted of laws establishing refuges for their complete protection, closed seasons during which they could not be hunted, restrictions against killing females, and limits on the number that could be killed. These controls ultimately increased deer numbers, but during the interval from the time that deer were virtually extirpated until herds were once again on the increase, a dramatic change had come over much of the forest. Young second-growth forests were closing in and reducing the availability of understory vegetation and the food supply for deer (Hosley 1956). As herd numbers increased, natural foods were depleted, depredations on agricultural crops increased, and many deer herds were faced with starvation (Hosley 1956). Faced with the decision of increasing kills to keep deer populations in balance with the available food supply or of trying to provide additional foods for starving herds, sportsmen who remembered the days of low deer numbers demanded that game departments try the latter.

With the propensity shown by deer for agricultural crops it was only logical that direct feeding, providing deer with previously harvested hay and grain, should be the first practice employed to sustain deer during periods of acute food shortage. Furthermore, the attraction of deer to forest openings led naturally to the construction of food plots combining the practices of clearing and of planting cultivated crops solely for the benefit of deer as a tool for habitat management.

The impetus for widespread use of food plots in deer management did not derive entirely from observations that deer liked forest openings and cultivated crops. Food plots had long been recognized as a useful tool for managing game birds. In fact, Marco Polo recorded that agricultural crops were being planted strictly for the benefit of various species of birds as early as 1270 to satisfy the hunting and eating pleasure of Kubla Khan (Leopold 1933). Direct feeding of grain that was planted and harvested especially for feeding game birds was also included in this early management program.

Though it is difficult to determine when these practices were first applied to ungulates, direct feeding of red deer (Cervus elaphus L.) and roe deer (Capreolus capreolus L.) was widely practiced in Germany prior to 1900. According to Leopold (1936a), direct feeding was largely responsible for maintaining huntable populations of these two species under the intensive system of forest management known as monoculture, a system whereby natural forests were converted almost entirely to pure, even-aged stands of pine or spruce. Food patches were also planted in these even-aged forests to provide winter food for red and roe deer (Leopold 1936b). Other factors, not mentioned by Leopold, that may have necessitated supplemental feeding of deer in German forests included the practice of gleaning. Tops of cut trees, fallen branches, and even litter, in some cases, were gathered and used for fuel and livestock bedding. Gleaning was practiced in some forests for hundreds of years. The activities of gleaners undoubtedly disturbed the habitat and constant removal of branches, twigs, and leaves adversely affected nutrient cycling resulting in reduced productivity of the understory vegetation (Aaltonen 1948). In any case, food plots or "wildacres" were still not commonly used in Germany by 1957 (Webb 1960).

Creating food plots for game management in the United States probably was stimulated mostly by the exhaustive work of Stoddard (1931) who documented years of observations on bobwhite quail (Colinus virginianus (Linnaeus)) management in the southeastern United States.

Although Stoddard seemed to prefer other means of habitat improvement, he reported that food patches were used with success on some large southern plantations managed for quail. Stoddard's work together with the published acknowledgement by Leopold (1930) on the desirability of clearings for good deer habitat deserve much of the credit for initiating the practice of constructing forage clearings for deer (Larson 1966). The fact that deer relished the foods produced on forage clearings was evidenced by their avid consumption of them, and this impressed the desirability of the practice in the minds of many sportsmen and game managers. That no evidence was collected to show that forage clearings were actually beneficial to deer was no hindrance to their widespread use.

In most states, the first interest in forage clearings resulted in an initial surge of construction followed by a leveling off, reduction, or complete curtailment of the program over a period of years (Larson 1967). The chief reason for this diminishing effort was usually the limitation of funds. The cost of clearing and maintaining forage clearings was so high that all operating funds could be expended quickly on a relatively small number of clearings.

No matter how successful any program of forage clearings may have been, all states ultimately had to resort to population control as a management technique to keep deer herds in balance with the habitat. In a few instances populations were reduced and controlled by hunting pressure, but in most cases dieoffs from starvation, disease, and parasitism were the ultimate factors responsible for reducing population excesses that forage clearings were created to support.

The current status of wildlife forage clearings in the United States is relatively static. Most states are currently maintaining those created earlier, but few are creating new ones. There is, however, a new era of forest management developing in the U. S. that may renew interest in the use of food plots for forest game management. This is the advent of intensive even-aged-forest management. The time is rapidly approaching, especially in the southeast, when pine monoculture and short-term even-aged rotations will be commonplace (Squires 1969). As in the monoculture of spruce and pine in Germany, these forests will probably provide poor deer habitat for at least a portion of their rotation (Halls and Stransky 1968). If deer are to survive in huntable populations, intensive management may be necessary to provide food. This is one of the chief reasons the present study was undertaken.

Description and History of the Study Area

Location

The 600-acre Caney enclosure, from which the bulk of the data in this dissertation was collected, is located in the Sylamore Experimental Forest, a portion of the Sylamore District of the Ozark National Forest. It lies in Stone County, Arkansas, in the White River drainage basin of the Ozark Mountains (Figure 1), approximately 8 mi southwest of the town of Calico Rock. The enclosure received its name from a small stream originating within its boundaries.

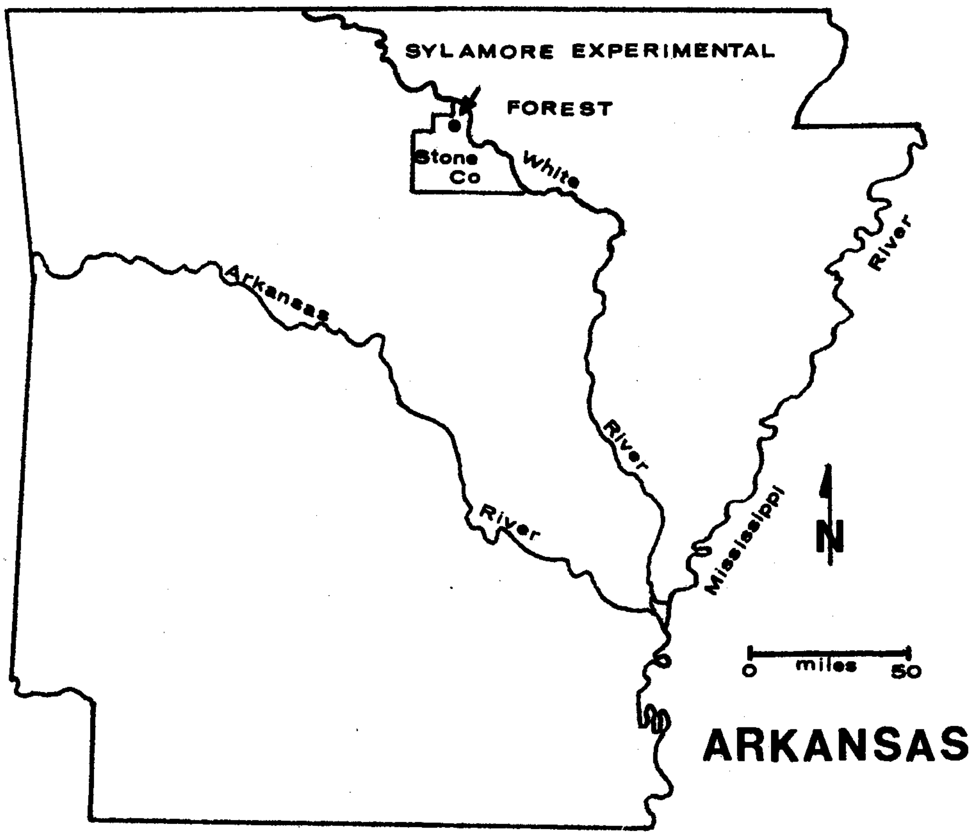

Figure 1. Location of the study area

Geology and Soils

Geologically, the study area is located in the Springfield Plateau division of the Ozark Highlands with surface rocks of Mississippian and Ordovician age (Goddard 1964). The area is deeply dissected, but elevations in the enclosure range from only 700 to 1,000 ft (Figure 2). Floodplains of the several small intermittent streams are narrow. Ridges are also narrow with well-weathered, rounded tops. Slopes range from 1 to 60 percent, but generally average about 25 or 30 percent. Two permanent springs occur within the enclosure, but flowing waters quickly sink into the porous subsoil.

Soils of the high ridges are formed from Boone chert and limestone (Goddard 1964). They are moderately deep with chert fragments frequently constituting 75 percent of the total soil volume. Soils of the slopes and lower elevations are formed from a combination of Boone cherty limestone and Everton dolomite and sandstone (Goddard 1964). On the steep convex slopes, soils are shallow and rocky. Deep colluvial loams and sandy soils are found on the concave slopes, lower slopes and smaller streambottoms. Deep sandy alluvial soils occupy the floodplains of the larger streams.

Climate

Precipitation at Calico Rock, Arkansas, the nearest reporting weather station, averages 45 inches annually with about 24 inches falling from April through September (Reinhold 1959). Snowfall in the north-central weather-reporting district of Arkansas, which includes Stone County, averages about 9 inches annually. Snow usually remains

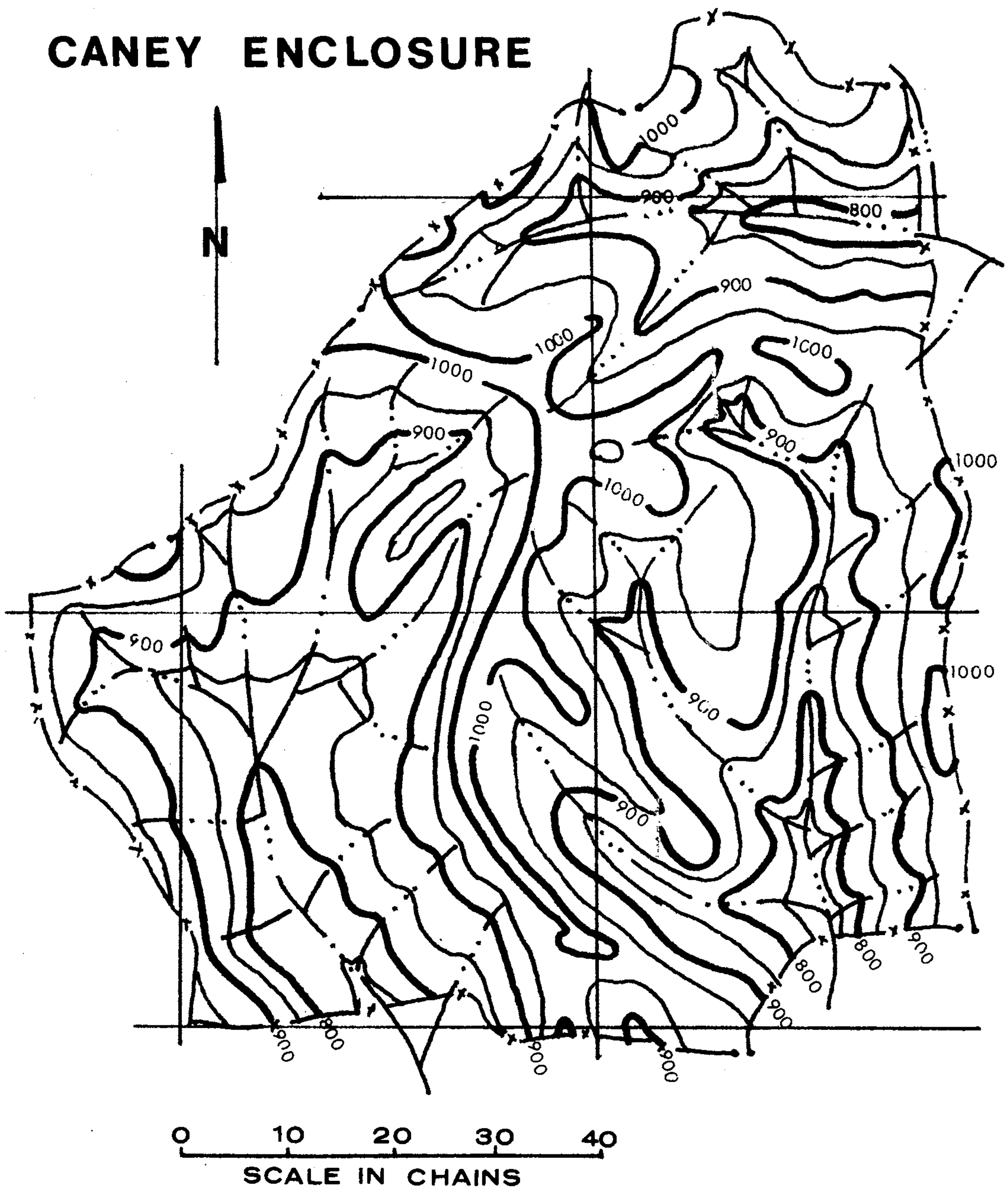

Figure 2. Topographic map of the Caney enclosure

on the ground for less than a week. However, in 1966-67 a total of 23 inches of snow was recorded, and during the winter of 1969-70 the ground remained covered to a depth of 1 to 10 inches for about 20 days. The mean minimum temperature for January is 26 F and the mean maximum is 48 F. In July the mean minimum is 66 F and the mean maximum is 92 F (Hickmon 1941). Summer highs commonly exceed 100 F and the lowest temperature ever recorded in Calico Rock was -23 F. Droughts of varying intensity and duration occur commonly. The most severe drought in recent years occurred from January 1962 through June 1964 during which time precipitation was below normal for 24 of 30 months and total precipitation averaged only 70 percent of normal.

Forest Types

The enclosure contains four types of forests determined by soils, slope, and direction of exposure. The four types are: upland hardwood, upland pine-hardwood, cedar glade, and streambottom hardwood (Figure 3).

The upland hardwood type occurs on the north and east exposures of ridge tops and upper slopes and makes up about 52 percent of the enclosure. Soils are cherty silt loams with chert fragments making up from 30 to 75 percent of the soil volume. The water-holding capacity is generally low. Tree basal area is about 107 sq ft per acre. The predominant species of trees are white oak (Quercus alba L.), black oak (Q. velutina Lam.), and hickory (Carya spp.). Steyermark (1963) is the authority for these and all subsequent plant names. A few northern red oak (Q. rubra L.), blackgum (Nyssa sylvatica Marsh.), and blackcherry (Prunus serotina Ehrh.) are also scattered throughout the

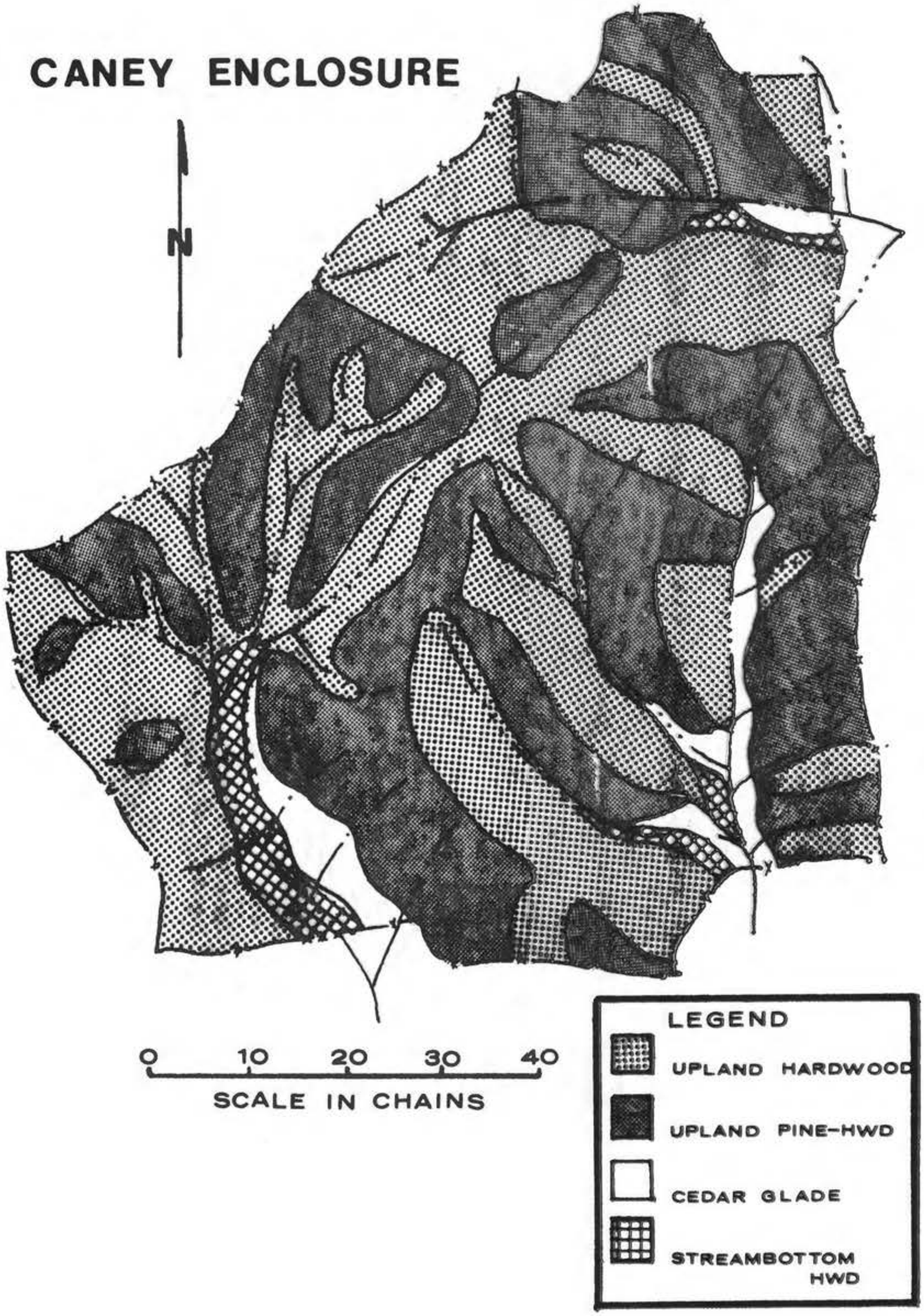

Figure 3. Forest types in the Caney enclosure

type. The site index, the average height of dominant trees at 50 yr of age, ranges from about 40 ft on the ridge tops to 60 ft on the slopes. Flowering dogwood (Cornus florida L.), a fairly shade-tolerant species, frequently forms a second canopy under the overstory of the dominant trees. There is little ground cover present under the low, dense canopy of the upland hardwood type. Understory browse is composed largely of flowering dogwood, oak, and hickory regeneration. There are few grasses or forbs present, and ferns constitute most of the nonwoody vegetation in the understory.

The upland pine-hardwood type occupies 41 percent of the enclosure. This type predominates on the south and west exposures of ridges and upper slopes. Soils and degree of slope are similar to those of the upland hardwood type, but the exposure results in a drier site. About 30 percent of the 98 sq ft of tree basal area is made up of shortleaf pine (Pinus echinata Mill.), a more drought-tolerant species than most of the upland hardwood trees. Hardwoods consist of most of the same species as in the upland hardwood type with the inclusion of more post oak (Q. stellata Wang.) and less northern red oak. Understory vegetation is more abundant than in the upland hardwoods. Woody understory species include the various oaks, flowering dogwood, and hickories in addition to sizable quantities of lowbush blueberry (Vaccinium vacillans Torr.) and common deerberry (V. stamineum L.). Herbaceous ground cover is slightly more abundant in the mixed pine-hardwoods than in the pure hardwoods of the uplands. Pussytoes (Antennaria plantaginifolia (L.) Hook.) a herbaceous composite commonly eaten by deer, frequently constitute the majority of the forbs. Various panicums (Panicum spp.) compose most of the grasses available.

Cedar glades have the roughest terrain, shallowest soil, and driest site of any type, and they make up about 4 percent of the area. Soils include sands, loams, and clays derived from chert, limestone, and sandstone. All are thin and rocky. Bedrock is near the surface and frequently exposed as ledges. The aspect is nearly always south or west. Timber stands are fairly open averaging only about 76 sq ft of tree basal area per acre. Most trees are small and scrubby and produce little merchantable timber. Eastern red-cedar (Juniperus virginiana L.) typifies the glades; and post oak, blackjack oak (Q. marilandica Muenchh.) winged elm (Ulmus alata Michx.), ironwood (Ostrya virginiana (Mill.) K. Koch), chinkapin oak (Q. prinoides Willd.), and hackberry (Celtis spp.) are all common. Because of the sparse overstory canopy, understory vegetation is most abundant on the glades. Woody understory species include greenbriers (Smilax spp.), farkleberry (Vaccinium arboreum Marsh.), and aromatic sumac (Rhus aromatica Ait.) in addition to reproduction of all the overstory species. Grasses and forbs abound and where the canopy is broken species typical of the tallgrass prairie predominate. Purple prairie clover (Petalostemon purpureum (Vent.) Rydb.) and goat's rue (Tephrosia virginiana (L.) Pers.) are two common forbs; big bluestem (Andropogon gerardi Vitman.) little bluestem (A. scoparius Michx.), Indian grass (Sorghastrum nutans (L.) Nash), sideoats grama (Bouteloua curtipendula (Michx.) Torr.), and panicums are common grasses.

The streambottom hardwood type comprises 3 percent of the study area. It occurs along the narrow streambottoms and lower slopes.

Soils are generally sandy or silty clay loams with a moderate to high water-holding capacity. The streambottoms have the most fertile soils of all types. There is approximately 90 sq ft of tree basal area per acre in this type. Trees include most of the upland hardwoods plus such species as American sycamore (*Platanus occidentalis*, L.), sweetgum *Liquidambar styraciflua* L.), ash (*Fraxinus* spp.), southern red oak (*Q. falcata* Michx.) and basswood (*Tilia* spp.). Understory vegetation is relatively abundant in spite of the dense overstory canopy because of better availability of moisture and better soil fertility. The overstory canopy is also much higher than in the uplands with site index ranging from 60 to 80 ft. Spicebush (*Lindera benzoin* (L.) Blume), Carolina buckthorn (*Rhamnus caroliniana* Walt.), Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.), and greenbriers, plus the reproduction of the various overstory trees, make up the bulk of the woody vegetation. Forbs consist of a wide variety of legumes and composites. Panicums, sedges, irises, and ferns abound on the moist site.

History

The Spaniard Hernando de Soto explored a portion of Arkansas in 1541, but the Ozarks were largely unexplored and uninhabited by people of European descent for the next 250 yr. During the period from 1541 to 1803 the region was alternately governed by the French and Spanish. In 1803, Arkansas was purchased by the United States as part of the Louisiana Territory. The population of the lands included in the Arkansas District of the purchase, excluding Indians, was given as 368 in 1799 and had grown to only 1,062 by 1810 (Hall 1941).

Prior to settlement, the Ozarks region consisted of open woods interspersed with large treeless areas (Sauer 1968). The vegetation cover ranged from grasslands in the prairie-like regions of the west and the undissected plateau remnants of the interior to open forests of pine and oak-hickory in the eastern and hilly regions. Forested areas consisted of park-like stands of large mature trees with little understory vegetation (Sauer 1968).

Habitat conditions in the White River region were among the most diversified in the Ozarks (Sauer 1968). The river and its tributaries contributed an element of bottomland with rich fertile soils and bottomland hardwood forests. Cliffs and bluffs rose abruptly from the valley floors to fertile bench lands and then to the roughtly dissected uplands heavily forested with pines and hardwoods. Innumerable park-like cedar glades and small grassy balds dotted the region. Isolated glades were periodically burned by Indians to improve grazing for game, a practice that obviously limited the encroachment of invading forests and kept the glades in a prairie-like condition (Sauer 1968).

French hunters and trappers were among the first Europeans to visit the White River region of the Ozarks, and toward the end of the 18th century a few cabins began to appear along the river (Hall 1941). As these early frontiersmen were primarily interested in the fur trade, they did little clearing or farming and made few permanent impressions on the land.

From 1790 to 1829 several thousand Cherokee and Choctaw Indians, displaced from various southeastern states, settled in northwestern Arkansas (Hall 1941). Among their other activities they cleared farms and planted orchards. Although the extent of these practices is not known, they undoubtedly affected habitat conditions along the White River to a certain degree. Shortly after the Indians sold the rights to their lands in Arkansas in 1829 and moved westward into Indian Territory, the first American settlements sprang up in the vicinity of the study area (McGuire 1941).

Although records of early wildlife abundance for the specific area of the study are difficult to establish, reports of early explorers and frontiersmen indicate that game of all kinds was abundant throughout the Ozark Highlands (Sauer 1968). The native fauna constituted one of the principal attractions of the region to early settlers. Early accounts indicate that the first settlers supported themselves largely by hunting bear, deer, elk, buffalo, raccoon and other animals (Schoolcraft 1821).

According to the following accounts abstracted from Sauer (1968), the open woodlands, rich grasses, many fine springs and numerous salt licks of the Ozark Highlands provided conditions under which deer, bison, and elk thrived. Also present were wolves, bears, panthers, and wild cats. In the streams lived beaver, otter, and muskrat. Other lesser furbearing animals, found mostly in the forests, were mink, raccoon, opossum, skunk, fox, gray squirrel, and cottontail rabbit. Game birds were similarly abundant in early years. In 1819 it was said that passenger pigeons were so numerous that the woods seemed alive with them. Quail and turkey flourished in the early forests and the streams were well stocked with fish.

Of all the sections of the Ozark Highlands, none ranked higher with the hunter frontiersmen than the White River country (Sauer 1968).

In his account of travels through Arkansas in 1818, Schoolcraft (1821) indicated that he wandered through the Ozarks for 20 days without seeing a human habitation and that the first house he encountered was located in a clearing on the North Fork of the White River where he saw innumerable quantities of deer, bear, and other skins stretched and hanging on poles to dry. Howell County, Missouri, located about 40 mi north of the study area abounded in deer, turkey, bear, wolves, and small animals in 1844 (Monks 1907). All of Arkansas's counties had sizable deer herds as late as 1900 (Donaldson et al. 1951) although other game species such as the elk, buffalo, and passenger pigeon had already been eliminated.

Cutting of the forests began at the same time as settlement for agriculture, but intensive private cutting in the vicinity of the study area probably began just prior to 1900 (Settel 1938). Sawmills were established in Arkansas about this time, following the coming of the railroads late in the 19th century (Hall 1941). Lumber towns were established along the White River around 1900 and intensive logging persisted until the advent of Prohibition disrupted the white oak stave market (McGuire 1941). Venison was one of the main dishes for the logger, railroad worker, and early farmer. Professional hunters soon began to take advantage of this demand (Donaldson et al. 1951). Market hunting continued legally until 1915, and the use of hounds to take deer became increasingly common.

In addition to intensive hunting pressure, deer had to contend with increasing competition from livestock. Settlers released many head of cattle, hogs, horses, mules, sheep, and goats into the forests to subsist on the free range. This combination of factors soon began to take its toll on deer.

Forest exploitation was rampant at the beginning of the 20th century in the Ozarks as well as the remainder of the United States, and as a result a movement was initiated to place certain lands under federal protection in National Parks and Forests. In 1908, the Ozark National Forest was established by proclamation of President Theodore Roosevelt (Kuenzel 1934). The original gross area was over 1,000,000 acres, less than one-half of which was federally owned. The boundaries of the Forest were reshaped into three units in 1915 for better administration: the Central, Eastern, and Western units. In 1933 the unit boundaries were adjusted to give each unit approximately 200,000 acres. The Eastern Division, subsequently designated the Sylamore District, presently contains about 175,000 acres.

There were originally about 15,000 acres of cleared lands within the boundaries of the Sylamore Division of the Ozark National Forest. In addition, cedar glades contributed a sizable amount of open or thinly wooded lands. Together, glades and man-made openings probably made up about 14 percent of the area. Much of the remaining area, especially the more inaccessible parts, was still virgin forest because commercial cutting of the forests in the vicinity of the newly established National Forest had not begun until just prior to 1900. Exploitation of the forests outside the boundaries of the National Forest ran the same course as it did in the rest of the South (McGuire 1941): high-grade cutting of the best hardwoods and clear cutting of the pines with no effort to regenerate either one. Commercial sales in the Sylamore Division began in 1911 (Settel 1938) and have been consistent with sustained yield practices, meaning that regeneration has kept pace with harvest. At the same time, however, timber management practices have extensively modified species and age-class composition of the forests.

Prior to 1907 burning in the region progressed without check and finding a thicket of hardwood reproduction over 3 yr of age was rare (Kuenzel 1934). Fall and spring fires were commonly set by the Indians and later by white settlers to improve grazing for game and livestock. This burning maintained openings in a prairie-like condition (Sauer 1968) and also created open woods with little understory vegetation (Kuenzel 1934). All of the old trees in many areas bore evidence of fire scars, but from 1907 to about 1930 more and more of the Sylamore District was placed under fire protection until burning was finally brought under control.

Deer were almost extirpated from the Sylamore Ranger District early in the 20th century. According to a survey (Donaldson et al. 1951), it was estimated that there were only about 35 deer on the Sylamore in 1926. Because of this scarcity, five federal game refuges were established on the Ozark National Forest from 1926 through 1928 (Kuenzel 1934). Two of the refuges, the 8,400-acre Livingston Refuge and the 5,300-acre Barkshed Refuge, were located on the Sylamore District.

Shortly after these refuges were established, a 2,800-acre area embracing soil and forest types representative of the region of northern Arkansas and southern Missouri, was set aside on the Sylamore District for experimental studies of timber stand improvement (Kuenzel 1934). This area, subsequently named the Sylamore Experimental Forest, was located wholly within the boundaries of the Livingston Refuge. In the winter of 1934, a herd of 14 deer was frequently seen ranging over the fields adjacent to the headquarters area (Kuenzel 1934). This group evidently constituted most of the deer on the refuge.

The first management procedures conducted on the refuges were to close the areas to hunting, to prohibit poaching, and to control predators (Donaldson et al. 1951). In 1931 a total of 44 wolves and 47 bobcats were killed on or near the Sylamore District by personnel of the Biological Survey (Kuenzel 1934). The response of the deer herd to these practices was dramatic and immediate. It was estimated that there were 350 deer on the District by 1932 and the area, exclusive of the refuges, was opened to buck hunting (Halls and Crawford 1960). The legal kill was 6 deer.

The deer herd continued to increase rapidly during the next few years and protection was intensified. In 1938 the entire Sylamore District was closed to hunting with dogs. By 1943 areas were noticed in which deer were damaging the forest, and 2 yr later it was estimated that there were 5,125 deer in the District (Donaldson et al. 1951). It is interesting to note that the two federal refuges on the Sylamore made up one of only a half-dozen areas in the southeastern United States that were included by Leopold et al. (1947) in a survey of over-populated deer ranges. Thus, the Sylamore was one of the first areas in the South in which overpopulations of deer were recognized as a problem.

Based on records of buck deer killed by hunters, populations probably reached a peak in the mid 1940's (Donaldson et al. 1951). In 1944, 463 deer were killed on the district. This number approximated

30 percent of all the deer killed in the state of Arkansas. From 1941-1948, 2,362 deer were shot and killed, and an additional 1,559 deer were trapped and moved from the area to restock other parts of the state. This removal of 3,921 deer over an 8-yr period, however, was not sufficient to keep deer populations within check. Overutilization of the range became more and more obvious and browse lines began to appear. Julander (1946), in a report to the Supervisor of the Ozark National Forest, stated that deer had severely cropped white oak, cedar, and black locust in the Sylamore area. Cedar was browsed as high as a deer could reach. In the early spring of 1950 approximately 30 dead deer were found on the area, and in August 1953 an additional 10 dead or sick deer were observed (Alexander 1954). These represent but a small portion of the deer that must have died. Although the exact cause of death is not recorded, some probably died from the effects of parasites and disease after they were weakened by starvation (Donaldson et al. 1951). For the next 20 yr the deer herd on the Sylamore continued to decline. During the 1950's kills declined to about 200 deer annually (Halls and Crawford 1960) and a combination of low populations and light hunting pressure further reduced kills to about 50 animals in the late 1960's (Ward and Segelquist 1969).

The irruptive response of white-tailed deer on the Sylamore District can be attributed to several factors. When the refuges were established there were few deer in the region because of overhunting and perhaps of predation to some extent. Habitat conditions were excellent. Old fields, pastures, and glades contributed an element of diversity to the forested surroundings. Many of these areas had a recent history of regular burning that tended to keep vegetation in a state of early secondary succession. Burned areas were covered with an abundance of grasses, forbs, and low-growing woody vegetation that provided high quality forage for deer. Much of the adjoining woodlands were still virgin forests with large mature hardwoods capable of producing enormous quantities of mast. The habitat was further enhanced by areas that had recently been logged. Such cut-over areas contained an abundance of shoot and sprout growth. These diverse conditions provided an abundance of forage and mast as well as optimum cover for deer. Thus, once deer received protection from hunting and predation, their natural reproductive potential was realized and the herd expanded rapidly.

The decline following this rapid buildup, contrary to the decline of the original herd in the early part of the 20th century resulting from exploitation, was in response to overpopulation and deteriorating habitat. At the time that deer herds were expanding, habitat conditions were changing. Commercial cutting of timber had eliminated many of the most productive mast-bearing trees, thereby reducing the amount of high-quality fall and winter food. Natural secondary succession on the old fields, pastures, and glades, in the absence of burning, reduced the amount of forage available to deer. As young trees grew out of reach, shading curtailed production of understory vegetation (Halls and Crawford 1960). Many old fields were planted to pine, further reducing the productivity of the range. The concentration of deer on the few remaining fields may have provided an opportunity for the buildup of parasites and spread of epidemic diseases. All of these factors resulted in declining deer populations.

When this study was begun, deer populations in the general vicinity of the study area were at low and apparently stable levels. Commercial cutting of merchantable timber was still progressing, but the acreage of recently cut-over lands was small. Open fields, with the exception of a very limited number of inholdings within the National Forest boundaries, were nonexistent. Cedar glades, being protected from fires, as was the remainder of the forest, were more densely forested than in earlier days and contained relatively little understory vegetation. Most timber stands consisted of thick stands of trees in sapling and pole size classes with little understory vegetation. Thus, the forests produced relatively little forage during the growing season, and availability of winter forage was exceedingly low. Mast yields were sporadic and relatively low because mature hardwoods were few and the density of the stand suppressed crown development of individual trees, thereby restricting mast yields.

In the study enclosure, annual summer forage yields ranged from 78 to 95 ovendry lb per acre from 1963 through 1967 (Segelquist et al. 1969). Availability of winter forage was very low, averaging about 10 to 13 ovendry lb per acre. Large mature hardwoods were somewhat more abundant on the Experimental Forest than in the remainder of the surrounding National Forest; consequently, fall mast yields in the enclosure averaged 149 ovendry lb per acre over the 5-yr period. Acorns made up 95 percent of the yield. However, in spite of the sizable average yield, annual yields varied from 11 to 429 ovendry lb per acre. During the period from 1963 through 1967, winter dieoffs of deer occurred on two occasions, both of which corresponded to periods of below-average mast yields. The factors responsible for these losses were believed to be nutritional deficiencies and complications resulting from destruction of pulmonary tissues by migrating larvae of protostrongylid nematodes. Based on all available information, it was concluded that the carrying capacity of the 600-acre enclosure, or the number of deer that could be expected to survive periods of lowest mast availability, was from 10 to 15 animals, or one deer per 40 to 60 acres.

Objectives

The general objective of this study, as outlined in the introduction, was to evaluate the usefulness of wildlife forage clearings as a habitat-management technique for white-tailed deer in a 600-acre enclosure in the Arkansas Ozarks. Specific objectives were:

1. to determine the feasibility of converting 2 percent of the enclosure into intensively managed wildlife forage clearings in the presence of continuous use by deer,
2. to determine how much more forage could be produced on intensively managed forage clearings than on unmanaged forest lands,
3. to compare by proximate analyses, *in vitro* and *in vivo* digestion trials, and analyses of non-nutritive fractions, the quality of forages produced on forage clearings against selected native forages, and
4. to determine how supplemental forages produced on forage clearings affected deer feeding habits.

Secondary objectives included:

1. efforts to determine what effects, if any, this source of supplemental forage had on deer population levels, and

2. comparisons of parasite numbers from deer collected from the enclosure prior to installation of forage clearings to those collected afterward to see if concentrating deer on small plots affected total parasite burdens.

CHAPTER II

MATERIALS AND METHODS

Construction of the Caney enclosure was begun in 1959 to serve as a facility in which to investigate relationships between deer and undisturbed forest habitat in a typical Ozark upland forest. These studies began in 1963 and were completed in 1967.

Current studies of relationships between deer and forest habitat, as affected by the establishment of wildlife forage clearings designed specifically to produce supplemental winter forage for deer, began in 1967. The approach to the problem involved cooperation between the Arkansas Game and Fish Commission, the Federal Aid Division of the U. S. Fish and Wildlife Service, the Southern Forest Experiment Station of the U. S. Forest Service, the Cooperative Wildlife Research Unit at Oklahoma State University, and the Southeastern Cooperative Wildlife Disease Study at the University of Georgia.

Selection and Preparation of Forage Clearings

In August 1967, four plots containing a total of 13.4 acres, about 2.25 percent of the Caney enclosure, were set aside for construction of wildlife forage clearings. Clearings were located with as much dispersion as possible, but ultimate locations were dictated by physiography (Figure 4). Clearings 1, 2, and 3 were located on ridges and Clearing 4 was located along a small stream

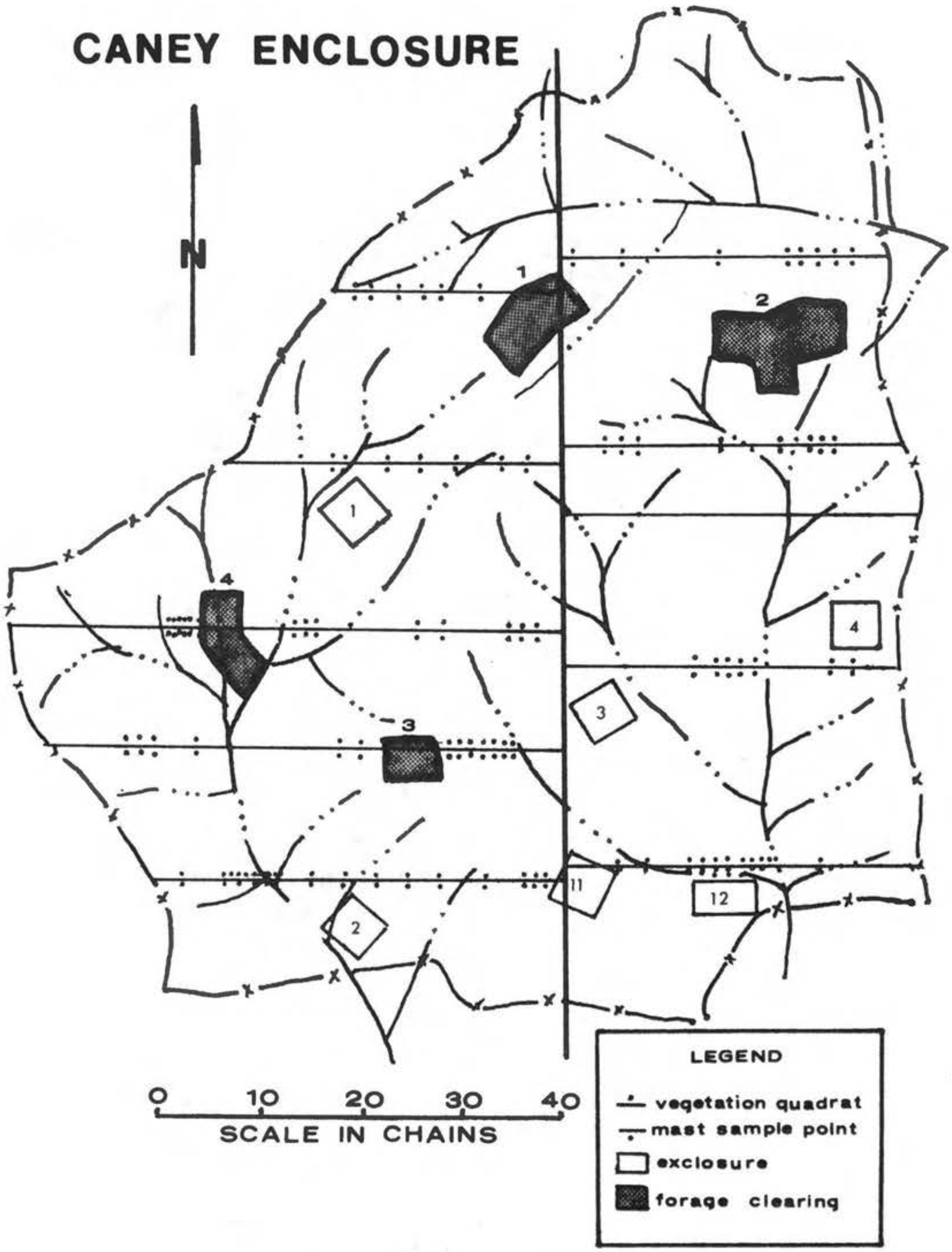

Figure 4. Location of exclosures, wildlife forage clearings, vegetation quadrats, and mast sample points

and an adjoining slope. The four clearings contained 3.76, 5.72, 1.72, and 2.20 acres, respectively.

All merchantable timber on the plots was harvested and sold. In February 1968, clearing of the remaining timber and slash was begun. Slash, nonmerchantable timber, stumps, and brush were piled and burned. About 250 stumps were removed with dynamite. Clearing was completed by the first of April and the plots were leveled and tilled in preparation for planting.

Patterns and Techniques of Planting

In early April 1968, one-half of Clearings 1, 3, and 4 and a little over one-third of Clearing 2, a total of 5.98 acres, were planted to Japanese honeysuckle (*Lonicera japonica* Thund.). One-year-old rooted cuttings were planted in 9- to 10-ft rows at 10- to 12-ft intervals. Plants were placed in furrows formed by a subsoiler, and dirt was packed around the roots with a tree-planting bar. Summer cover crops of Korean and kobe lespedeza were seeded at the rate of 25 lb per acre on the remainder of each food plot to prevent soil erosion and to provide summer forage for deer.

A mixture of elbon rye and ladino clover was broadcast on portions of each clearing for a total of 3.49 acres in September 1968, and 7.42 acres were planted in 1969, 1970, and 1971. Rye was seeded at the rate of 3 bushels per acre and ladino clover at 6 lb per acre. Rye reached maturity and died in the spring. Ladino clover made maximum growth in the spring and early summer and together with volunteer lespedeza made up summer cover crops from 1969 through 1971.

Application of Lime and Fertilizers

Annual summer and winter crops were fertilized in 1968 according to recommendations based on soil analyses by the Arkansas Agricultural Extension Service. One and one-half tons of lime per acre were spread on Clearing 4, but lime was not required on the others. A supplemental top dressing of sodium nitrate was applied to all clearings in the spring of 1969. Standardized rates of fertilizer were applied to winter crops on all clearings in subsequent years, but spring and summer fertilization was terminated following the initial application. Rates and dates of fertilizer applications for annual winter crops are included in Appendix Table XXXVI.

About 1.5 tons of lime per acre were applied to honeysuckle in 1968. Nitrogen was also supplied in 1968 and each succeeding year thereafter. In 1969 a complete fertilizer (12-12-12) was added. Because no guidelines were available for fertilizing honeysuckle, a variety of combinations and rates of fertilizer were tested on Clearings 1 and 2 in 1971 in an effort to establish the optimum levels at which to fertilize. These treatments were distributed randomly in equal proportions on both clearings, thus the effects of the various treatments were accounted for in subsequent measures of average yield. Detailed results of this fertilization test are not included in this report. Clearings 3 and 4 were treated as they had been in 1970. Rates of fertilizer applications are shown in Appendix Tables XXXVII and XXXVIII.

Estimation of Forage Yield and Utilization on Forage Clearings

Summer Crops

Yields of summer legumes were estimated each August from 1968 to 1971 inclusive, by sampling 10 randomly located 3.1-ft-sq quadrats per acre for each forage clearing. To determine the location of sample quadrats, two numbers were drawn from a table of random numbers to indicate the distance that quadrats were to be established from a common starting point. By measuring along and at right angles to a base line beginning at a preselected corner of each clearing, the location of each sample quadrat was located accurately.

All cultivated forage growing on each quadrat was clipped, placed in a paper bag, and ovendried to a constant weight. The average weight per quadrat was converted to ovendry lb per acre. Because of the apparent low grazing pressure, summer utilization by deer was not estimated.

Annual Winter Crops

Ten pairs of 3.1-ft-sq quadrats were installed per acre to sample winter forage yields and utilization. One quadrat of each pair was protected against grazing by a 4 ft X 4 ft movable wire cage; the adjacent quadrat was left unprotected. Quadrats were randomly located just as for the summer measurements. In midwinter, vegetation inside each cage and on the adjacent unprotected quadrat, was clipped, ovendried, and weighed. Cages were then relocated and the clipping process was repeated in late winter. The quantity inside protected quadrats was considered the amount produced and the difference between protected and unprotected quadrats was considered the amount eaten by deer. Elbon rye made up the bulk of the winter forage because ladino clover made little growth until spring and was scarce in winter.

Honeysuckle

Honeysuckle did not make enough growth in 1968 to warrant sampling, but yields were measured in August 1969, 1970, and 1971. Production was estimated by clipping a portion of 20 randomly located plants on each of the two large plots and 10 randomly located plants on the two smaller plots. In 1969 one-half of each plant selected for sampling was clipped, dried, and weighed. As plants grew larger, progressively smaller portions were taken. One-fourth of each sample plant was clipped in 1970, but in 1971 only one-eighth of each plant was clipped. From the clipped samples a smaller subsample was taken and the leaves and stems separated to estimate the leaf-to-stem ratio. After yields per plant were computed, yields per acre were calculated on the basis of the number of plants per acre.

Cages were placed over 10 randomly selected plants per acre in the fall of 1969, 1970, and 1971 and estimates of winter utilization were obtained in the following March by comparing protected and unprotected plants. Leaf retention was also estimated on protected March plants. Samples of protected and unprotected plants were clipped and weighed to estimate utilization and leaf retention in March 1971. During other years conditions were such that adequate estimates of utilization and leaf retention were achieved by visual observations.

Estimation of Native Vegetation Yield

One hundred permanently marked 6.2-ft-sq quadrats were established in the Caney enclosure, at the time of its construction, to measure annual vegetation yields. Vegetation sample plots were located on ten transect lines, one-half of which extend east and one-half west from a base line that bisects the enclosure (Figure 4). Transect lines and quadrats were all located randomly.

A double sampling system similar to that described by Wilm et al. (1944) was used to estimate native vegetation yields. Browse was sampled by species whereas herbaceous vegetation was divided into three major classes: forbs, ferns, and grasses and grass-like plants. The green weight of all current annual growth of vegetation up to 5 ft in height was estimated on all permanent quadrats. At every fourth permanent quadrat a temporary quadrat was established at a prescribed distance and direction from the permanent markers. On temporary quadrats the green weight of vegetation was estimated and then clipped and weighed. From this data, separate arithmetic ratios of estimated to actual green weight were computed for browse, forbs, ferns, and grasses and grass-likes. All estimated weights were then adjusted by being multiplied by the appropriate ratio.

Clipped samples of vegetation were ovendried until a constant weight was reached. A conversion factor was then calculated from the ratio of green weights to ovendry weights, and all weights were converted to a dry weight basis.

Estimates of winter browse availability were determined by stripping the leaves from the deciduous browse samples collected during the summer and calculating the percent of the total weight that was made up of twigs. Evergreen browse estimates for summer and winter were the same because leaves were retained in winter. Winter herbage availability was estimated on permanent quadrats each March. Because of the extremely small yields of winter herbage, it was not deemed necessary to clip samples to obtain reasonable accuracy.

Estimation of Native Forage Utilization

Browse utilization was based primarily on the percent of growing points cropped for each species encountered on permanent and temporary quadrats at the time that yield estimates were being made each August and March. Green weight utilized was also estimated for each species of browse and for each of the other major vegetation groups. In addition, the stomach contents of all deer removed from the enclosure were analyzed to determine the kind and quantity of foods eaten.

Utilization estimates and rumen analyses were supplemented by comparing vegetation yields in six 1-acre exclosures, that were fully protected from deer, against yields in the remainder of the enclosure (Figure 4). There were ten 6.2-ft-sq permanent quadrats in each exclosure. The sampling procedure for estimating forage production in exclosures was the same as that described for the enclosure except that only two temporary quadrats were clipped in each exclosure, a ratio of one temporary quadrat for each five permanent quadrats. These exclosures were sampled in 1969 and 1971.

Determination of Forage Nutritive Quality

Collection of Forages for Analyses

Samples of forages grown on food plots and samples of some of the most commonly eaten native species were collected for nutritive analyses during two annual periods from the summer of 1969 through the spring of 1971.

Forage samples from food plots consisted of honeysuckle leaves and twigs and, depending on the season, various combinations of elbon rye, ladino clover, and lespedeza. Native forages from the surrounding forest included panic grasses, pussytoes, eastern redcedar, flowering dogwood leaves, and flowering dogwood twigs. Three replicates of each sample were collected during each season of the year.

Each replicate of honeysuckle leaves and twigs was made up of portions of several different plants collected from widely dispersed locations on each of the four wildlife forage clearings. Only stems and leaves from the terminal 12 inches of current annual growth were collected. Samples of legumes and rye were collected from several different locations on each of the four clearings. Only new growth of annual crops was collected for analyses.

Native species were collected throughout each of the forest types where they were represented in the approximate proportion to their abundance. Samples of flowering dogwood leaves, flowering dogwood twigs, and the foliage of eastern redcedar were collected from the terminal 4 inches of current annual growth below 5 ft. Each replicate consisted of portions of several trees or shrubs growing from widely dispersed locations in each of the forest types where it was represented. Samples of panicums and pussytoes also consisted of collections from widely dispersed locations and were constituted in proportion to their abundance in the various forest types. All forage collections were taken to the laboratory, ovendried, ground, and thoroughly mixed prior to analysis.

Analyses Performed

Chemical analyses for the collections made during the first annual period, using standard procedures described by the Association of Official Agricultural Chemists (1960), included evaluations of crude protein, Ca, P, and Mg. Cell-wall contents and acid-detergent fiber were measured according to techniques outlined in Goering and Van Soest (1970). Lignin was measured by the sulfuric acid method. *In vitro* digestibility was estimated using bovine rumen liquor and pepsin following the two-step procedure of Tilley and Terry (1963).

During the second year, silica analyses were added. Mg was dropped, and lignin was determined by the permanganate method of Goering and Van Soest (1970). In addition, the pepsin digestion step of the two-step, *in vitro* procedure was eliminated. All analyses were performed by the Department of Animal Science and Industry at Oklahoma State University.

In vivo dry matter digestion was also determined for each forage sample using ruminally cannulated domestic goats and the nylon bag procedure described by Lowery (1970). Weighed forage samples were placed in small nylon bags and then suspended in the rumen of cannulated goats. Bags were retained in the rumen for 48 hr. They were then removed from the rumen, gently washed under running water until a clear rinse was obtained, immersed in ethyl alcohol for 5 min, and dried at 104 F for 48 hr. Dry matter digestion was determined by weight differences of the initial and digested samples. Digestibility values for each forage were the results of two replicates of each forage in each of two goats. During digestion trials goats were maintained in a 5-acre fenced paddock and fed on native east Texas forages including grasses, forbs, and browse.

Mast Inventories

Mast sampling was conducted annually. There were 83 mast-sampling points in Caney. These were located in conjunction with randomly selected permanent vegetative quadrats. Two 55-gal barrels were located at each mast sample point or, if potential mast-bearing trees were absent, simply recorded as a zero point in estimating mast yields. Barrels were turned up in late summer when vegetation estimates were being conducted. By the time that mast fall began, each barrel usually contained several inches of water that protected acorns and other fruit from predation by rodents. Barrels were examined after mast fall had ended. Numbers of acorns and other fruit were counted and recorded. A factor for converting numbers of fruit to ovendry weight was calculated each fall from a collection of the various mast species being sampled. Numbers of fruit per sample point were multiplied by the appropriate constants to convert yields to ovendry lb per acre.

Deer Census Drives

Deer census drives were held biannually, once in late fall and again in late winter. From 55 to 100 people assisted with each drive.

The Arkansas Game and Fish Commission and the Sylamore District of the Ozark National Forest furnished most of the personnel for drives, but students from Arkansas Polytechnic College, the Job Corps, and Mountain View High School also assisted on various occasions.

Drives began at the eastern boundary of the enclosure and proceeded to the west. Drivers were stationed at regular intervals, usually from 1 to 2 chains apart, with selected personnel following yellow-painted guide lines at 5-chain intervals. At the sound of a prearranged signal all drivers would proceed abreast at a slow pace. Deer were counted and recorded by each driver as the deer passed through the drive line to the driver's left. To keep the advancing front of the drive line properly aligned, all drivers halted, rested, and regrouped on red-painted lines at one-half and again at three-fourths of the way through the enclosure. Upon reaching the western boundary of the enclosure, drivers regrouped and redrove the area from west to east. Thus, the final count was the result of two drives.

Similar census techniques were used to census the George Reserve enclosure in Michigan (Chase and Jenkins 1962). As in the George Reserve, the technique was not foolproof. Occasionally, deer were apparently not counted or they were counted twice. These types of errors were minimized by the double drive. With few exceptions duplicate counts resulted in the same population estimates. When counts differed, they never differed by more than a few deer.

Deer Activity on Forage Clearings

Observations of deer activity of wildlife forage clearings began in August 1970 and continued at about 6-wk intervals through July 1971.

Towers were located overlooking each of the four clearings (Figure 5). Observation periods were designed to encompass an entire 24-hr period over a span of 3 days. Each observation period was 4 hr long and consecutive periods were broken by 4- to 8-hr intervals.

Night-time observations were made with the aid of a 6-volt dry-cell spotlight. The light was turned on and the beam rotated slowly around the clearing, taking care not to shine the spot directly into the eyes of deer and scare them from the plot.

Records were obtained on individually marked animals, the sex and age class of each animal, the number of times individuals departed and returned during an observation period, the length of time spent on the clearing by each animal, the activity of each animal, and the total number of animals observed were recorded.

Counts of fecal pellet groups were made at approximately 3-wk intervals on transect belts comprising 10 percent of each forage clearing from September through March in 1970-71 and 1971-72. All pellet groups were cleared from the transects following each count. These records of relative deer use on forage clearings were used to supplement observations of deer activity.

Deer Removal and Necropsy

Five deer were shot and removed from the enclosure in each of years 1967 and 1971. All deer were necropsied by personnel from the Southeastern Cooperative Wildlife Disease Study. Detailed records were obtained on physical condition and the incidence and degree of parasitism. The stomach contents of all deer killed were collected and analyzed for identification of foods eaten. Two additional deer

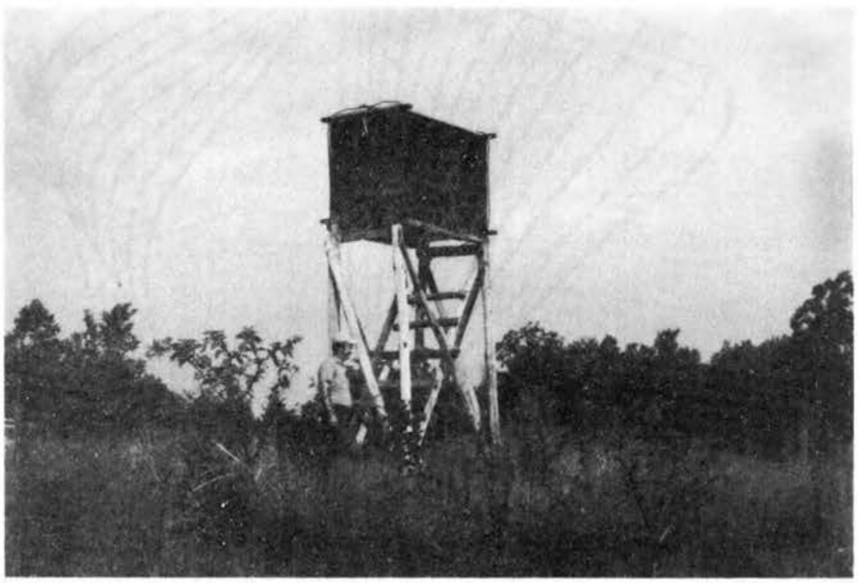

Figure 5. Example of tower from which deer activities were observed on forage clearings

were also killed and necropsied by a graduate student from the University of Arkansas during the winter of 1970-71.

Deer Trapping

An attempt was made by Arkansas Game and Fish Commission personnel to trap deer and examine them for external parasites, reproductive status, and general physical condition. Trapping success was extremely sporadic. Deer were successfully captured only for a brief period when they would come to specially prepared salt licks. Other baits were never successful in luring deer into traps, and deer were not attracted by salt except in the early spring. Little useful information was obtained by the trapping program. However, each deer that was captured was fitted with a distinctive color-coded collar to which was attached a small bell. This facilitated the identification of individual animals at food plots during observation of deer activities.

Use of Supplemental Data

Most of the data included in the remainder of this report were obtained from the Caney enclosure following the procedures described in this chapter. However, to explain certain changes that occurred in Caney after establishing forage clearings, it was necessary to draw upon data collected prior to 1967 and data obtained from the adjoining 675-acre Big Spring enclosure before and after 1967. Big Spring was also located on the Sylamore Experimental Forest, but it contained no food plots. These data are contained in published references and are cited following standard procedures when they are included in the text.

CHAPTER III

RESULTS

Deer Population Levels

Total population changes from the spring of 1968 through the spring of 1972 are recorded in Table I. Of the 14 deer in the enclosure prior to the breeding season of 1968, 10 were females and four were males. The structure of the herd during the winter of 1970-71, as determined by observations on forage clearings, was eight adult and yearling does, eight adult and yearling bucks, six fawns, and two deer of undetermined age and sex. During the remainder of the study it was not possible to determine accurately the age or sex structure of the herd.

Five deer were stocked in 1968 to increase population levels. Two deer were classed as stocked in 1971. One was a doe, trapped just outside of the enclosure, that had evidently escaped sometime earlier as it already had a collar. This deer may have been one of the two that escaped from the enclosure in 1970 during the fall census drive. The other deer was an unmarked doe that was observed jumping into the enclosure.

Four deaths were recorded during the study; one was an adult doe, one was a mature buck, and two were of unidentified age and sex. The

TABLE I

RECORDS OF DEER POPULATION CHANGES
IN THE CANEY ENCLOSURE

Source of Data	Spring to Spring Population Changes 1968-69	1969-70	1970-71	1971-72
Spring Census Count	9	15	22	13
Reproduction	9	11	6	1
Recorded Deaths	0	0	0	1
Kill Records	0	0	2	1
Unrecorded Losses	0	0	2	0
Stocked	5	0	0	2[1]
Fall Census Count	23	26	24	14
Escapes	0	2	0	0
Recorded Deaths	0	2	0	1
Kill Records	0	0	6	0
Unrecorded Losses	8	0	5	0

[1]One of these deer was an unmarked doe which jumped into the enclosure and the other was a doe that was trapped and returned after having escaped from the enclosure.

doe was killed by a bobcat, but the cause of death for the others was undetermined.

Nine deer were killed during the study. Seven were shot for necropsies (Table II), a doe fawn was accidentally killed during a census drive, and a yearling buck was killed in a trapping accident. The majority of all losses was due to unknown causes.

Records of reproduction are probably not complete. Unrecorded losses may have occurred during the intervals from the spring to the fall census counts causing depressed estimates of reproduction.

Necropsy Results

Seven deer were taken from the enclosure and necropsied in 1970 and 1971. Two were fawns examined by a graduate student from the Zoology Department at the University of Arkansas and five were examined by personnel of the Southeastern Wildlife Disease Study from the School of Veterinary Medicine at the University of Georgia. Detailed results of necropsies by the University of Georgia group are included in Table II and the following report was submitted following their examination.

> "Adult meningeal worm burdens (*Parelaphostrongylus tenuis*) were low at the time of the study. Microfilaria of the abdominal worm (*Setaria yehi*) were present, but of little importance. Protostrongylid larvae were present in the lungs. These larvae are capable pathogens at the high levels encountered. Abdominal worm incidence and intensity of infection was low. Gullet worms (*Gongylonema pulchrum*) were present in low numbers, but were unimportant to the well-being of the herd. Adult stomach worms (*Ostertagia-Skrjabinagia* complex) were at low levels of infection and the adult to immature ratio of approximately 14:1 was not suggestive of a build-up in progress. Helminth fauna (*Capillaria bovis* and *Thysanosoma actinioides*) of the small intestine were of little importance to the health of the deer herd. The parasitologic and physiologic data

TABLE II

AGE, WEIGHT, SEX, AND CONDITION OF DEER KILLED IN THE CANEY ENCLOSURE AND THE NUMBER OF HELMINTH PARASITES RECOVERED FROM EACH DEER DURING NECROPSY

		Animal Number						
Characteristics		1	2	3	4	5[1]	6	7
	Date Killed	8-20-70	12-3-70	3-4-71	3-4-71	3-4-71	3-4-71	3-5-71
	Age (yr)	¼	½	2½	8½	1½	1½	1½
	Sex	M	M	F	F	M	M	M
	Weight (lb)	42	68	102	105	88	105	100
	Condition	excellent	good	good	good	fair	good	good
Location in host	Parasite							
Brain	*Parelaphostrongylus tenuis*	-	2	6	2	4	-	2
Circulatory System	Microfilaria	-	-	-	-	-	-	48
Lungs	Protostrongylid larvae	-	+	+	+	+	+	+
Abdominal Cavity	*Setaria yehi*	2	-	-	-	-	-	4
Esophagus	*Gongylonema pulchrum*	-	-	18	5	6	1	-
Abomasum	*Ostertagia mossi*			5	35	-	-	-
	Skrjabinagia odocoilei			48	139	186	146	27
	Immature parasites			-	7	-	20	14
	Total abomasal parasites	6	346	71	186	192	167	45
Small Intestine	*Capillaria bovis*	-	-	15	2	7	-	-
	Thysanosoma actinioides	-	-	-	-	-	-	1
	Monesia spp.	-	3	-	-	-	-	-

[1]This deer had an unhealed compound fracture of the right front foot.

> indicate that protostrongylid larvae may be holding the deer herd at a level below that which the food supply could support."

Based on the necropsy results obtained by the graduate student at the University of Arkansas, the preceding statement would appear to apply to the two fawns killed in 1970 as well as the deer killed in 1971.

The protostrongylid larvae deserve special attention because of their unusually high numbers. Until recently P. tenuis was the only protostrongylid recovered from white-tailed deer. However, Prestwood (1972) recovered an unidentified protostrongylid from the musculature of white-tailed deer and described it as a new species, P. andersoni. The adult stages of P. tenuis inhabit the spaces between the meninges of the brain (Anderson 1963) and the adults of P. andersoni inhabit the musculature, but adult females of both species lay eggs which together with developing larvae are carried by the circulatory system to the lungs. Based on the low density of the adult meningeal worms and the high density of protostrongylid larvae in the lungs, it is likely that both P. tenuis and P. andersoni were present in the deer taken from Caney in 1971 as well as in similar collections in 1962 and 1967 (Segelquist et al. 1969). In the lungs, the unhatched eggs and larvae are found in the parenchyma where they form minute enbolisms and cause destruction of tissue. Although there have been no definitive studies of the pathology of either species, the report by the Southeastern Wildlife Disease Study indicates that the larvae are "capable pathogens."

Overall results of necropsies of deer taken from Caney in 1970-71 are essentially the same as necropsies of deer taken from the same enclosure in 1967 and 1962 (Segelquist et al. 1969). Neither were there any differences in the results of necropsies between deer taken from Caney and Big Spring in 1971 (Segelquist *et al*. 1972a).

Mast Yields

Mast measurements include only species producing fruit in late summer and fall. Fruit produced during the spring and early summer was not measured. In addition, fruit produced by low-growing shrubs was not sampled. Of the unsampled mast-bearing species, blackcherry was probably the most numerous. Infrequent plum trees bore fruit, but the various species of *Vaccinium* never produced sizable quantities of fruit despite their abundance. Although there was a wide variety of unmeasured potential by fruit-producing woody species in the enclosure, their total fruit production appeared to be relatively small. Evidently, the dense canopy cover restricted yields. Crawford and Harrison (1971) found that within 4 yr after removing the dense overstory canopy in similar stands in the Missouri Ozarks fruit production of low-growing species increased substantially.

Fall mast yields ranged from a low of 3 ovendry lb per acre in 1968 to 174 lb per acre in 1971 (Table III). White oak and black oak acorns provided the bulk of the yield. Northern red oak acorns and the fruit of flowering dogwood, blackgum, sassafras, and grape made up the remainder.

A common characteristic of mast yields in general and of acorns specifically is the wide variation in size of the annual crop throughout the United States. Collins (1961) in Louisiana, Downs (1944) in the Appalachians, Christisen and Korschgen (1955) in Missouri, and Gysel (1957) in Michigan have all reported on the highly

TABLE III

ANNUAL MAST YIELDS FOR ALL FOREST TYPES COMBINED. YIELDS ARE IN OVENDRY LB PER ACRE

Species	Year 1968	1969	1970	1971
White Oak	2.72	27.21	4.51	60.18
Black Oak	-	4.94	5.33	107.45
Northern Red Oak	-	0.70	-	1.72
Flowering Dogwood	0.21	3.53	0.23	0.70
Blackgum	0.18	0.35	1.08	0.49
Sassafras	-	0.53	-	-
Grape	0.05	1.23	-	3.57
Total Acorns	2.72	32.85	9.84	169.35
Other	0.44	5.64	1.31	4.76
Total Mast	3.16	38.49	11.15	174.11

variable nature of acorn yields. However, efforts to determine the factors responsible for the high variability of acorn yields have been largely unsuccessful.

Goodrum _et al_. (1971) found no relationship between acorn yields and annual precipitation in Louisiana, but on one occasion a late freeze severely limited acorn yields. Yield of the white oak group was depressed in the same year of the freeze and those of the black oak group in the following year. In this study, there was no apparent relationship between the size of the mast crop and precipitation or late freezes.

Sharp and Sprague (1967) reported that good white oak crops occurred in Pennsylvania when comparatively cool periods followed warm periods early in the flowering season allowing male and female flowers to mature at the same time. Efforts to relate heavy white oak yields to this phenomena were unsuccessful, probably because accurate temperature data were not available on the study area.

The importance of mast to deer is widely recognized. Lay (1965) reported that some species of fruit were evident each month of the year in a collection of 2,295 separate pellet groups collected over a 7-yr period in East Texas. Thirty-one different kinds of fruit were identified. Acorns ranked first in occurrence. In a survey conducted from 1948 through 1953, acorns were the principal source of deer food for extended periods in the Missouri Ozarks (Korschgen 1954). Only after all mast was consumed did deer turn to alternate foods.

Yield and Utilization of Native Vegetation

Summer Vegetation

Total vegetation yields in the cedar glade type, under its sparse canopy cover, averaged 185 ovendry lb per acre over the years of the study and was by far the most productive of the four forest types (Table IV). Grasses, grass-like plants, and forbs were extremely abundant, contributing about 80 lb per acre. Ehrenreich and Murphy (1962) also recorded higher vegetation yields in the cedar type than in any other type in the Missouri Ozarks.

The streambottom hardwood forest type averaged 130 lb of dry vegetation per acre and ranked next to the glades in vegetation yields. Herbage was relatively abundant on these moist fertile soils, and ferns were more plentiful than in any other type. In spite of the fact that the glades and streambottoms were the most productive forest types, their importance as contributors to the total vegetation yield was minimized by their small acreage. The glades comprised about 4 percent of the area and the streambottoms only 3 percent.

The two types that were least productive, the upland hardwood and pine-hardwood forests, made up 93 percent of the total area and were the major contributors of forage. During the 4 yr in which yields were measured, the upland pine-hardwood type averaged 103 ovendry lb of vegetation per acre (Table IV), but herbaceous vegetation was scarce, yielding only about 10 lb per acre. The heavily shaded upland hardwood type was the least productive and averaged only about 70 ovendry lb per acre. Grasses, grass-like plants, and forbs were especially scarce, but shade-tolerant ferns were relatively abundant.

TABLE IV

AVERAGE SUMMER VEGETATION YIELDS BY VEGETATION CLASS AND FOREST TYPE FROM 1968 THROUGH 1971. YIELDS ARE IN OVENDRY LB PER ACRE

Vegetation Class	Forest Type: Upland Hardwood	Upland Pine-Hwd.	Cedar Glade	Streambottom Hardwood	Average for All Types
Grasses and Grass-likes	3.18	5.32	40.82	26.50	9.25
Forbs	2.74	6.47	38.78	22.94	8.93
Ferns	6.87	0.22	0.44	7.23	4.17
Preferred Browse	32.57	54.81	40.02	38.63	41.04
Nonpreferred Browse	24.29	36.22	65.12	35.13	32.60
Total Vegetation	69.65	103.04	185.18	130.43	95.99

In 1968, total summer vegetation yields for all types combined averaged 91 ovendry lb per acre (Table V). Herbaceous species contributed 17 lb per acre and browse made up the remainder. Average summer yields increased to 101 ovendry lb per acre in 1969. Herbaceous species produced 29 lb per acre and were responsible for all of the increase. Summer yields averaged 95 and 98 ovendry lb per acre in 1970 and 1971, with herbage making up 20 and 23 lb respectively.

Highest forage yields occurred in 1969, coinciding with the period of highest annual rainfall (Appendix Table XXXIX). This probably stimulated the growth of short-lived annuals accounting for the increased productivity in herbaceous species. Variations in sampling procedures may have resulted in minor discrepancies in estimated yields, but 95 percent confidence intervals for annual means overlapped each year of the study, indicating little change in vegetation yields. In fact, yields in Caney have varied only moderately since 1963 (Segelquist et al. 1969) with lowest yields generally coinciding with below-average rainfall and peak yields with near- or above-average precipitation. This is a reflection of the continuous canopy cover in the enclosure which restricts understory vegetation. Although there has been no cutting in the area for several years, logging and timber-stand-improvement practices on the Sylamore Experimental Forest, as on most Forest Service lands in the Ozarks prior to the recent policy of clearcutting, consisted only of selectively removing scattered individual trees. This system creates small openings which close quite rapidly and does not greatly increase understory vegetation (Murphy and Ehrenreich 1965).

TABLE V

ANNUAL SUMMER VEGETATION YIELDS BY VEGETATION CLASS FOR ALL FOREST TYPES COMBINED. YIELDS ARE IN OVENDRY LB PER ACRE

Year	Vegetation Class					
	Grasses and Grass-Likes	Forbs	Ferns	Preferred Browse	Non-Preferred Browse	Total Vegetation
1968	7.10	6.86	3.09	36.52	36.93	90.50±13.04[1]
1969	13.17	11.84	4.30	39.34	31.92	100.57±14.67
1970	7.23	7.59	5.44	43.79	31.27	95.32±16.35
1971	9.50	9.42	3.86	44.52	30.26	97.56±14.05
Average for All Years	9.25	8.93	4.17	41.04	32.60	95.99

[1]±95 percent confidence intervals.

During all years of the study forbs, grasses and grass-likes, and ferns contributed an average of 9, 9, and 4 percent, respectively, of the total vegetation yield. Browse constituted the remaining 77 percent, with species preferred by deer comprising 43 percent of the yield and nonpreferred species the remaining 34 percent (Appendix Table XL).

Browse yields were recorded by species or species groups throughout the study, but because of the relatively small amounts that each contributed to the total yield, it is difficult to compare yearly changes. More than 45 species or species groups were recorded, but only 12 of these contributed an average of 1 lb or more to the 4-yr average yield (Table VI). Seven were preferred by deer and five were nonpreferred.

Winter Vegetation

As in the summer, there was more vegetation on the cedar glades than on any other forest type (Table VII), but even on the glades there was only 26 lb per acre. In the upland hardwood type, winter vegetation availability averaged about 15 lb per acre.

Total vegetation estimates for all types combined varied from 15 to 19 ovendry lb per acre from 1969 through 1972 (Table VIII). Deciduous browse twigs made up 68 percent of the combined average winter vegetation over the 4-yr period. Most appraisals of winter forage for deer include only estimates of browse availability. Ripley and McClure (1963) reported on the winter browse yields in the forests of northern Georgia, Moore and Strode (1966) reported on the winter browse in the Uwharrie National Forest in North Carolina, and

TABLE VI

AVERAGE ANNUAL SUMMER YIELDS OF THE 12 MOST ABUNDANT SPECIES OR SPECIES GROUPS OF BROWSE. YIELDS ARE IN OVENDRY LB PER ACRE

Species	1968	1969	1970	1971	Average for All Types
Preferred					
Cornus florida	13.32	12.82	16.58	18.21	15.23
Sassafras albidum	3.15	4.23	5.16	3.78	4.08
Vaccinium stamineum	3.55	2.52	2.66	3.63	3.09
V. vacillans	6.26	7.68	8.21	7.89	7.51
Acer rubrum	3.73	2.53	1.14	2.19	2.39
Vitis spp.	2.69	3.20	4.44	2.62	3.23
Smilax spp.	1.55	1.80	2.62	3.02	2.24
Nonpreferred					
Carya spp.	11.19	8.83	8.43	9.08	9.38
Ostrya virginiana	2.00	3.01	2.76	3.16	2.73
Quercus alba	12.17	6.94	8.14	5.81	8.26
Q. stellata	4.04	4.38	3.68	3.73	3.95
Q. velutina	4.30	0.53	3.06	2.91	2.70

TABLE VII

AVERAGE AMOUNT OF WINTER VEGETATION AVAILABLE IN MARCH BY VEGETATION CLASS AND FOREST TYPE FROM 1969 THROUGH 1972. YIELDS ARE IN OVENDRY LB PER ACRE

Vegetation Class	Forest Type: Upland Hardwood	Upland Pine-Hwd.	Cedar Glade	Streambottom Hardwood	Average for All Types
Grasses and Grass-Likes	0.50	0.94	4.46	1.44	1.07
Forbs	0.07	0.28	2.48	0.40	0.37
Ferns	4.83	0	0.04	5.52	2.96
Preferred Browse	5.30	8.75	6.42	6.26	6.62
Nonpreferred Browse	3.96	7.08	12.39	5.57	5.63
Total Vegetation	14.68	17.08	26.17	19.20	16.65

TABLE VIII

ANNUAL WINTER VEGETATION AVAILABLE IN MARCH BY VEGETATION CLASS FOR ALL FOREST TYPES COMBINED. YIELDS ARE IN OVENDRY LB PER ACRE

	Vegetation Class					
Year	Grasses and Grass-Likes	Forbs	Ferns	Preferred Browse	Non-Preferred Browse	Total Vegetation
1969	1.10	0.30	1.75	6.20	6.05	15.40
1970	1.33	0.39	2.84	6.12	5.40	16.08
1971	1.05	0.43	4.33	7.14	6.06	19.01
1972	0.80	0.38	2.92	7.01	5.03	16.14
Average for All Years	1.07	0.37	2.96	6.62	5.63	16.65

Segelquist and Pennington (1972) described winter browse on the Ouachita National Forest of Arkansas. In all of these studies total winter browse ranged from 12 to 58 ovendry lb per acre, and the desirable or preferred species frequently made up one-half or less of the total yield. Browse appraisals, however, give only a partial clue to the availability of winter food for deer. Studies by Dunkeson (1955) in the Missouri Ozarks, as well as others from many regions of the United States, indicate that browse forms only a relatively small portion of the winter diet of white-tailed deer. In this study, green forbs, grasses, and grass-like plants in combination with preferred evergreen browse averaged less than 2 lb per acre annually. Thus, the amount of preferred winter forage available to deer was very limited in the Caney enclosure even when all forage classes were combined.

Utilization of Native Vegetation

Based on utilization estimates made in August each year from 1968 through 1971, consumption of native summer forages was restricted largely to herbaceous vegetation and perhaps to leaves of deciduous browse species. There was almost no evidence of foraging on woody browse twigs. Estimates of the quantities of forage eaten averaged less than 1 ovendry lb per acre each summer. This was less than 0.5 lb of forage per day for each deer in the enclosure during the growing season.

Evidence of browsing on deciduous twigs became somewhat more apparent during the winter, but March estimates of browse utilization were still extremely low. Utilization of flowering dogwood twigs, the most heavily browsed species, ranged from only 1 to 6 percent from

1968 through 1972. There was no evidence of utilization on most species of browse encountered on vegetation quadrats.

According to Dunkeson (1955), who spent much time in the field observing the feeding habits of tame deer, much of the effects of foraging by deer cannot be detected by examining growing plants on the range. New growth soon obliterates signs of foraging, delicate feeding on aments and overwintering green plants cannot be seen, and some food plants are eaten in their entirety. Thus, it is not surprising that the biannual utilization estimates in this study accounted for only a small fraction of the foods that must have been eaten by deer over an annual period.

Native Vegetation Yields in Exclosures

Total yields in the six exclosures in which vegetation was protected from deer averaged 130 and 123 ovendry lb per acre respectively in 1969 and 1971 (Table IX). Heaviest yields were recorded in the cedar glades with progressively lighter yields in the upland pine-hardwood and upland hardwood forest types (Table X). There were no exclosures located in the streambottom hardwood forest type.

Grasses and grass-like plants, forbs, and ferns contributed 12, 20, and 1 percent of the average vegetation yields for the 2 yr that exclosures were measured. Preferred browse made up 41 percent of the total yield and nonpreferred species formed the remaining 26 percent (Appendix Table XLI).

Comparisons of vegetation yields in the six 1-acre exclosures protecting forages from deer to yields in the remainder of the

TABLE IX

AVERAGE ANNUAL SUMMER VEGETATION YIELDS BY VEGETATION CLASS FOR THE SIX EXCLOSURES COMBINED. YIELDS ARE IN OVENDRY LB PER ACRE

	Vegetation Class					
Year	Grasses and Grass-Likes	Forbs	Ferns	Preferred Browse	Non-Preferred Browse	Total Vegetation
1969	17.88	27.65	1.54	52.91	29.78	129.76±24.44[1]
1971	13.64	22.06	0.18	50.42	36.37	122.62±18.92

[1]±95 percent confidence intervals.

TABLE X

AVERAGE VEGETATION YIELDS BY VEGETATION CLASS AND FOREST TYPE IN THE SIX EXCLOSURES COMBINED FOR 1969 AND 1972. YIELDS ARE IN OVENDRY LB PER ACRE

Vegetation Class	Forest Type: Upland Hardwood	Upland Pine-Hwd.	Cedar Glade	Averages for All Types
Grasses and Grass-Likes	3.69	0.50	43.12	15.77
Forbs	9.85	9.98	54.71	24.85
Ferns	0.42	-	2.17	0.86
Preferred Browse	51.24	67.56	36.40	51.73
Nonpreferred Browse	18.84	27.86	52.76	33.15
Total Vegetation	84.04	105.90	189.16	126.36

enclosure where deer could forage at will revealed no differences that could be attributed to utilization (Table XI). During the interval from 1969 to 1971, yields of preferred browse increased where available to deer, but decreased where deer were excluded. Yields of nonpreferred browse during this same interval increased in exclosures and decreased elsewhere. Such changes are the reverse of what would be expected if utilization by deer was influencing changes in vegetation composition. The changes recorded are probably attributable to variations in sampling procedures rather than to environmental factors.

Exclosures are commonly used to measure the effects of foraging by deer on vegetation composition and growth. Halls and Crawford (1960) noted that vegetation in the Sylamore region generally responded immediately to protection from heavy use afforded by exclosures during the interval from 1947 to 1956. However, where the canopy cover was very dense there was no response to reduced pressure from deer. Evidently the canopy cover in Caney was so dense and foraging was so light that there was no response to protection during this study.

Forage Yield and Utilization on Forage Clearings

Spring and Summer Cover Crops

Lespedeza was heavily fertilized in the spring of 1968, the year it was originally planted, and yields averaged 1,053 ovendry lb per acre (Table XII). After 1968, spring and summer cover crops consisted of volunteer stands of lespedeza mixed with fall-planted ladino clover. These stands were not fertilized and yields declined from 884 to 480 ovendry lb per acre from 1969 to 1971. Weeds, principally green

TABLE XI

CHANGES IN VEGETATION YIELDS FROM 1969 TO 1971 IN AREAS WHERE FORAGES WERE AVAILABLE TO DEER AND IN EXCLOSURES WHERE THEY WERE PROTECTED

Vegetation Class	Percent Change in Yields	
	Available to Deer	Protected from Deer
Grasses and Grass-Likes	-28	-24
Forbs	-20	-20
Preferred Browse	+13	- 5
Nonpreferred Browse	- 5	+22
Total Vegetation	+ 5	- 4

TABLE XII

ANNUAL YIELDS OF SUMMER LEGUMES ON CANEY FORAGE CLEARINGS. YIELDS ARE IN OVENDRY LB PER ACRE

Year	Clearing No. 1	2	3	4	Average for all Clearings
1968	2187±541 a[1]	1745±335 b	1963±1176 b	1893±1007 a	1953±216 [2]
1969	1126±255 ac	603± 56 bc	790± 583 bc	1180± 966 ac	884± 55
1970	711± 46 ac	677± 63 bc	952± 410 bc	460± 249 ac	698± 34
1971	559±103 ac	552± 89 bc	263± 155 bc	308± 103 ac	480± 59

[1]a = Korean lespedeza
b = Kobe lespedeza
c = Ladino clover

[2]±95 percent confidence interval.

foxtail (Setaria viridis (L.)), common ragweed (Ambrosia artemisifolia L.), and crab grass (Digitaria ischaemum (Schred.) Muhl.), which were not included in yield estimates, became increasingly abundant in succeeding years, contributing to reduced yields of summer legumes.

Utilization was not estimated because of the apparent light grazing pressure. Contrary to the relatively heavy use of Korean lespedeza recorded in Missouri by Korschgen (1954), there was never any indication that either Korean or kobe lespedeza was being eaten by deer to any extent. However, following the planting of ladino clover in the fall of 1968, clover became a regular part of the spring and summer diet. Fawns were commonly seen on food plots during the 1969 growing season, but evidence of grazing on clover was not pronounced until just prior to the time that food plots were tilled in preparation for planting winter forage crops. Clover leaves were cropped just below the point where the leaflets joined the petiole, but the petioles and stems were not eaten, thus the total quantity of clover eaten appeared to be relatively small. Similar grazing was evidenced in subsequent years. In contrast, 100 percent utilization of ladino clover was recorded on food plots in Virginia during the spring of 1964 (Larson 1966).

Ladino clover is one of the most popular of all the forage species planted for deer, as is indicated by its frequent inclusion in forage mixtures used for wildlife food plantings on power line rights-of-way (Arner 1951) and forage clearings (Moore et al. 1964). According to Larson (1966) yields as high as 796 ovendry lb per acre have been obtained from wildlife food plots planted solely to ladino clover; but as was noted in this study as well, its usefulness as deer food is limited by its failure to produce green forage prior to the appearance of new growth on native vegetation. The low utilization of ladino clover and Korean lespedeza, two of the most highly preferred species of cultivated legumes in the U. S., apparently indicates that seasonal native forages were available in sufficient quantities to satisfy the deer in Caney during the spring and summer.

Annual Fall and Winter Crops

In the fall of 1968 only 3.7 acres were planted to elbon rye and ladino clover. Yields on the four food plots averaged 1,980 ovendry lb per acre (Table XIII) for a total on all plots of 7,344 ovendry lb of forage. An estimated 98 percent of the total forage was eaten by deer during the winter. Elbon rye made up almost all of the winter yields in 1968-69 as it did in subsequent years since ladino clover did not produce substantially until the warmer spring months.

After the first year, approximately 7.4 acres were planted to annual winter crops each year. Yields averaged 1,678 ovendry lb per acre in the winter of 1969-70 (Table XIV). Total yields for all plots combined were 12,448 lb of dry forage of which deer consumed an estimated 56 percent.

In 1970-71 the food plots produced 1,303 ovendry lb of forage per acre or a total of 9,667 lb (Table XV). This reduced yield was probably the result of moisture stress in late winter since rye made very good growth during the fall and early winter when moisture was plentiful. Deer took 57 percent of the total winter growth.

Forage yields on the four food plots averaged 1,824 ovendry lb per acre during the winter of 1971-72 (Table XVI). Total forage

TABLE XIII

PRODUCTION AND UTILIZATION OF ELBON RYE DURING THE WINTER OF 1968-69. ALL WEIGHTS ARE ON AN OVENDRY BASIS

Clearing Number	Acreage	Items Measured	Sep. 15 to Jan. 14	Jan. 15 to Apr. 7	Sep. 15 to Apr. 7
1	0.94	lb/ac produced	479±304[1]	990±476	1469
		total lb produced	450	931	1381
		lb eaten	450	878	1328
		percent eaten	100	94	96
2	1.79	lb/ac produced	1768±582	588±235	2356
		total lb produced	3165	1053	4218
		lb eaten	2692	1471	4163
		percent eaten	85	140	99
3	0.43	lb/ac produced	765±651	830±132	1593
		total lb produced	328	357	685
		lb eaten	328	332	660
		percent eaten	100	93	96
4	0.55	lb/ac produced	580±141	1348±596	1928
		total lb produced	319	741	1060
		lb eaten	319	705	1021
		percent eaten	100	95	96
All Clearings Combined	3.71	lb/ac produced	1149±345	831±166	1980
		total lb produced	4262	3082	7344
		lb eaten	3789	3386	7155
		percent eaten	89	110	98

[1]±95 percent confidence intervals.

TABLE XIV

PRODUCTION AND UTILIZATION OF ELBON RYE DURING THE WINTER OF 1969-70. ALL WEIGHTS ARE ON AN OVENDRY BASIS

Clearing Number	Acreage	Items Measured	Sep. 15 to Feb. 9	Feb. 10 to Apr. 6	Sep. 15 to Apr. 6
1	1.88	lb/ac produced	340±90[1]	1242±193	1582
		total lb produced	639	2335	2974
		lb eaten	639	1265	1904
		percent eaten	100	54	64
2	3.58	lb/ac produced	526±271	1298±156	1824
		total lb produced	1883	4646	6529
		lb eaten	762	2137	2899
		percent eaten	40	46	44
3	0.86	lb/ac produced	459±209	1007±217	1466
		total lb produced	394	866	1260
		lb eaten	394	701	1095
		percent eaten	100	81	87
4	1.10	lb/ac produced	445±82	1086±293	1531
		total lb produced	490	1195	1685
		lb eaten	490	631	1121
		percent eaten	100	53	67
All Clearings Combined	7.45	lb/ac produced	459±53	1219±110	1678
		total lb produced	3406	9042	12448
		lb eaten	2285	4734	7019
		percent eaten	67	52	56

[1] ±95 percent confidence intervals.

TABLE XV

PRODUCTION AND UTILIZATION OF ELBON RYE DURING THE WINTER OF 1970-71. ALL WEIGHTS ARE ON AN OVENDRY BASIS

Clearing Number	Acreage	Items Measured	Sep. 15 to Jan. 13	Jan. 14 to Apr. 1	Sep. 15 to Apr. 1
1	1.88	lb/ac produced	603±182[1]	308±54	911
		total lb produced	1134	579	1713
		lb eaten	624	470	1094
		percent eaten	55	81	64
2	3.58	lb/ac produced	1086±224	413±154	1499
		total lb produced	3887	1478	5365
		lb eaten	1594	855	2449
		percent eaten	41	58	46
3	0.86	lb/ac produced	788±364	667±130	1455
		total lb produced	677	573	1250
		lb eaten	677	400	1077
		percent eaten	100	70	86
4	1.10	lb/ac produced	483±142	737±171	1220
		total lb produced	531	810	1341
		lb eaten	270	631	901
		percent eaten	51	78	67
All Clearings Combined	7.42	lb/ac produced	839±134	464±46	1303
		total lb produced	6225	3442	9667
		lb eaten	3165	2356	5521
		percent eaten	51	68	57

[1]±95 percent confidence intervals.

TABLE XVI

PRODUCTION AND UTILIZATION OF ELBON RYE DURING THE WINTER OF 1971-72. ALL WEIGHTS ARE ON AN OVENDRY BASIS

Clearing Number	Acreage	Items Measured	Sep. 15 to Jan. 13	Jan. 14 to Apr. 1	Sep. 15 to Apr. 1
1	1.88	lb/ac produced	1339±491[1]	945±114	2284
		total lb produced	2517	1777	4294
		lb eaten	680	540	1220
		percent eaten	27	30	28
2	3.58	lb/ac produced	685±206	873±148	1558
		total lb produced	2452	3125	5577
		lb eaten	196	558	754
		percent eaten	8	18	14
3	0.86	lb/ac produced	673±392	912±372	1885
		total lb produced	579	784	1363
		lb eaten	0	213	213
		percent eaten	0	27	16
4	1.10	lb/ac produced	1240±517	905±242	2145
		total lb produced	1364	996	2360
		lb eaten	218	0	218
		percent eaten	16	0	9
All Clearings Combined	7.42	lb/ac produced	924±180	900±253	1824
		total lb produced	6856	6678	13534
		lb eaten	1028	1254	2282
		percent eaten	15	19	17

[1]±95 percent confidence intervals.

yields were the greatest ever recorded with 13,534 lb produced, but utilization by deer was the lightest on record, amounting to only 17 percent.

Elbon rye offers early fall and midwinter growth, but if it is not properly managed its lush foliage may lodge, lie flat on the ground, retarding subsequent growth (Allen and Ellzey 1970). This may be the reason that highest yields per acre coincided with the period of greatest utilization. Although production of elbon rye did not equal the dry forage yields of over 2 tons per acre obtained by the Louisiana Dairy and Pasture Experiment Station (Allen and Ellzey 1970), it compared very favorably with yields of eight other domestic grasses and legumes tested for winter forage on wildlife forage clearings in South Carolina (Webb 1965).

Japanese Honeysuckle Plantings

The yield of honeysuckle was not measured in 1968, the year it was first planted, because individual plants were so small. In the winter of 1968-69 all leaves on the newly established plants were eaten by deer and the twigs were cropped back to a diameter of 0.10 to 0.15 inches. However, this severe browsing did not appear to have any detrimental effect on survival because from 92 to 97 percent of all plants were still alive 30 months after they were planted (Segelquist et al. 1971).

By late summer of 1969, about 16 months after it was planted, honeysuckle averaged 67 ovendry lb per acre or a total of 401 lb of dry forage on all food plots combined (Table XVII). Leaves made up

TABLE XVII

YIELD AND UTILIZATION OF HONEYSUCKLE ON FORAGE CLEARINGS. YIELDS MEASURED IN LATE SUMMER OR EARLY FALL AND UTILIZATION IN MARCH. ALL WEIGHTS ARE ON AN OVENDRY BASIS

Clearing Number	Acreage	Items Measured	1969-70	1970-71	1971-72
1	1.88	lb/ac produced	75±14[1]	323±128	793±118
		total lb produced	141	607	1491
		lb eaten	134	364	45
		percent eaten	95	60	3
2	2.14	lb/ac produced	74±31	203± 59	735±140
		total lb produced	159	435	1573
		lb eaten	151	252	47
		percent eaten	95	58	3
3	0.86	lb/ac produced	46±19	196± 75	664±176
		total lb produced	39	169	571
		lb eaten	37	103	17
		percent eaten	95	61	3
4	1.10	lb/ac produced	58±29	195±106	780±206
		total lb produced	64	214	858
		lb eaten	61	150	26
		percent eaten	95	70	3
All Clearings Combined	5.98	lb/ac produced	67±11	239± 50	750± 75
		total lb produced	401	1431	4485
		lb eaten	381	873	135
		percent eaten	95	61	3

[1]±95 percent confidence interval.

66 percent of the total growth. It was estimated that deer ate 95 percent of all new growth during the winter of 1969-70.

Honeysuckle yields averaged about 239 ovendry lb per acre for a total of 1,431 lb of forage in 1970 (Table XVII). Leaves made up 58 percent of the growth. Based on comparative samples clipped from protected and unprotected plants in March 1971, it was estimated that 61 percent of all growth had been consumed.

By 1971, total yields averaged 750 ovendry lb per acre for a gross yield on all four plots of 4,485 ovendry lb of forage (Table XVII). Leaves made up 49 percent of the growth. Utilization of honeysuckle was very slight during the winter of 1971-72 averaging an estimated 3 percent of the total yield.

The heaviest utilization of honeysuckle occurred when snow covered all other vegetation growing on food plots. Handley (1940) also recorded highest use during heavy snows on Jamestown Island in Virginia.

Leaf retention on honeysuckle was excellent throughout the winter months from 1968-69 through 1970-71. On plants protected by wire cages the percent that leaves contributed to the total quantity of honeysuckle available was essentially the same in late winter as in fall. This varied from about 50 to 66 percent. However, during the winter of 1971-72, leaves remaining on protected plants in late winter made up only about 1 to 2 percent of the total honeysuckle available. All leaves did not drop simultaneously, but fell gradually throughout the winter. Thus, some green leaves were available all winter long. Leaf drop apparently began after a severe ice storm.

Honeysuckle yields on the Caney forage clearings had not reached maximum productivity in 1972 because the plants were still young, but they were already comparable to the 697-to-948 ovendry lb per acre produced in dense natural stands in upland and bottomland hardwood forests in western Louisiana (Craft and Haygood 1972). They had not matched the growth of over 2 tons per acre achieved by Lay (1968) on fertilized plantings in East Texas.

The importance of Japanese honeysuckle as a source of forage for deer has long been recognized (Handley 1940), but not until recently had the magnitude of its importance been realized. A report by Harlow and Hooper (1971) on analyses of rumen contents of 956 deer taken from six southeastern states indicated that honeysuckle was eaten in every season of the year and that it made up as much as 38 percent of the total winter diet in some areas. Other wildlife biologists have also documented the desirability of Japanese honeysuckle for deer, but it has probably received more attention from foresters trying to control it than from wildlife biologists trying to propagate it.

Foresters contend that honeysuckle seriously interferes with establishing young pine trees and that it must be controlled where timber production is the prime objective (Nelson 1957). For this reason much time and effort have been expended developing means to control it (Hitchcock and Zimmerman 1948, Brender 1960, and Bruner 1967). However, the increasing awareness of the importance of honeysuckle to wildlife has resulted, in recent years, in a growing effort on the part of wildlife managers to develop means to manage it for maximum productivity (Craft and Haygood 1972).

Use of Forage Clearings by Deer

Observation Data

A total of 864 man hours was spent observing deer activities on the four forage clearings from August 1970 through July 1971. During this period 200 sightings were recorded. Feeding was the principal activity engaged in by deer while on cultivated openings.

Practically all feedings on clearings were restricted to the annual crops. Deer were observed feeding on honeysuckle only twice and then for only very brief periods. There may have been some feeding on honeysuckle that was not observed because vegetation on the portion planted to honeysuckle on each food plot was often several feet high and may have obscured deer from view, but such instances were probably very few.

Some deer were frightened away by observers. At night, the spotlight beam occasionally scared deer from the plot, especially when it was shined directly into their eyes. Consequently, care was taken to keep the beam above the level of a deer's head whenever possible. Noises made by the observer moving about in the blind also frightened some deer. However, the observer's scent seemed to be the most probable factor in frightening deer away from the forage clearings. When the wind was blowing in the direction of feeding deer, no matter how gently, they would move off the clearing. At times deer would return to the same clearings where they were first seen feeding and at other times they would go to another clearing or simply remain in the woods. For this reason, the number of sightings may have been inflated; but at the same time, the length of time that deer spent on clearings was probably shortened by the observer's presence.

The length of the average feeding period for deer, excluding those frightened away from clearings within the first 15 min, was 35 min (Table XVIII). This is based on 140 sightings and 91.8 hr of deer feeding time.

In order to compare numbers of sightings for different periods, it was necessary to adjust the data since the population varied from 13 to 25 animals during the observation period. This was accomplished by weighing or expanding the results during periods of low population levels and expressing them on the basis of a hypothetical stable population level of 25 animals. From this weighted data several facts are evident.

More deer utilized forage clearings from November through February than at any other time (Table XIX). This coincided with the period when native forage availability was least and all of the relatively small mast crop had been expended. The fewest deer were observed in September just after that portion of each clearing usually in annual crops had been planted and for all practical purposes consisted of bare soil.

Most of the activity on forage clearings was restricted to the time period from 1600 to 0400 hr (Table XIX). As a rule, deer would move onto clearings shortly before dusk, feed heavily for a time, and then leave. Throughout the night they would move back and forth between clearings and the surrounding forest at irregular intervals. There was little activity on clearings during the daylight hours. Michael (1970) found that the majority of feeding occurred during

TABLE XVIII

AVERAGE NUMBER OF MIN SPENT BY EACH DEER FEEDING ON FORAGE CLEARINGS FROM AUGUST 1970 THROUGH JULY 1974

	Time						
Date	0000 0400	0401 0800	0801 1200	1201 1600	1601 2000	2001 2400	Total
August	0	1.4	0	2.4	2.4	7.2	13.4
September	0	0	0	0	0	1.3	1.3
November	9.0	0	0	0	44.0	11.0	64.0
January	13.9	0	0	0	30.8	0.1	44.8
February	14.4	0.1	0	0	27.0	8.2	49.7
March	22.2	0	0	0	19.4	0	41.6
May	0.4	0	0	0	1.3	13.3	15.0
June	5.1	1.3	0	0	18.9	10.7	36.0
July	32.1	0.1	0.4	0	1.3	11.1	45.0
Average for All Months	10.8	0.3	0.1	0.3	16.1	7.0	34.5

TABLE XIX

PERCENT OF DEER SIGHTINGS RECORDED FOR EACH OBSERVATION PERIOD FOR ALL CLEARINGS FROM AUGUST 1970 TO JULY 1971. DATA ARE ADJUSTED TO A HYPOTHETICAL STABLE POPULATION LEVEL

	Time						
Date	0000 0400	0401 0800	0801 1200	1201 1600	1601 2000	2001 2400	Total
August	0.00	0.39	0.00	0.39	1.93	1.55	4.26
September	0.39	0.00	0.00	0.00	0.39	0.39	1.17
November	3.10	0.30	0.00	0.00	9.69	4.65	17.83
January	4.26	0.00	0.00	0.00	9.30	1.16	14.72
February	4.65	0.39	0.00	0.00	10.08	4.65	19.77
March	6.59	0.00	0.00	0.00	5.04	0.00	11.63
May	0.78	0.00	0.00	0.00	0.78	5.04	6.60
June	2.71	1.55	0.00	0.00	2.71	4.26	11.23
July	4.26	1.55	0.78	0.00	1.55	4.65	12.79
Total for All Months	26.74	4.27	0.78	0.39	41.47	26.35	100.0

the daylight hours with peaks near sunrise and sunset in south Texas deer. If deer in the Caney enclosure were feeding during the daylight hours they were feeding wholly within the forested areas; however, belled deer were seldom heard moving during the daylight period.

Another important factor of interest was the amount of time deer spent on various forage clearings. Several times during the study the same deer were seen, or specific belled deer were heard, on or adjacent to more than one of the clearings during the same 4-hr observation period. Over the entire course of the study several of the same deer were seen on all four clearings. Thus, all forage clearings were apparently used by all deer. There was relatively little difference in the total percent of sightings on the various forage clearings (Table XX). However, in terms of sightings per acre there was an inverse relationship between the size of the clearings and the number of sightings. There were, in order of descending clearing size; 92, 51, 32, and 18 weighted sightings per acre on the four cultivated clearings. There were about five times as many deer sighted per acre on the smallest clearings as on the largest ones.

Pellet Group Counts

All pellet groups deposited on transect lines making up 10 percent of each wildlife forage clearing were counted at approximately 3-wk intervals from the early fall until the early spring in 1970-71 and 1971-72. These data provide an index to the relative amount of time spent on forage clearings by deer and serve to supplement observation data and utilization estimates on clearings.

TABLE XX

PERCENT OF DEER SIGHTINGS RECORDED ON EACH FORAGE CLEARING FROM AUGUST 1970 TO JULY 1971. DATA ARE ADJUSTED TO A HYPOTHETICAL STABLE POPULATION LEVEL

Month	Clearing Number			
	1	2	3	4
August	0.76	3.46	0.00	0.00
September	0.00	0.00	0.76	0.38
November	3.07	5.38	8.84	0.76
January	1.15	2.69	3.84	7.30
February	1.53	2.69	8.46	7.30
March	5.00	0.76	5.00	0.76
May	0.76	5.00	0.00	0.76
June	5.00	3.46	1.53	1.53
July	5.38	1.92	1.92	2.69
Total for All Months	22.65	25.36	30.35	21.48

A total of 79 pellet groups were counted on all cultivated clearings in 1970-71 when mast yields were low, but only three groups were counted in 1971-72 when mast was plentiful. As with the observation data, it was necessary to adjust pellet group information to a common basis in order to take into account changing population levels. This was done by adjusting all counts to a common basis just as with the observation data. Because of the very small number of groups counted in 1971-72, these results were not tabulated.

In 1970-71, approximately 75 percent of all pellet groups were counted from January 4 through March 1, the period when native forages and mast were least available (Table XXI). The largest of the forage clearings received the greatest total number of pellet groups, but the smallest clearing received the largest number of groups per acre. The total number of adjusted pellet groups per acre on each clearing, in order of ascending clearing size, for the entire 210 days that pellet groups were counted were 163, 127, 74, and 134. Deer apparently concentrated on the smallest clearing to a greater extent than they did on the largest one. This was also evidenced by utilization estimates and observation data.

Rumen Analyses of Deer Killed for Necropsies

Rumen analyses of the five deer removed from Caney in March 1971 revealed that elbon rye composed 96 percent of all foods eaten (Table XXII). Honeysuckle leaves made up 1 percent of the contents while dead browse leaves and mushrooms contributed about 2 and 1 percent, respectively. Honeysuckle twigs, dogwood twigs, pine needles, and acorns were all present in trace amounts. Over 97 percent of all foods

TABLE XXI

PERCENT OF PELLET GROUPS COUNTED ON EACH FORAGE CLEARING DURING VARIOUS PERIODS. DATA ARE ADJUSTED TO A HYPOTHETICAL STABLE POPULATION LEVEL

Date of Count	Days Since Last Count	Clearing Number 1	2	3	4	Total
10-6-70	22	0.00	0.00	0.00	0.00	0.00
10-26-70	20	0.00	0.00	0.00	0.00	0.00
11-16-70	21	0.00	0.00	0.00	0.00	0.00
12-7-70	21	2.22	3.33	0.00	1.11	6.66
1-4-71	28	0.00	0.00	0.00	0.00	0.00
1-8-71	14	3.33	22.22	1.11	3.33	29.99
2-12-71	25	1.11	5.55	3.33	4.44	14.43
3-1-71	17	4.44	17.77	5.55	2.22	29.98
3-23-71	22	0.00	0.00	4.44	0.00	4.44
4-12-71	20	4.44	4.44	1.11	4.44	14.43
4-12-71	210	15.54	53.31	15.54	15.54	99.93

eaten came from cultivated forage clearings. Rumen contents of five deer taken in March 1971 from the Big Spring enclosure, which lacked forage clearings, showed that forbs, eastern redcedar, dead deciduous browse leaves, and mushrooms made up 91 percent of the diet (Table XXIII).

To indicate that forages produced on cultivated clearings were responsible for differences in rumen contents between the two enclosures, rumen analyses of five deer taken from each area in March 1967, prior to the construction of forage clearings in Caney, are included in Table XXIV. For these 10 deer, native green forages contributed 49 percent of the forage eaten while making up only 11 percent of the vegetation in the habitat (Segelquist _et al_. 1972b). Grasses and sedges constituted 33 percent whereas forbs and eastern redcedar each made up 8 percent. On the other hand, deciduous browse twigs constituted about 69 percent of the vegetation available in the two enclosures, but only 30 percent of that eaten. With this preference for green forage it is not surprising that deer in Caney concentrated on forage clearings where green forages were most plentiful in March 1971.

Estimation of Forage Quality

Forage quality is usually defined in relation to animal responses such as feed intake, weight gain, or milk production, but it can also be expressed in terms such as palatability, nutritive composition, digestibility, energy content, and ruminal end products (Dietz 1970). Techniques for determining quality include chemical analyses, feeding trials, _in vitro_ rumen techniques, and grazing trials (Dietz 1970).

TABLE XXII

RUMEN CONTENTS, IN PERCENT DRY WEIGHT, OF DEER KILLED IN CANEY IN MARCH 1971

Deer Number	Elbon Rye	Honeysuckle Leaves	Honeysuckle Twigs	Dogwood Twigs	Pine Leaves	Dead Leaves	Mushrooms	Acorns
1	81	6	T	2	0	2	9	0
2	94	1	2	0	0	T	0	3
3	96	1	0	0	T	2	1	0
4	97	0	0	0	0	3	0	0
5	99	0	0	0	0	1	0	0
Average for All Deer	96	1	T	T	T	2	1	T

TABLE XXIII

RUMEN CONTENTS, IN PERCENT DRY WEIGHT, OF DEER KILLED IN MARCH 1971 IN THE BIG SPRING ENCLOSURE WHERE THERE WERE NO FORAGE CLEARINGS

Deer Number	Grasses & Sedges	Forbs	Eastern Redcedar	Dogwood Twigs	Pine Leaves	Dead Leaves	Fungi	Acorns	Unknown
1	0	11	71	11	0	7	0	T	0
2	6	9	58	6	T	21	0	0	0
3	T	0	16	T	0	40	8	0	35
4	T	6	53	3	T	38	0	0	0
5	1	59	3	2	T	3	32	0	0
Average for All Deer	1	27	35	4	T	15	14	T	4

TABLE XXIV

RUMEN CONTENTS, IN PERCENT DRY WEIGHT, OF TEN DEER, FIVE TAKEN EACH FROM CANEY AND BIG SPRING IN MARCH 1967, WHEN THERE WERE NO FORAGE CLEARINGS IN EITHER ENCLOSURE

Item	Caney	Big Spring
Acorns	19	13
Grasses & Sedges	39	17
Forbs	6	8
Ferns	-	T
Eastern redcedar	3	12
Shortleaf pine	T	-
Flowering Dogwood	4	2
Red maple	-	17
Low blueberries	6	1
Ash	-	1
Plum	-	T
Aromatic sumac	T	-
Serviceberry	T	-
Unidentified Browse	7	9
Dead oak leaves	4	11
Mushrooms	T	T
Unidentified	12	9
Total	100	100

Another technique involves an in vivo procedure in which digestible dry matter is estimated by placing forage samples in nylon bags which are then suspended in the rumen (Harris et al. 1967).

The procedures used in this study included certain chemical analyses, in vitro rumen techniques, and dry matter digestion estimated by the nylon bag procedure. Bovine rumen liquor was utilized for in vitro trials, and in vivo dry matter digestion trials were accomplished with ruminally cannulated goats. White-tailed deer were the preferred animals with which to accomplish the various digestion procedures, but they were not available.

Chemical Analyses

There is a multitude of chemical analyses that have been used to estimate forage quality. Those used in this study include analyses of crude protein, Ca, P, and Mg. The system of forage analysis developed by Van Soest (1965) was also used in the attempt to evaluate forage quality. Duncan's new multiple-range test (Steel and Torrie 1960) was used to compare means of the crude protein analyses and estimated digestibility values computed from the results of the Van Soest system of forage analysis. The results of Ca, P, and Mg trials were not subjected to statistical tests since the relationship of one of these minerals to another is often more important in determining dietary requirements than is the total quantity of the mineral present.

Crude Protein. Protein is one of the most important nutrients required by animals. A serious deficiency results in failure of the body to maintain itself, while even a slight deficiency adversely affects reproduction, lactation, growth, and fattening processes (Morrison 1957). Dietary protein levels for white-tailed deer have been suggested as 13 to 16 percent for optimum growth and as 6 to 7 percent for maintenance (French et al. 1955).

The crude protein content of planted annual crops ranged from 8.9 to 38.9 percent over the two annual periods that forages were sampled (Table XXV) and were above the level required for growth for all seasons with one exception. Crude protein was significantly higher in planted annuals than in any other forage tested for all seasons except in the spring of the first year. The wide variation in the crude protein content of annual crops resulted from forage maturation and changing species composition. Fall and winter samples consisted almost entirely of elbon rye. Spring samples contained rye in various stages of maturity in addition to some ladino clover. Summer samples consisted of ladino clover and lespedeza.

The crude protein content of Japanese honeysuckle leaves ranged from 11.2 to 16.0 percent and ranked next to the annual crops for all seasons during both annual periods except during the first spring when it was highest. The protein content of honeysuckle leaves was consistently above the level required for maintenance. The relatively small variation in the crude protein of honeysuckle leaves can be attributed to its lengthy period of active growth and its semi-evergreen nature. Honeysuckle begins growth at temperatures of 34 to 48 F (Brender 1960), consequently, it has a longer growing season than many of the native browse species. The twigs of Japanese honeysuckle contained only 4.5 to 7.5 percent protein and were

TABLE XXV

CRUDE PROTEIN CONTENT AS A PERCENT OF OVENDRY WEIGHT FOR FORAGES COLLECTED OVER TWO ANNUAL PERIODS. MEANS HAVING THE SAME LETTER IN THEIR SUPERSCRIPTS ARE NOT SIGNIFICANTLY DIFFERENT ($P < 0.05$)

	Year 1				Year 2			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	11.2	12.8	13.7	15.9	13.7	14.5	12.3	16.0
Japanese Honeysuckle Twigs	4.5^{a}	4.6^{a}	5.2	6.6	5.0^{a}	5.6^{a}	4.6	7.5
Annual Crops	15.7	38.5	19.7	8.9	23.8	31.2	25.2	17.8
Flowering Dogwood Leaves	7.9^{bc}	7.4^{b}	9.7^{a}	12.9	9.6^{b}	7.8^{b}	9.0^{a}	11.7
Flowering Dogwood Twigs	3.7^{a}	5.1^{a}	8.0^{b}	4.8	4.1^{a}	6.3^{a}	6.1	5.5^{a}
Eastern Redcedar	7.1^{cd}	7.4^{b}	7.5^{b}	7.8^{a}	7.4^{c}	8.4^{b}	8.5^{a}	6.1^{a}
Panic Grasses	8.8^{b}	7.3^{b}	10.1^{a}	10.6	9.1^{bd}	7.6^{b}	9.5^{a}	14.7
Pussytoes	6.4^{d}	7.0^{b}	7.0^{b}	8.2^{a}	8.4^{cd}	8.1^{b}	8.7^{a}	9.8

frequently below the level required for maintenance and were often the lowest of all forages tested.

The protein content of the native species seldom reached the level required for optimum growth, but it was generally above the level required for maintenance in all forages except dogwood twigs. Of the native species, panic grasses were highest in crude protein during each winter, averaging 9.5 and 10.1 percent respectively (Table XXV). Dogwood leaves and panic grasses averaged 7.9 and 8.8 percent in the summer of the first year and 9.6 and 9.1 percent, respectively, during the second summer. These two ranked the highest of all native forages during these seasons. The same two forages were also highest in protein content during the spring of both years, averaging in the same order, 12.9 and 10.6 percent the first year and 11.7 and 14.7 the second. In the first fall, eastern redcedar and dogwood leaves both averaged 7.4 percent and during the second fall cedar averaged 8.4 percent for the highest crude protein value for native species.

Protein was most plentiful when forages were actively growing. Thus, Japanese honeysuckle, flowering dogwood, panic grasses, and pussytoes all contained highest levels of protein in the spring. Elbon rye, the fall-planted annual and a cool-season species, was responsible for the high protein levels in annual crops in the fall whereas legumes, ladino clover and lespedeza, boosted summer protein contents of annual crops.

Minerals. Although not determined precisely, the Ca and P requirements of white-tailed deer were approximated in feeding trials by Magruder et al. (1957). They found that deer survived on rations containing 0.25 percent P and 0.30 percent Ca, but that best antler growth was obtained with rations containing 0.56 percent P and 0.64 percent Ca. Proper Ca and P metabolism depends not only upon having a sufficient quantity of the two minerals, but also on the proper ratio of one to the other. A ratio of 2:1 to 1:2 is generally regarded as optimum for ruminants (Maynard and Loosli 1962).

Because of difficulties encountered in analytical procedures, Ca values for the winter and spring of the first annual period were not obtained. However, values were obtained for all other collection periods (Table XXVI).

The Ca content of flowering dogwood leaves and twigs was in excess of 2 percent during all seasons except the spring and was usually higher than in any other species tested. High Ca content is a common characteristic of the foliage of flowering dogwood (Fowells 1965).

Eastern redcedar contained from 1.64 to 2.87 percent Ca, more than other forages except for flowering dogwood leaves and twigs. Pussytoes, a herbaceous composite was next; honeysuckle leaves rated fifth. The Ca content of these two forages ranged from 1.08 to 2.05 percent. Native panic grasses and honeysuckle twigs contained from 0.39 to 0.80 percent, the least of all forages tested. All forage samples contained adequate supplies of Ca for maintenance and all except honeysuckle twigs and panic grasses consistently contained enough for good antler growth.

The P content of honeysuckle leaves and annual crops grown on fertilized forage clearings was consistently higher than that of the native forages (Table XXVII). Planted annuals contained from 0.16 to 0.74 percent P with most values ranging above 0.40 percent.

TABLE XXVI

CALCIUM AS A PERCENT OF OVENDRY WEIGHT FOR FORAGES COLLECTED OVER PORTIONS OF TWO ANNUAL PERIODS

Forage	Year 1		Year 2			
	Summer	Fall	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	1.57	1.47	-	1.08	1.54	1.35
Japanese Honeysuckle Twigs	0.51	0.48	0.39	0.61	0.65	0.61
Annual Crops	1.25	1.08	1.05	0.94	0.67	0.88
Flowering Dogwood Leaves	3.19	2.94	2.46	3.16	4.53	1.28
Flowering Dogwood Twigs	2.07	1.38	2.08	3.21	2.60	1.99
Eastern Redcedar	1.49	2.33	1.64	1.66	2.87	1.99
Panic Grasses	0.45	0.73	0.50	0.80	0.61	0.61
Pussytoes	1.55	1.07	1.08	1.48	2.05	1.16

TABLE XXVII

PHOSPHORUS AS A PERCENT OF OVENDRY WEIGHT FOR FORAGES
COLLECTED OVER TWO ANNUAL PERIODS

Forage	Year 1				Year 2			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	0.21	0.28	0.23	0.28	0.23	0.21	0.18	0.16
Japanese Honeysuckle Twigs	0.20	0.09	0.09	0.17	0.18	0.14	0.10	0.13
Annual Crops	0.20	0.74	0.45	0.32	0.42	0.59	0.43	0.16
Flowering Dogwood Leaves	0.13	0.14	0.12	0.26	0.14	0.12	0.17	0.08
Flowering Dogwood Twigs	0.11	0.10	0.14	0.14	0.11	0.10	0.11	0.10
Eastern Redcedar	0.13	0.15	0.14	0.14	0.16	0.15	0.14	0.05
Panic Grasses	0.12	0.11	0.16	-	0.13	0.08	0.14	0.10
Pussytoes	0.15	0.15	0.11	0.19	0.19	0.14	0.13	0.10

There was less variation in the P content of honeysuckle leaves, but levels were lower, ranging from 0.16 to 0.28 percent. P values for all native forages as well as for honeysuckle twigs ranged from 0.05 to 0.26 percent. The bulk of the values were in the 0.10 to 0.20 range.

As a rule, P was below the maintenance level in all forages except the planted annual crops, and they were above the levels required for best antler development in planted annuals only during the fall of the year. Antler growth was essentially complete by the time that P levels reached the optimum level for development. Low P levels are commonly reported for southern forage (Campbell and Cassady 1951, Lay 1957, and Blair and Epps 1969).

The ratio of Ca:P was highest for dogwood leaves, dogwood twigs, and eastern redcedar, ranging from 10.3:1 to 39.9:1 (Table XXVIII). It was generally lowest, ranging from 1.6:1 to 8.6:1, in planted annuals, honeysuckle leaves, and honeysuckle twigs. Ca:P ratios seldom fell within the recommended range of 1:2 to 2:1 in any forage sampled.

Forages were tested for Mg during the first annual period only (Table XXIX). Although Mg requirements for deer have not been established, the levels recorded were generally higher than the 0.06 to 0.1 percent levels recommended for cattle (Maynard and Loosli 1962). As with Ca, Mg was generally most abundant in flowering dogwood leaves with amounts ranging from 0.23 to 0.54 percent. Dogwood twigs contained from 0.26 to 0.45 percent. After dogwood, honeysuckle leaves contained the most Mg with values ranging from 0.33 to 0.40 percent. Pussytoes contained from 0.14 to 0.28 percent followed closely by annual crops with from 0.13 to 0.21 percent. Honeysuckle twigs, panic grasses, and

TABLE XXVIII

CALCIUM TO PHOSPHORUS RATIOS FOR FORAGES COLLECTED OVER PORTIONS OF TWO ANNUAL PERIODS

Forage	Year 1		Year 2			
	Summer	Fall	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	7.5:1	5.3:1	-	5.1:1	8.6:1	8.4:1
Japanese Honeysuckle Twigs	2.6:1	5.3:1	2.2:1	4.4:1	6.5:1	4.7:1
Annual Crops	6.3:1	1.5:1	2.5:1	1.6:1	1.6:1	5.5:1
Flowering Dogwood Leaves	24.5:1	21.0:1	17.6:1	26.3:1	26.6:1	16.0:1
Flowering Dogwood Twigs	18.8:1	13.8:1	18.9:1	32.1:1	23.6:1	19.9:1
Eastern Redcedar	11.5:1	15.5:1	10.3:1	11.1:1	20.5:1	39.8:1
Panic Grasses	3.8:1	6.6:1	3.8:1	10.0:1	4.4:1	6.1:1
Pussytoes	10.3:1	7.1:1	5.7:1	10.6:1	15.8:1	11.6:1

TABLE XXIX

MAGNESIUM AS A PERCENT OF OVENDRY WEIGHT FOR FORAGES
COLLECTED OVER ONE ANNUAL PERIOD

Forage	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	0.38	0.38	0.40	0.33
Japanese Honeysuckle Twigs	0.15	0.13	0.12	0.16
Annual Crops	0.21	0.21	0.15	0.13
Flowering Dogwood Leaves	0.54	0.37	0.23	0.52
Flowering Dogwood Twigs	0.30	0.26	0.36	0.45
Eastern Redcedar	0.14	0.16	0.19	0.19
Panic Grasses	0.12	0.13	0.16	0.15
Pussytoes	0.22	0.14	0.28	0.22

eastern redcedar all contained similar amounts ranging from 0.12 to 0.19 percent during all seasons.

The interrelations between Ca, P, and Mg metabolism are complex and incompletely understood. The following discussion abstracted from Maynard and Loosli (1962) is indicative of this complexity.

> If Mg levels are excessive and P levels are low then Ca retention is impaired, but provided that both Ca and P, especially P, are plentiful then an excess of Mg is not detrimental. On the other hand, if Mg is adequate and excesses of Ca or P or both occur then symptoms of Mg deficiencies may occur. High Ca and P intakes increase minimum Mg requirements. If both Mg and Ca are excessive then it interferes with P absorption.
>
> Vitamin D increases retention of both P and Ca. More vitamin D is required for proper Ca and P metabolism if either element is low or the ratio between them is suboptimal. In fact, when vitamin D is ample the Ca:P ratio may be even more important than the total amount of either in the diet. Excessive ingestion of Ca and P are not detrimental if their ratio is correct and vitamin D is not excessive. However, even massive quantities of P may be inadequate for growth if CaP ratios are over 4:1 and vitamin D is not abundant.

Vitamin D deficiencies probably did not exist in Caney because deer were regularly exposed to sunlight, but P deficiencies and mineral imbalances in native forages may have created problems. Most native forages had highly distorted Ca:P ratios, high levels of Ca, and low levels of P which may have resulted in improper mineral metabolism. Cultivated forages had better Ca:P ratios and higher P contents than native forages.

Non-nutritive Analyses and Predicted Digestibility. The complete results of non-nutritive analyses for all forages over both annual periods are included in the Appendix (Tables XLII through XLIX). From these data, predicted dry-matter digestibility was calculated using the summative equations developed by Van Soest (1965) and Van Soest and Wine (1967).

Digestion as predicted by the original equation (Van Soest 1965), is based on the observations, determined by experimentation, that the cell contents are 98 percent digestible and that the digestibility of the cell wall constituents can be estimated by the equation $W(147.3 - 78.9 \log L)$, where W is the percent of cell contents and L is the percent of lignin, as determined by the 72 percent sulfuric acid method, in acid detergent fiber. A later technique, developed to facilitate chemical analyses, involved the determination of lignin by the permanganate method (Van Soest and Wine 1967) and requires that the equation be modified as follows, $W(180.8 - 96.6 \log L')$, where L' is the percent of lignin as determined by the permanganate method. These equations can be further refined by the inclusion of a correction factor reducing three units of digestibility for each unit of silica contained in the forage sample (Van Soest and Jones 1968).

Estimates of the dry-matter digestibility for each forage, as determined by the summative equations, are included in Table XXX. Results for the two annual periods may not be directly comparable. The correction factor for silica was included in the analyses for the second annual period, but not for the first. In addition, lignin was determined by the sulfuric acid method in the first annual period and by the permanganate method in the second.

The summative equation was designed primarily to predict the digestibility of pasture grasses and legumes commonly eaten by domestic ruminants, consequently, it does not adequately represent all of the foods eaten by white-tailed deer. It provides a fairly good index to

TABLE XXX

PERCENT DRY MATTER DIGESTIBILITY AS ESTIMATED BY SUMMATIVE EQUATIONS.
MEANS HAVING THE SAME LETTER IN THEIR SUPERSCRIPTS
ARE NOT SIGNIFICANTLY DIFFERENT ($P < 0.05$)

Forage	Year 1				Year 2			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	71.7	76.9	74.6^{a}	65.7^{ab}	65.1^{a}	79.5^{a}	81.7^{a}	89.6^{ac}
Japanese Honeysuckle Twigs	54.3	49.6	42.8	50.6	58.6	67.0^{b}	63.2^{b}	90.1^{a}
Annual Crops	78.3^{a}	87.0^{a}	76.6^{a}	62.8^{ac}	76.6^{b}	66.2^{b}	62.1^{b}	82.4^{d}
Flowering Dogwood Leaves	88.0	88.4^{a}	75.6^{a}	79.3	87.2^{c}	77.8^{a}	71.9	88.1^{abc}
Flowering Dogwood Twigs	68.9^{b}	63.2	66.5^{b}	70.2^{d}	71.4^{bd}	73.5	78.8^{ac}	82.8^{bd}
Eastern Redcedar	69.5^{b}	65.8	56.2^{c}	59.8^{c}	66.4^{ad}	79.0	74.9^{d}	84.5^{bcd}
Panic Grasses	76.8^{a}	60.6	60.2	68.1^{bd}	47.7	35.8	32.7^{c}	76.6
Pussytoes	82.5	81.2	69.3^{b}	75.0	82.1^{c}	69.4^{b}	77.7^{d}	86.5^{abcd}

the digestibility of grasses and forbs as well as to the leaves and succulent twig tips of woody plants, but it overestimates the digestibility of mature woody twigs (Short et al. 1973).

In this study an additional shortcoming of the Van Soest procedure was encountered. Analytical difficulties in the laboratory resulted in acid detergent fiber values greater than neutral detergent fiber values in dogwood leaves. Evidently some chemical fraction in the dogwood leaves adversely affected the normal reaction process. Similar phenomena may have occurred in other forages, especially dogwood twigs, but if they did the magnitude of the effect was too slight to be detected. Lignin values as predicted by the permanganate method also varied greatly and without any apparent pattern from those predicted by the 72 percent sulfuric acid method for the same forages collected at similar seasons between the two annual periods. Wilson et al. (1971) found that the permanganate method of lignin analysis gave less reliable estimates of digestibility than the 72 percent sulfuric acid method.

During the first annual collection period, dogwood leaves had a predicted digestibility of 88 percent in the summer and fall and 79 percent in the spring, the highest of all forages tested during these seasons (Table XXX). These samples were characterized by having very high cell contents and low lignin levels. Winter samples of dogwood leaves consisted of dead material that had been exposed to several weeks of weathering. These samples had relatively high cell contents, but were also high in lignin and their digestibility averaged only 76 percent. Dogwood twigs were consistently about 10 to 20 percent lower than leaves in predicted digestibility because of their lower cell contents and higher lignin levels.

Honeysuckle leaves also had relatively high levels of cell contents, but their lignin levels were higher than those of dogwood leaves for all seasons except the winter, and their predicted digestibility was lower than that of dogwood leaves, ranging from 66 to 77 percent. During the winter, predicted digestibility of honeysuckle leaves was about 75 percent, about the same as for dogwood leaves, but estimated digestibility alone does not adequately indicate the relative merits of dogwood and honeysuckle leaves. Dogwood leaves were dead, dry, partially decomposed, extensively leached, and were undoubtedly less palatable than the succulent green leaves of honeysuckle.

Samples of eastern redcedar included both leaves and stems, consequently they were even higher in lignin than were honeysuckle leaves. The estimated digestion of redcedar ranged from 56 to 70 percent.

Predicted digestibility of pussytoes was 83 and 81 percent in the summer and fall, respectively, at which times its cell contents were highest and its lignin levels were lowest. During the winter when pussytoes is most often eaten by deer, it averaged only 69 percent.

Predicted digestibility of elbon rye averaged 87 and 77 percent for the fall and winter and ranked second and first, respectively, in dry matter digestibility during these periods. Cell contents decreased from 64 to 40 percent from winter to fall; however, elbon rye maintained its high ranking and relatively high digestibility by virtue of its low lignin levels. Low lignin levels and high quantities of hemicellulose and cellulose are considered typical of the grasses. Panic grasses, however, contained considerably more lignin and were less digestible than rye except in the spring when their lignin content dropped.

Honeysuckle twigs were predicted to be the least digestible of all forages for all seasons during the first annual period. Predicted digestion ranged from 43 to 54 percent. Honeysuckle twigs had very high lignin levels and very low cell contents.

Predicted digestion values for the second annual period varied considerably from those obtained during the first. Some variation was expected as a consequence of including the correction factor for silica and the substitution of permanganate lignin for 72 percent sulfuric acid lignin, but variations in lignin levels exceeded the expected. Cell wall and cell content components also varied in an unexpected manner.

Predicted digestion of dogwood leaves was 87 percent during the second summer, the highest of all forages during this season (Table XXX). Honeysuckle leaves ranked first during the fall and winter, having values of 80 and 82 percent, respectively. Dogwood and honeysuckle leaves had the highest cell contents and least lignin levels of all forages tested during the second annual period just as they did in the previous year.

Digestibility of elbon rye was lower during the fall of the second period than during the first as a result of lower cell contents, higher lignin levels, and the presence of 1 percent silica. In the second winter, digestibility was also lowered because of lignin and silica in spite of the fact that cell contents were higher during the second period than during the first.

Predicted digestibility of honeysuckle twigs averaged 90 percent during the second spring, the most digestible of all forages. This unexpectedly high level was the consequence of reduced lignin contents as estimated by the permanganate technique.

Panic grasses contained from 2.6 to 7.1 percent silica over all seasons. This was more than in any of the other forages, consequently panic grasses were more seriously affected by the inclusion of the silica correction factor than any other forage. Predicted digestion of panic grasses was lowest for all seasons.

Despite the relatively low predicted levels of digestibility recorded for twigs during all periods, except during the spring of the second annual period, they were still probably overestimated. According to Short *et al*. (1974), the digestibility of twigs containing over 50 percent cell wall contents and/or an acid-detergent-fiber to acid-detergent-lignin ratio of 25 or higher are better predicted simply by the percent of the cell contents. Thus, predicted values for twig digestibility are probably too liberal.

In Vitro Digestion Trials

Results of *in vitro* digestion trials are comparable within annual periods, but not between annual periods. The regular two-stage Tilley and Terry (1963) technique was used for forages collected during the first annual period, but the 48 hr pepsin digestion stage was omitted during the second period. Although Monson *et al*. (1969) indicated that omitting the acid pepsin digestion stage did not appear to be especially detrimental in determining the ranking of the dry matter digestion of various bermuda grass samples, they indicated that there may be differences between different species. This was apparently verified by the work of Meyer et al. (1971) which showed that further digestion beyond a rumen microbial fermentation was necessary for estimating the nutritive values in a variety of forages.

Annual planted crops and the leaves of Japanese honeysuckle were the two most digestible forages during each season for all collection periods except for the second spring when panic grasses replaced annual crops as the number two forage (Table XXXI). Digestibility of honeysuckle leaves ranged from 67 to 83 percent and that of annual crops from 60 to 96 percent. Annual crops were most digestible during the fall and winter while digestion of honeysuckle leaves was generally highest in the winter and spring. During fall and winter, digestion of annual crops and honeysuckle leaves was significantly greater than that of any of the native species.

Woody twigs, either flowering dogwood or honeysuckle, were the least digestible forage during each season for both annual periods. Digestion of honeysuckle twigs ranged from 27 to 62 percent and dogwood twigs ranged from 33 to 52 percent.

In Vivo Nylon Bag Digestion

In view of the divergent values obtained with in vitro digestion trials and digestibility as predicted by the summative equation, each forage was further subjected to the in vivo, nylon bag dry matter digestion technique. Since the size of some of the remaining forage samples was quite small, it was not possible to obtain the same number

TABLE XXXI

IN VITRO DIGESTIBILITY AS A PERCENT OF DRY MATTER. MEANS HAVING THE SAME LETTER IN THEIR SUPERSCRIPTS ARE NOT SIGNIFICANTLY DIFFERENT ($P < 0.05$)

Forage	Year 1				Year 2			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	67.3	68.5	75.9	67.6	66.9^{a}	75.1^{a}	82.9^{a}	82.0^{a}
Japanese Honeysuckle Twigs	32.7	29.9^{a}	27.2	44.0^{ab}	34.7^{b}	45.5^{b}	34.3^{b}	61.6^{b}
Annual Crops	59.5^{a}	86.1	69.8	52.9^{a}	67.5^{a}	80.9^{a}	95.8^{a}	77.9^{a}
Flowering Dogwood Leaves	42.1^{b}	50.2	50.1^{a}	46.8^{ab}	41.2^{c}	51.7^{b}	55.7^{cd}	56.2^{bc}
Flowering Dogwood Twigs	51.6	31.7^{a}	34.6	35.8^{c}	33.0^{b}	36.3	43.3^{bd}	44.9^{c}
Eastern Redcedar	43.7^{b}	42.9^{b}	43.8^{b}	38.0^{bc}	45.8^{c}	48.8^{b}	59.1^{c}	52.3^{bc}
Panic Grasses	56.9^{a}	45.7^{b}	42.1^{b}	49.5^{a}	47.9^{c}	51.5^{b}	56.6^{c}	83.4^{a}
Pussytoes	43.8^{b}	43.1^{b}	52.8^{a}	49.5^{a}	65.3^{a}	61.2^{c}	69.2^{c}	74.4^{a}

of replicates for *in vivo* trials as *in vitro* trials. However, each trial consisted of two replications in each of two goats. Duncan's new multiple range test (Steel and Torrie 1960) was used to compare the results of *in vivo* trials (Table XXXII).

Digestion of honeysuckle leaves averaged from 88 to 92 percent over the two annual periods and were either highest or next to the highest in digestibility for all seasons. Fall and winter digestion of annual crops ranged from 89 to 95 percent and ranked near the top during both years.

Of the native forages, dogwood leaves were generally most digestible with values ranging from 87 to 91 percent. Pussytoes were next with dry matter digestibilities of from 79 to 98 percent.

Honeysuckle twigs were the least digestible of all forages for all periods and as a rule dogwood twigs and panic grasses were next to the lowest in total dry matter digestion.

Comparisons of Methods of Estimating Digestion

Regression equations were computed for all possible combinations of the three methods of estimating forage digestibility for both annual periods. Since Short *et al*. (1974) found that twig digestion values were better represented by cell contents than by standard summative equations, additional regression equations were computed to include this technique. Predicted twig digestion values as determined by the method of Short *et al*. (1974) were combined with the results of browse leaf, forb, and grass digestion values as determined by standard summative equations and these combined values were regressed on the results of the *in vitro* and *in vivo* digestion trials. Although these

TABLE XXXII

PERCENT DRY MATTER DIGESTIBILITY AS DETERMINED BY THE NYLON BAG PROCEDURE USING RUMINALLY CANNULATED GOATS. MEANS HAVING THE SAME LETTER IN THEIR SUPERSCRIPTS ARE NOT SIGNIFICANTLY DIFFERENT ($P<0.05$)

Forage	Year 1				Year 2			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
Japanese Honeysuckle Leaves	89.6^{a}	87.5^{a}	91.6^{a}	89.8^{a}	88.9^{a}	90.7	90.9^{a}	92.0
Japanese Honeysuckle Twigs	41.1	29.4	29.7	45.6	39.7	38.2	35.9	55.6
Annual Crops	80.1	93.7	89.2^{a}	59.5	82.3^{b}	94.6	92.6^{a}	79.8
Flowering Dogwood Leaves	86.6^{a}	88.6^{a}	91.0^{a}	87.6^{ab}	86.7^{ab}	87.9^{a}	87.4^{b}	87.5
Flowering Dogwood Twigs	56.8	56.4	68.8	68.1^{d}	-	69.3	69.1	74.9^{a}
Eastern Redcedar	70.5	68.7	77.8	77.6	74.8	75.9	77.8	76.1^{a}
Panic Grasses	61.0	49.9	61.6	68.0^{d}	56.0	56.3	59.9	74.9^{a}
Pussytoes	87.6^{ab}	78.6	89.3^{a}	88.3^{b}	84.8^{ab}	85.6^{a}	86.9^{b}	89.4

tests do not prove which measures of forage digestion are best for predicting nutritive quality, they provide a basis for comparing similarities or dissimilarities of the various techniques.

All combinations except the summative equation and the *in vitro* digestion for the second annual period were significantly related at the .01 level (Table XXXIII). However, r^2 values were much higher for comparisons of the results of the *in vivo* nylon bag digestion technique to predictions of grass, forb, and browse leaf digestion as determined by the summative equation together with predictions of twig digestion as determined by cell contents than for any other combination. Coefficients of determination (r^2) averaged .76 for these comparisons over both annual periods. This included the summative equation based on lignin determined by the sulfuric acid method as well as the summative equation based on permanganate lignin combined with the silica correction factor. The relationship between these methods is depicted in Figure 6.

Monson *et al*. (1969) found higher correlations between *in vitro* and *in vivo* trials than were noted in the present study. However, Monson's group used steers for both *in vivo* and *in vitro* trials, and rumen fluid for *in vitro* trials was collected at the same time that *in vivo* trials were being conducted whenever possible. In this study, steers were used for *in vitro* work and goats were used for *in vivo* trials and the two species were fed different rations. Goats were fed on native East Texas forage range whereas steers were fed cured hay supplemented with concentrates.

Based partially on the results of these regression analyses, discussion of forage digestibility throughout the remainder of this

TABLE XXXIII

COMPARISON OF THE VARIOUS TECHNIQUES USED TO ESTIMATE FORAGE DIGESTION

Methods Compared	Regression Equations	F Values	Coefficients of Determination (r^2)
Year 1			
Summative Equation and Cell Contents x *In Vitro*	Y = 29.69 + 0.72X	17.00**	0.36
Summative Equation x *In Vitro*	Y = 47.40 + 0.44X	12.78**	0.30
In Vitro x *In Vivo*	Y = 13.69 + 0.49X	23.48**	0.44
Summative Equation x *In Vivo*	Y = 34.42 + 0.48X	52.52**	0.64
Summative Equation and Cell Contents x *In Vivo*	Y = 9.15 + 0.78X	92.45**	0.76
Year 2			
Summative Equation and Cell Contents x *In Vitro*	Y = 30.77 + 0.59X	10.77**	0.25
Summative Equation x *In Vitro*	Y = 62.92 + 0.17X	0.80 N.S.	0.04
In Vitro x *In Vivo*	Y = 11.21 + 0.63X	19.81**	0.40
Summative Equation x *In Vivo*	Y = 35.23 + 0.50X	15.91**	0.35
Summative Equation and Cell Contents x *In Vivo*	Y = 12.04 + 1.02X	96.70**	0.76

**Significant at the 0.01 probability level

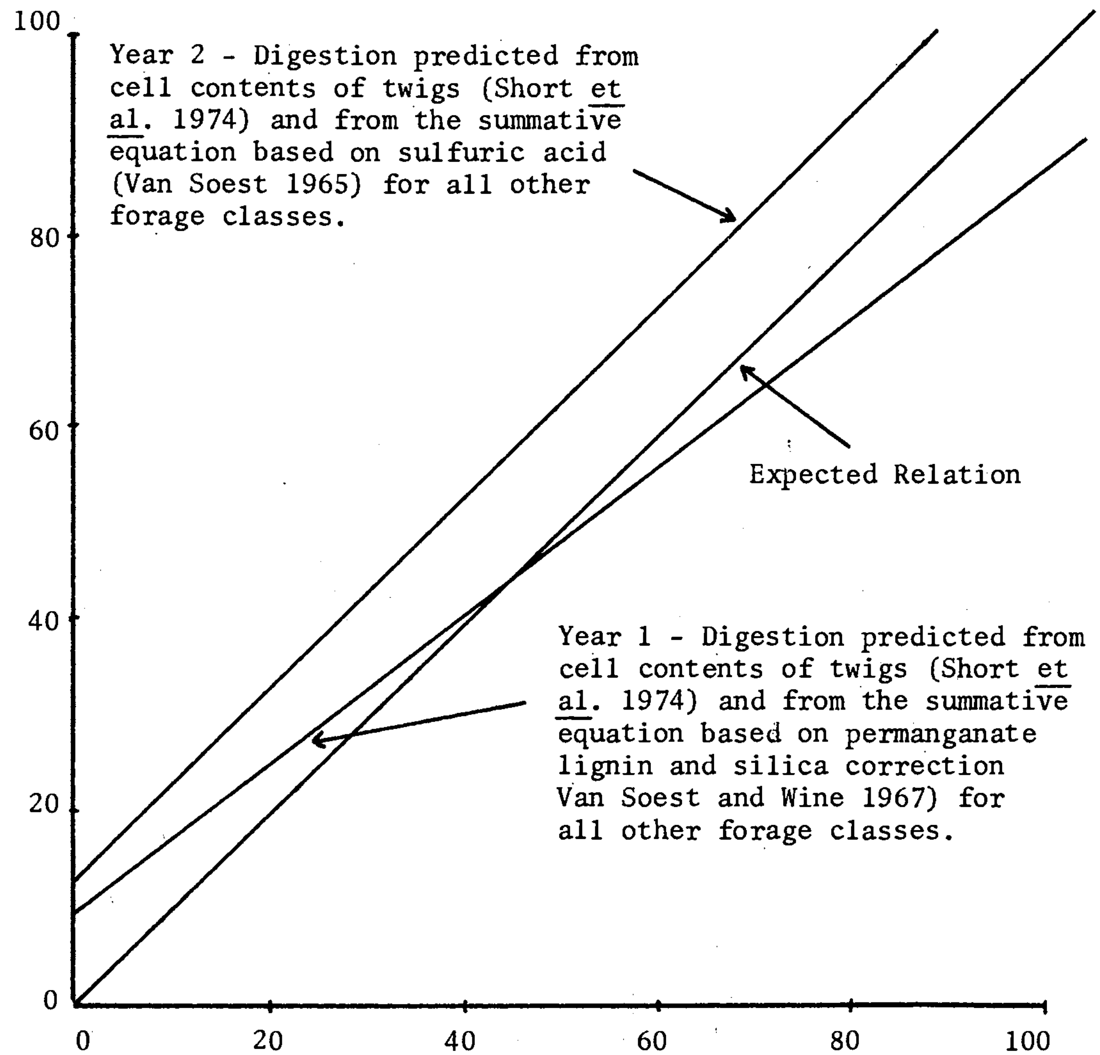

Figure 6. Relation between *in vivo* dry matter digestion as determined by the nylon bag procedure and predicted digestion.

report will be limited largely to the results of *in vivo* nylon bag dry-matter digestion trials. Reasons for limiting discussion of digestion values to *in vivo* results also include the similarity of results obtained with *in vivo* trials over the two annual collection periods. Such values would be expected for identical forage species collected at approximately the same time from the same place over two successive annual periods. Values of *in vivo* trials were probably more alike than others because the same techniques were used for *in vivo* trials of forage samples collected over both annual periods whereas different techniques were used for each annual collection for both the Van Soest and the *in vitro* procedures. Another reason for using *in vivo* results to explain nutritive differences is that goats have feeding habits more like those of white-tailed deer than have other classes of domestic livestock even though their preference for forbs is somewhat lower (McMahan 1964). Goats and deer presumably have similar digestive capabilities as well. Finally, it has been shown that dry-matter digestion of forages by the nylon bag technique are highly correlated with values determined by conventional digestion trials (Lowery 1970 and Neathery 1972). While the *in vitro* and the Van Soest procedures are also correlated to conventional digestion trials, the simpler *in vivo* technique, which requires less mechanical and chemical manipulation, appeared to give the best results of all procedures tested in this study.

CHAPTER IV

DISCUSSION

The results of this study indicate that wildlife forage clearings were beneficial to deer in the Caney enclosure and that they could be beneficial elsewhere where conditions exist that are similar to those in Caney. Throughout this discussion it will be shown how forage clearings were beneficial, why their beneficial aspects are so often questioned, and under what conditions they might be practical.

Aspects of Forage Clearings Beneficial to Deer

In his review of the status of wildlife forage clearings, as used in habitat management for forest game animals, Larson (1966) discovered that substantive data for objectively evaluating the usefulness of forage clearings were lacking in several critical areas. Larson posed several questions that he felt must be answered before the true value of wildlife forage clearings could be determined. This study provides answers to some of the questions raised by Larson, specifically as they apply to the management of white-tailed deer.

Forage Production

One reason that it has not been possible to objectively evaluate wildlife forage clearings for white-tailed deer management is because there is a lack of information indicating whether or not they actually supplement the quantitative food base. Prior studies failed to compare the yield of native foods to those produced on cultivated clearings (Larson 1966). Such comparisons were accomplished in this study.

Summer. From 1968 through 1971, total summer vegetation measured each August averaged about 32 ovendry tons annually. Native vegetation in the undisturbed forest made up 89 percent of the vegetation measured and cultivated forages only 11 percent (Table XXXIV). Thus, forage clearings made up a relatively small portion of the summer yield, but clearings were constructed primarily to provide supplemental winter forage. Summer legumes were given only minimal care after the first year in which they were planted and yields declined accordingly. In addition, honeysuckle yields, while increasing greatly from 1968, had not reached a peak in 1971 when they were last measured.[1/]

Winter. Forage clearings may have supplied a relatively small portion of the total summer vegetation, but they furnished a much larger portion of the winter forage available. Total winter vegetation averaged about 11 ovendry tons annually. Native vegetation in the undisturbed forest contributed 44 percent and cultivated clearings produced 56 percent of the total (Table XXXV). Again it should be noted that honeysuckle had not reached maximum productivity.

[1/]Honeysuckle yields increased by over 200 percent to contribute a total of about 6.5 ovendry tons in 1972 the year after this study was terminated.

TABLE XXXIV

SUMMER VEGETATION AVAILABLE IN CANEY
IN OVENDRY LB

Date	Native Vegetation	Cultivated Forage		Total Vegetation
		Annual Crops	Honeysuckle	
1968	53,235	7,233	0	60,468
1969	59,085	6,541	401	66,027
1970	55,575	5,165	1,431	62,171
1971	57,330	3,552	4,485	65,367

TABLE XXXV

WINTER VEGETATION AVAILABLE IN CANEY
IN OVENDRY LB

Date	Native Vegetation	Cultivated Forage		Total Vegetation
		Annual Crops	Honeysuckle	
1968-69	8,775	7,344	0	16,119
1969-70	9,360	12,448	401	22,209
1970-71	11,115	9,667	1,431	22,213
1971-72	9,360	13,534	4,485	27,379

Comparing the amounts of preferred native green winter vegetation available to the green forage produced on wildlife forage clearings indicates the magnitude of the contribution made by forage clearings to winter deer foods. There was an average of only 1,170 ovendry lb of preferred native green winter vegetation in Caney as compared to an average of 11,537 ovendry lb of green annuals and honeysuckle leaves on wildlife forage clearings. Thus, 91 percent of the green winter forage available to deer was provided by cultivated clearings.

Forage Quality

Although these quantitative measures are impressive, they do not adequately reflect the potential usefulness of native or cultivated forages because they fail to indicate the relative value to deer of either kind of forage. An abundant low-quality forage may not be as beneficial as a less plentiful but more nutritious one. Larson (1966) was unable to discover any instance in which the quality of native forage was compared to cultivated forage produced on forage clearings. However, in this study measures of crude protein, P, Ca-to-P ratios, and *in vivo* dry matter digestibility all indicated the superior quality of cultivated forages as compared to native vegetation.

Protein. The highest levels of crude protein for all seasons during both annual periods were always found in forages growing on fertilized wildlife forage clearings, and with only one exception, cultivated forages also ranked second in crude protein contents (Table XXV). Some cultivated forage contained at least 16 percent protein during all periods sampled. The protein content of honeysuckle leaves and annual crops were consistently above 6 percent, the minimum level required for maintenance of deer (French et al. 1955), and they were above 13 percent, the level required for growth, in annual crops for all periods except one. During the fall and winter, annual crops consistently contained between 20 and 39 percent protein. The protein content of all native forages except dogwood twigs ranged from 6 to 13 percent and were generally above the levels required for maintenance, but they seldom reached the levels required for growth. Dogwood twigs and honeysuckle twigs contained from 4 to 8 percent protein and were frequently below maintenance levels.

Phosphorus. P ranged from 0.16 to 0.74 percent in cultivated forages and from 0.05 to 0.26 in native vegetation (Table XXVII). Although the P content of annual crops was generally above 0.25 percent, the estimated level required for maintenance of deer (Magruder et al. 1957), it seldom reached maintenance levels in native forages. P was above the level required for optimum growth, 0.56 percent, only in annual fall crops and never approached this level in other forages. The P levels of honeysuckle leaves were generally lower than in annual crops, but they were always higher than in native vegetation.

Calcium-to-phosphorus ratios. Ratios of Ca:P seldom fell within the recommended range of 1:2 to 2:1 in any forage sampled during either annual period, but ratios were nearer the optimum range for forages growing on forage clearings than for any of the native forages sampled (Table XXVIII).

Digestion. *In vivo* digestion of honeysuckle leaves averaged from 88 to 92 percent (Table XXXII) over the two annual periods sampled and were either highest or next to the highest in all seasons. Digestibility of annual crops ranged from 80 to 95 percent in all periods sampled and from 89 to 95 percent during the critical fall and winter season of both annual periods. Digestion of pussytoes and dogwood leaves ranged from 79 to 91 percent. Frequently, differences in the digestibility of annual crops, honeysuckle leaves, pussytoes, and flowering dogwood leaves were not statistically significant at the 95 percent level, but all other forages were consistently lower in digestibility than annual crops and honeysuckle leaves. Twigs of flowering dogwood and honeysuckle were frequently lowest in dry matter digestion of all forages sampled.

Utilization

The fact that forages grown on wildlife forage clearings were superior to native forages, as indicated by these measures of quality, lends credibility to the contention that cultivated forages may be beneficial to deer in certain circumstances, but it does not indicate how well cultivated forages were accepted by deer.

Throughout this study the production and utilization of cultivated forages were compared to the availability and utilization of native vegetation as well as to the availability of mast. This information was supplemented by observations of deer feeding behavior on wildlife forage clearings, systematic counts of pellet groups on transect lines located on annual winter crops, and comparing the results of rumen analyses of all deer removed from the Caney enclosure to rumen analyses of a similar number of deer taken from an adjoining enclosure where there were no forage clearings.

To a large degree, mast yields were apparently the factor controlling or regulating the consumption of cultivated forages, especially during the fall and winter. This was substantiated by appraisals of food availability and deer feeding habits. Throughout the study, availability and consumption of native winter forages were constantly low. However, availability of mast, one of the most highly preferred of all deer foods, fluctuated widely from year to year.

In the fall of 1968, mast yields averaged about 3 ovendry lb per acre. During this period only 3.7 acres of rye and clover were planted on food plots, and deer kept these crops grazed extremely close all winter. Depending upon the size of the herd, which ranged from a high of 23 deer in the fall to a low of 15 in the spring, deer ate from 1.6 to 2.4 lb of ovendry forage per day from about October 1 through January 15. From January 16 through March 31 each deer consumed 1.8 to 2.7 lb per day. Plantings were so closely cropped that deer ate most of the new growth as soon as it appeared. Honeysuckle furnished only a few pounds of forage during the winter of 1968-69 and contributed very little to the total food supply.

Mast yields averaged 38 ovendry lb per acre in 1969 and contributed a substantial quantity of winter food for deer. This was reflected in utilization estimates of forage clearings. Each of the 22 to 24 deer in Caney ate only 0.7 to 0.8 ovendry lb of rye and clover per day from about October 1 through February 9 when mast was plentiful. This was substantially less per deer than was consumed during the previous winter when mast was scarce. However, from February 10 through March 31, consumption per deer increased to 3.9 to 4.3 pounds per day, reflecting the declining availability of mast. During the previous year, cultivated forages were so limited that total consumption was less although the percent of the total yield eaten was greater. In addition to the rye and clover eaten in the winter of 1969-70, deer also consumed 380 ovendry lb of honeysuckle leaves. Total food consumption during the last portion of the winter in 1969-70 was at least 44 percent greater per deer than the amount eaten during the same period in the previous year. Apparently, deer fed on mast and native vegetation in the early winter, but in the late winter they obtained a much larger portion of their food from supplemental plantings.

Mast yields were low, averaging only 11 lb per acre, in the fall of 1970 and each of the 24 deer in Caney ate about 1.2 lb of rye and clover per day from October 1 through January 14. From January 15 through the end of March the herd ranged from 19 to 24 deer and consumption increased to 1.9 to 2.5 lb per day depending upon the number of animals present. This was considerably less than the amount eaten during the late winter period in the previous year and may reflect a modification of deer feeding habits caused by the disturbance of periodic observations of deer activities on forage clearings and hunting over clearings in early March. In addition to the rye and clover, deer consumed about 870 lb of honeysuckle during the winter of 1970-71, about 0.2 lb per deer per day from mid September to April.

Despite the reduced consumption of cultivated forages in the fall and winter of 1970-71, comparisons of the rumen contents of the five deer removed from Caney in March 1971 to the five removed from the adjoining enclosure where forage clearings were not present, indicated the importance of the cultivated forages. Rumen contents of deer from Caney contained rye almost exclusively (Table XXII), whereas deer from the adjoining enclosure had eaten a variety of foods including sizable quantities of relatively low quality forage (Table XXIII).

Observation of deer activity in 1970-71 indicated that deer spent more time on forage clearings in the fall and winter than during other seasons of the year (Table XXVIII). Pellet group counts indicated that deer were concentrating on forage clearings during the mid-winter period (Table XXI).

Mast yields averaged 169 ovendry lb per acre in the fall of 1971 and the herd of 13 to 14 deer consumed a correspondingly low amount of cultivated forage. From October 1 to January 13, each deer ate from 0.7 to 0.8 ovendry lb of rye and clover per day. From January 14 to April 1 consumption increased to 1.2 to 1.3 lb per day. Honeysuckle utilization averaged less than 0.1 lb per day for each deer in Caney. The percent of the total rye and clover that was eaten in the winter of 1971-72 was the lowest for any year. The number of pellet groups counted on clearings was also much lower than in the previous winter.

Although quantitative, qualitative, and utilization data all indicated that wildlife forage clearings were beneficial to deer, Larson (1966) noted that evidence should be provided to show that cultivated forages are actually filling a need. He pointed out that just because forages on cultivated clearings may be actively sought out and avidly consumed is not evidence that they are filling a need, but could merely be reflecting preference. In other words, sufficient native foods might be available but simply less preferable than the cultivated ones. To show that forage clearings are actually beneficial, a deficiency in the range should be evidenced.

While the findings of this study do not necessarily prove that deficiencies existed in the winter range in the Caney enclosure, they do indicate that cultivated forages were serving to supplement the natural food base and not to replace native foods. In every instance from the winter of 1968-69 through the winter of 1971-72, forage consumption on forage clearings was greater during the latter part of the winter than during the early part, coinciding with declining mast availability. Apparently, as long as mast was available utilization of cultivated forages was relatively low, but when mast was expended, deer moved onto the forage clearings and obtained much of their total diet from the crops planted there.

Response of Deer to Supplemental Foods

The preceding information supports the contention that forage clearings in this study were beneficial to deer; but it is still true, as Larson (1966) noted, that the value of such clearings to white-tailed deer must ultimately be reflected by the animals themselves. Some improvement should be noted in such aspects as physical condition, survival, reproductive success, or population levels. Unfortunately, it is in this area that data collected in this study are weakest.

It was seldom possible to determine the sex and age structure of the herd or to monitor such aspects of population dynamics as reproduction and mortality. While it was possible to obtain some observational data on forage clearings during periods of mast shortages, it was impossible to observe deer in the densely wooded portions of the enclosure. Efforts to trap animals were only partially successful as certain animals were captured repeatedly while others were trap shy and were never caught.

It was not possible to show an improvement in animal conditions or reproductive success following the introduction of forage clearings in Caney, but comparisons of the total population levels from 1963 through 1967, prior to the establishment of forage clearings, to population levels during this study indicate some positive response. During the interval from 1963 through 1967 the herd declined from levels of 22 and 23 to 10 and 15, respectively, during winters of below-average mast availability (Segelquist et al. 1969). In the present study, the herd also experienced overwinter declines from 23 and 24 to 15 and 19 in 1968 and 1969, respectively, but an evaluation of the habitat conditions as compared to animal numbers indicates the positive influence of the forage clearings.

In the fall of 1968, 23 deer were counted in Caney, but in the spring of 1969 only 15 remained in the enclosure. This loss of eight deer was substantial, but this was the first year in which winter annuals were planted, only about one-half of the area available for annual crops was planted, and the total amount of cultivated forage available to deer was relatively small. During the fall of 1968, mast yields averaged only 3 ovendry lb per acre. Much of this was undoubtedly eaten by animals other than deer. Gray squirrels, flying squirrels, chipmunks, and other rodents as well as a variety of birds are common in the enclosure and eat substantial quantities of mast. The scarcity of native winter forages has already been documented.

Thus, food shortages could have been an important factor contributing to the decline in deer numbers.

Five deer were lost to undetermined causes in the winter of 1970-71. Twenty-four were counted in the fall but only 19 were alive preceeding the shooting of six deer in March. Mast yields averaged 11 pounds per acre in the fall of 1970, a relatively small amount, but forage clearings contributed over 5 tons of ovendry annual winter crops and green honeysuckle leaves. Less than half of this supplemental forage was eaten by deer. Consequently, food shortages were apparently not responsible for these losses.

During all other periods reasons for losses were related to specific causes other than food shortages, were nonexistent, or, as could be the case when losses occurred during the period of reproduction, were not recognized as having occurred.

As indicated previously, some fluctuations in population estimates may have resulted from incorrect census counts, but such errors were probably small. The greatest source of variability was caused by animals simply disappearing between census counts. Some instances of deer jumping the fence were recorded, but it seems unlikely that deer would have jumped the fence unless they were severely pressed as they were during census drives. Records obtained on deer that were discovered shortly after death indicated that predators and/or scavengers completely devoured the edible portions and so scattered the few remaining bones that chances of discovering their remains would have been extremely difficult even within a few days post mortem. One deer was known to have been killed by a bobcat, but deaths due to other causes were not documented.

The small size of the population in Caney made it difficult to obtain from deer enough information for valid analyses. It is possible that some of the losses recorded, as well as those not recorded, were caused by factors unrelated to habitat conditions. Deaths due to predation and accidents are probably not related to the presence or absence of forage clearings. Segelquist et al. (1969) speculated that severe losses in Caney prior to installation of forage clearings were indirectly related to deficiencies in the winter range during periods of mast scarcity, but that it was an interaction of several factors that actually caused the death of animals. These factors included, in addition to range deficiencies, destruction of pulmonary tissues by migrating protostrongylid larvae resulting in verminous pneumonia and excessive stress caused by the exertion of being run by dogs during harvest hunts. Parasitism is frequently associated with poor nutritional status, but is possible that deaths due to migrating protostrongylid larvae, as they existed in deer in Caney, could be independent of habitat conditions. Although dogs were not used to hunt deer during this study, freeranging dogs, coyotes, and bobcats may have chased deer on occasions. Poaching and escapes cannot be accurately determined, thus firm conclusions cannot be drawn from the responses of gross population changes. However, the evidence that is available indicates that winter-range deficiencies were responsible for losses in Caney prior to construction of wildlife forage clearings and that any increase in numbers recorded since that time can be attributed to the supplemental foods produced on cultivated forage clearings.

The increase in terms of total numbers was small, 19 deer survived the period of greatest mast shortage after clearings were well established as compared to 10 in 1965 and 15 in 1967 prior to their establishment. However, this represents an increase of at least 25 percent. If the carrying capacity of the 175,000-acre Sylamore Ranger District was similar to that of Caney prior to 1967 and could be increased by a comparable amount through the use of forage clearings, then it would represent a minimal increase in the deer herd from 4,375 to 5,468.

Reasons for Questioning the Beneficial Aspects of Forage Clearings

Two reasons for questioning the beneficial aspects of wildlife forage clearings are that they are thought to be unduly expensive and that they do not supply needed forage. Both of these arguments have merit and are undoubtedly true in many instances. However, range deficiencies are frequently not recognized until they become acute and the expense of providing needed forage through the use of forage clearings may actually be less than alternate means of habitat improvement.

Failure to Recognize Habitat Deficiencies

According to Verme and Ullrey (1972), the population dynamics and physical welfare of deer depends principally upon their nutritional status. Taylor (1934) expanded Liebig's law of the minimum beyond its original scope of indicating the suppression of plant growth or the result of specific nutrient deficiencies to include the concept that when a multiplicity of factors are adversely affecting animal populations, the one nearest the limits of tolerance will be the one controlling animal numbers. Most studies documenting mechanisms of population regulation in white-tailed deer indicate that the availability of food is the most important factor, and in the natural state, the scarcity of winter food frequently controls population numbers. Predation, parasitism, climatic conditions, or a host of other potentially limiting influences are seldom identified as the agents controlling population numbers. Thus, on almost any range, the addition of food during any period when it is limited, either by direct feeding, wildlife forage clearings, manipulations of the timber stand, or by any means should increase deer numbers. If these arguments are valid then the conclusion that wildlife forage clearings can be beneficial to deer in certain instances should not be difficult to accept, and such conclusions could probably be reached without conducting elaborate experiments. But such has not been the case.

Biologists frequently have an aversion to anything in the habitat which they consider unnatural. Verme and Ullrey (1972) pointed out that the very idea of emergency feeding is repugnant to most biologists on general principles. Properly used forage clearings do no more than provide a form of emergency or supplemental feeds, thus it is not surprising to find that their usefulness is often questioned. One of the main reasons for this is that wildlife biologists fail to understand the nutritional requirements of deer and what actually constitutes a good diet for deer.

In the natural state, the availability and nutritional quality of deer foods vary with the seasons as do the deer's nutritional requirements and levels of consumption. In the early spring deer are often in poor physical condition as a result of the combined stress of severe climatic conditions and the scarcity of high-quality winter foods. Fortunately, the phenological growth patterns of many kinds of vegetation are such that preferred deer foods are most abundant and most nutritious in the spring. Levels of food consumption by white-tailed deer are greatest at this time (Short et al. 1969, Long et al. 1965) as are rates of digestion (Short et al. 1974). This results in a period of rapid weight gains for deer in the early spring and provides the additional nutrients required for lactating does after parturition.

In the summer, nutritional quality, digestibility, and rates of consumption all decline, but are probably above maintenance levels. Exceptions to this may occur in the southwestern part of the range where prolonged droughts result in overutilization, food shortages, malnutrition, and die offs (Marburger and Thomas 1965) or in the hot humid south (Short et al. 1969), but probably not in the Arkansas Ozarks.

In the late summer and early fall there is another period of increased food consumption which coincides with the period when the reproductive structures of many species of vegetation reach maturity. These fruits and seeds are frequently high in protein and energy enabling deer to undergo a period of rapid weight gain and lipogenesis. At this time large amounts of fat are deposited that serve as a reservoir of energy for deer during the long winter period when food is once again scarce and climatic conditions are extreme.

All deer apparently experience a voluntary reduction in food consumption during the late fall and winter. This reduction is greatest in bucks and coincides with the rut, the period of greatest sexual activity. The reduction is more gradual and less severe in does. All deer apparently lose a substantial amount of body weight during the winter, but bucks lose the most. These losses occur even if an abundance of food is available. If deer are in good physical condition in the fall such losses are not detrimental, but if their fall condition is poor, weight losses will be more severe, productivity may be affected, and mortality may occur. Feeding studies with captive deer indicate that substantial fawn losses may occur when does are fed deficient diets in the winter. Does fed poor winter rations in Michigan lost 35 percent of their fawns despite receiving adequate diets in the spring (Verme 1962).

Chronic nutritive shortages may also be detrimental to deer even though they are difficult to detect. In Missouri, does fed rations containing from 7 to 11 percent protein throughout the year lost 25 percent of their young fawns (Murphy and Coates 1966).

This brief discussion does not exhaust the knowledge of deer nutritional requirements by any means, but knowledge concerning the metabolic requirements and physiological processes of deer is still rather sparse (Verme and Ullrey 1972). Feeding studies have not been numerous. The nutritional needs of the different sex and age classes of deer under various physiological conditions such as pregnancy, lactation, growth, lipogenesis, and maintenance are but poorly known. As a result, even the most knowledgeable biologists have a limited understanding of deer nutritional requirements, and many biologists have only the most rudimentary understanding of the nutritional requirements and dietary needs of deer. How these needs are fulfilled under natural condition is even more poorly understood.

Of all the aspects of wildlife biology, probably none has been studied more often with such conflicting and confusing results as the food habits of white-tailed deer. It has long been recognized that the diet of the white-tailed deer is composed of a wide variety of foods, but early studies emphasized their browsing nature. Browse as defined by Hanson (1962) includes the twigs or shoots, with or without attached leaves, of shrubs, trees, or woody vines. This definition has been adopted by the Wildlife Society (Mosby 1963). Browsing is simply the act of consuming browse; but in spite of the fact that deer eat far more than browse alone, they are characterized chiefly as browsers.

The section on white-tailed deer foods in the Wildlife Management Institute publication, The Deer of North America, edited by W. P. Taylor (1956), begins with the statement that the daily browse requirements of deer have been satisfactorily determined (Hosley 1956). This implies that alternate foods are of minor importance. Others have reinforced this position. Miller (1961) states that the white-tailed deer is essentially a browsing ruminant. According to Erickson et al. (1961) the white-tailed deer does not graze like a cow, it is a browsing animal. Madson (1961) states simply that white-tailed deer are browsers. Even today browse and food supplies for deer are used interchangeably (Davis 1973). Since much of the browse available to deer is composed of deciduous species which lose all of their leaves in the winter, the concept of the deer as a browsing ruminant carries with it the implication that woody browse twigs form an acceptable part of the diet for deer.

Attempts to evaluate the condition of deer ranges through the use of browse surveys (Ripley and McClure 1963, Moore and Strode (1966) have resulted largely from the conclusion that browse is either the most important or one of the most important foods for deer and that woody browse twigs form an acceptable winter diet. Detailed food-habit studies, however, indicate that browse constitutes only a portion of the diet and that woody twigs generally form an insignificant portion of the deer's diet.

Lay (1964) indicated that deer in eastern Texas may eat something other than browse a majority of the time. In Florida, Harlow (1961) found that the food in 423 deer stomachs consisted of 40 percent mast, 11 percent herbaceous material, 9 percent mushrooms, and about 37 percent browse, mostly evergreen leaves. In a five-state area in the southeast, Cushwa et al. (1970) concluded that browse twigs were eaten only during the period when the plant was growing rapidly and that hardened winter twigs were seldom eaten. Leaves of browse plants, especially evergreen species, mushrooms, acorns, corn, and various fruits made up most of the food in 489 stomach samples analyzed. Harlow and Hooper (1971) examined 956 rumen samples collected in an area of eight southeastern states and found that the most important foods were green leaves of woody species, fruits, forbs, grasses and sedges, mushrooms, and succulent twigs. The concept that browse is the principal food of white-tailed deer in the northeast is also open to debate. Recent surveys have indicated that the use of woody twigs is inversely related to the availability of other winter food in the heavily forested areas of northeastern United States (Stiteler and Shaw 1966).

The importance of browse in the diet of Ozark deer has been seriously questioned by studies conducted in Missouri. Korschgen

(1954) found that in summer samples collected from 440 deer throughout the state of Missouri over a 5-yr period, the most important food items, in their approximate order of consumption were: acorns, corn, fruit of certain woody species, cultivated forage crops, grasses, sedges, and forbs. Leaves and twigs of woody perennials were among the least important of all foods eaten. The food habits of Ozark deer compared favorably with other deer throughout the state. Dunkeson (1955) substantiated that browse was of relatively minor importance to deer in the Missouri Ozarks by observing the feeding habits of tame deer.

In view of the evidence showing that deer eat such a wide variety of foods it is interesting to speculate why they are so often classified as browsers. One reason is that deer do eat a lot of browse; succulent twigs in the spring, deciduous leaves of certain species, and the leaves of some evergreen species during the winter, but the term browse has been incorrectly applied to almost every class of deer forage and occasionally even to fruit. In addition, many early studies were conducted in areas of heavy overpopulation where browse was about the only vegetation remaining, all other forage having been consumed. Many early food habit studies were also conducted in northern ranges where snow covered other vegetation and browse was all that was available. Finally, persistent evidence of utilization by deer is much more obvious on woody twigs than on any other class of food eaten, thus range surveys frequently indicate that browse is the most important deer food.

The reason that browse twigs are such poor deer foods is because they become highly lignified, their cell contents decline, and digestibility is limited as soon as growth ceases in the spring (Short et al. 1973). Woody twigs that contain high levels of lignin probably provide inadequate nutrition to deer (Short and Reagor 1970).

As Cushwa et al. (1970) indicated, deer will eat almost anything that is green before they will eat hardened winter twigs. When deciduous browse twigs form the bulk of the food available to deer, the winter range may be deficient even if deciduous browse is present in great abundance. When winter forage averages only 15 to 19 ovendry lb per acre, as it did in Caney prior to the construction of wildlife forage clearings, and is composed of approximately 90 percent woody twigs, then the quantity as well as the quality of the winter food supply may be severely limited especially during periods of mast shortage.

Biologists often fail to recognize range deficiencies until they become acute because they are masked by an abundance of low quality browse. Lay (1967) has indicated that chronic range deficiencies may be affecting the deer herd before excessive utilization is obvious. The results of feeding studies by Murphy and Coates (1966) appear to substantiate this conclusion. However, most studies documenting cases where the carrying capacity of the range has been exceeded are associated with obvious range abuse and severe dieoffs. The failure of biologists to recognize the criteria indicative of adequate deer range is responsible for this condition and is the chief reason why they are hesitant to acknowledge that management practices such as wildlife forage clearings may be beneficial to deer.

Failure to Recognize Costs of Habitat Improvement

The fact that forage clearings are expensive to construct and maintain, as pointed out by Larson (1969), cannot be questioned. Although records of the expenses incurred in the construction and maintenance of forage clearings in Caney were not obtained, they were quite substantial. However, no effort was made to limit expenses since the objective of forage clearings was to produce as much forage as possible on a limited acreage. By limiting cultivation to periods of mast shortage and by accepting lower yields, costs could have been reduced. It should also be noted that the cost of producing honeysuckle was much less than of producing annual crops. Annuals required complete renovation annually: mowing and raking to remove old litter, tilling, planting, and fertilizing. Maintenance of honeysuckle was limited to occasional mowing and biannual fertilizing. Admittedly, the yield of annuals was greater than that of honeysuckle for the period of the study, but as honeysuckle matures its yields may well approach or even exceed that of the annuals.

Larson (1969) noted that coordination of wildlife management with other aspects of forest management can enable costs to be applied to more than one function and thereby reduce the expense for wildlife management. However, any plan that would increase the cost of other practices, such as altering timber cutting, would have to be charged to wildlife management. These may be as great or greater than the cost of managed food plots. This discussion is largely academic and cannot be resolved until detailed economic analyses are conducted, and that is beyond the scope of this study. The application of alternate methods of habitat improvement, however, are seldom practiced rigorously even by state and Federal land management agencies specifically charged with the responsibility of wildlife or multiple-use management. In addition, alternative methods of habitat improvement may not provide the amount or quality of forage at the particular time when the need is greatest. Clearcutting may greatly increase the availability of forage during the growing season, but it may only slightly increase winter food availability.

Provided that deer numbers can actually be increased by the judicious use of cultivated wildlife forage clearings, it is the responsibility of the land manager to determine if larger deer herds are desirable and what measures are economically feasible. It may well be that alternative methods can be used in many areas to improve habitat conditions for deer, but forage clearings should not be rejected without careful consideration.

Recommendations for Using Forage Clearings

Wildlife forage clearings have their greatest potential for white-tailed deer management in forests containing sufficient foods available for sustaining larger populations of deer throughout most of the year, but where seasonal or periodic food shortages prohibit the expansion of the herd and hold populations below desired levels. The agency or the individual responsible for wildlife management must have the responsibility to determine the desirable population level, which must vary depending upon land use and the purpose for which deer are to be managed. Where the primary goal is to produce an annual surplus of animals for the hunter, approximately the same number of deer may be harvested annually on a sustained basis by limiting the harvest to about 30 percent of the total fall population. Thus, the size of the harvestable surplus depends upon the size of the herd which in turn is regulated by the productivity of the range.

Regardless of population levels or habitat management practices, deer numbers should be kept in balance with the available food supply. Where hunting is the principal method of control, game harvest regulations must be flexible enough to allow the proper proportions of all sex and age classes of deer to be removed each year. If deer numbers are not effectively regulated they may overpopulate the range and overutilize forage resulting in increased parasitism and disease, poor physical condition, reduced reproductive success, and in extreme cases severe malnutrition and death. If proper harvests are not accomplished there is little value in initiating habitat improvement programs designed to increase deer numbers because deer will quickly increase until range resources are once again deficient.

Where proper harvest levels can be attained, two types of habitat conditions prevail where food shortages exist and where wildlife forage clearings may be both beneficial and practical for the management of white-tailed deer. In both situations food shortages must be restricted to relatively brief periods or seasons of the year. It will probably never be practical to supply all of the foods required by a large number of deer on cultivated forage clearings.

Presently, wildlife forage clearings can probably be used with greatest benefit where large areas are covered by forest stands having closed overstory canopies that severely suppress understory forage production and where timber cutting is not or cannot be practices. In such forests, forage clearings can be utilized to create habitat diversity and supply the foods necessary for maintaining deer populations at desired levels without disturbing the remainder of the forest. Such practices would not only benefit deer, but other game animals such as wild turkey as well as a host of nongame birds and mammals.

The second area in which forage clearings can be used is where intensive timber management practices restrict the productivity of the forest for deer foods during certain portions of the rotation. Few such areas may currently exist in the United States, but with increasing demands for lumber and other wood products the potential for the development of such forests is great and nowhere is it greater than in the southeast. A report entitled The South's Third Forest published by the Southern Forest Resource Analysis Committee, sponsored by the Forest Farmers, the Southern Pine Association, the Southern Hardwood Lumber Manufacturers Association, and the American Plywood Association, projects anticipated demand for wood and fiber to the year 2000 and documents methods needed to achieve these demands (Squires 1969). According to this report, the amount of timber cut in the South will more than double in the next 30 years.

To produce the amount of wood and fiber required to meet projected demands will require intensive management on an extremely large scale. Clearcutting, type conversion, site preparation, and timber stand improvement are called for to develop stands composed of single species of genetically superior commercially valuable trees. Widespread use of silvicides, insecticides, and fertilizers may be required to maintain and achieve maximum growth from these stands.

Such practices will extensively modify the forest ecosystem by affecting a wide range of factors including nutrient cycling, energy flow, soil structure and texture, hydrologic cycles, and species diversity of all forest flora and fauna.

There is no way that the consequences of practices designed to increase the timber supply can be judged fairly until they are actually in operation. However, the optimistic pronouncement by Wheeler (1970) that there will be an abundance of wildlife in the South's Third Forest must be tempered with the acknowledgement that intensive silviculture carried to extremes can result in plantations with little or no mast-producing capability entirely devoid of understory vegetation. In such plantations the only way that deer or most species of wildlife can be maintained is by artificial means such as supplemental feeding or wildlife forage clearings. Theoretically, sizable deer herds can be maintained in such forests by these procedures. In some European forests where the monoculture of timber is intensively practiced, huntable populations of red and roe deer are currently being maintained by supplemental feeding and cultivated food plots. To suggest that forage clearings have their greatest potential for white-tailed deer management in such intensively managed forests in the United States may be somewhat pessimistic, but existing trends and projected demands indicate that it is possible.

Wildlife forage clearings should never be considered the ultimate solution to habitat management for white-tailed deer. It may be possible to produce enough forage on cultivated clearings to maintain large deer populations in forests that are intensively managed for high timber yields, but the ecological consequences of such actions should be considered carefully. Plans designed to maximize the production of either deer or timber may be detrimental to future forest environments for deer and timber as well as to other forest resources. All forest management practices should be considered from the standpoint of their impact on the total forest environment. This consideration should have precedence in all land management decisions, but before it does, man must develop a new ethic. As Leopold (1949) so eloquently stated, there is a need to develop a land ethic that acknowledges that man is simply a part of the ecosystem and not its conqueror. Until such an ethic is evolved, economics and politics will continue to take precedence over ecological considerations in most land management decisions.

CHAPTER V

SUMMARY AND CONCLUSIONS

The principal objectives of this study were to determine how intensively managed wildlife forage clearings affected the habitat, health, and population levels of white-tailed deer in a 600-acre Arkansas Ozark enclosure. Four clearings were established in 1967 ranging in size from 5.72 to 1.72 acres. About 2.25 percent of the enclosure, a total of 13.4 acres, was cleared and planted. Data were obtained on production, quality, and utilization of native and cultivated forages, mast yields, deer condition, and deer population changes from the spring of 1968 through the spring of 1972.

Japanese honeysuckle was planted on a portion of each clearing in the spring of 1968. A total of 5.98 acres was planted to honeysuckle. Cover crops of Korean or kobe lespedeza were planted on the remainder of each clearing in the summer of 1968. A mixture of elbon rye and ladino clover was planted in the fall of 1968 and each fall thereafter. In 1968, cool season crops were planted on only 3.49 acres, but 7.42 acres were planted to rye and clover in subsequent years. Following the initial planting of summer legumes, summer cover crops consisted entirely of volunteer stands of lespedeza and fall-planted ladino clover.

Clearings were limed in 1968 based on recommendations of the Arkansas Extension Service following soil analyses. Summer legumes were fertilized when they were first planted, but not in subsequent years. Japanese honeysuckle was fertilized twice annually each year of the study and cool season forages were fertilized at the time they were planted each year.

Production of summer legumes declined from a high of 1,953 ovendry lb per acre in 1968 to 489 lb per acre in 1971. Lack of cultivation, fertilization, and reseeding together with increased competition from weeds caused reduced yields. However, clearings were managed primarily for the production of winter forages, accounting for the lack of special care given summer crops. Production of cool-season crops, primarily elbon rye, remained high throughout the study, ranging from 1,303 to 1,980 ovendry lb per acre annually.

Japanese honeysuckle plants were not sampled in 1968, the year they were planted, but from 1969 to 1971 yields increased from 67 to 750 ovendry lb per acre. When this study was terminated, however, honeysuckle plants were still immature and yields had not reached a peak.

Native summer vegetation yields varied little from year to year and averaged about 96 ovendry lb per acre from 1968 through 1971. Total native winter vegetation available each March from 1969 through 1972 averaged only 17 ovendry lb per acre.

Total summer vegetation, including that produced on forage clearings and all native species combined, averaged about 32 ovendry tons annually. Native species made up 89 percent and cultivated forages 11 percent of the yield.

Total winter vegetation averaged 11 ovendry tons annually and cultivated forages contributed 56 percent. Preferred green winter forage available to deer averaged 6.3 ovendry tons annually and 91 percent was produced by forage clearings.

Cultivated wildlife forage clearings not only produced very substantial quantities of green winter forage, but also produced forage of quality higher than that of selected native species commonly eaten by deer. The crude protein and P contents, Ca:P ratios, and estimated dry-matter digestibility of cultivated forages were all superior to those of native species collected during the winter months.

Total mast yields fluctuated widely during this study. Yields ranged from 3 to 174 ovendry lb per acre. Acorns, one of the most highly preferred of all deer foods, were the single largest contributor to total mast yields. The total amount of mast available in the Caney enclosure ranged from over 50 ovendry tons to less than one ton annually. During periods of high mast yields there was an abundance of winter food available for deer and other wildlife, but when mast yields were low the competition among deer and other wildlife species quickly expended available supplies. It was during these periods of food shortage that the supplemental forage produced on cultivated clearings was important to the deer herd in Caney.

Estimates of forage utilization indicated that foraging pressure on native vegetation was very light during the growing season. There was some evidence of utilization of ladino clover on forage clearings, but grazing pressure was very low. Evidence of winter utilization of native forages was also low during this study, but there was some indication that usage of deciduous browse twigs increased during periods of low mast yields.

Consumption of cool-season cultivated forages, as indicated by utilization estimates, observations of deer activities on forage clearings, and counts of fecal pellet groups on forage clearings, was closely linked to the availability of mast. Each year consumption of cool-season crops was greater during the latter part of the winter than during the fall and early winter. This pattern of forage consumption coincided with declining availability of mast. Annual consumption of cultivated forages was greatest during periods when availability of mast was low and least during periods of high yields of mast. As long as they were available, acorns appeared to furnish the bulk of the winter food for deer, but when acorns were expended deer moved onto forage clearings and obtained much of their total diet from the crops planted there.

It was difficult to determine precisely how forage clearings affected the health or population levels of deer in the Caney enclosure because of the small number of deer present and the difficulty of determining changes in the sex and age structure of the herd. However, there was no evidence to indicate that levels or degree of parasitism were increased by concentrating deer on small forage clearings, and there was some increase in size of the deer herd that appeared to be related to the additional winter forage provided by forage clearings. The total number of deer surviving the period of greatest mast scarcity after forage clearings had become well established was at least 25 percent greater than the number surviving similar periods of mast shortages prior to the construction of forage clearings.

Based on the evidence collected in this study it was concluded that forage clearings were beneficial to deer in the Caney enclosure and that they could be elsewhere where conditions similar to those in Caney exist. The reason that their beneficial aspects are so often questioned is because of the failure of wildlife biologists to recognize range deficiencies until they become acute and because biologists often have an aversion to any habitat management practice, such as cultivated forage clearings, which they consider unnatural. Furthermore, biologists often feel that cultivated clearings are too expensive for practical habitat management purposes. Admittedly, cultivated clearings are expensive, but costs of suggested alternative techniques of habitat improvement are often not assigned to wildlife as they should be when they are recommended. Thus, alternative habitat improvement practices are often more expensive than they are purported to be.

The cost of forage clearings can be minimized by limiting cultivation to periods of mast shortages or by using perennial forage species such as Japanese honeysuckle rather than crops that require annual cultivation. The yield of annuals was greater than the yield of honeysuckle in the present study, but as honeysuckle matures its yield may approach or even exceed that of annual crops.

Wildlife forage clearings can probably be used to improve deer habitat conditions and increase deer numbers in certain instances where seasonal or periodic food shortages are limiting deer population levels. They can be used with greatest benefit in extensive forest stands having closed overstory canopies which severely suppress understory forage production and where timber cutting cannot be practiced. Clearings can also be used where intensive timber management practices restrict the production of the forest for deer foods during certain portions of the timber rotation. The development of extensive evenaged monocultures as called for by the proponents of the plan for the South's Third Forest may well require such intensive habitat management techniques if huntable populations of deer are to be maintained in southern forest ecosystems.

Wildlife forage clearings appear to have certain attributes that may facilitate their use in white-tailed deer habitat management, but they should never be considered the ultimate solution to habitat management for any species of wildlife. All forest management practices; including those for deer, timber, and other forest resources, should be considered from the standpoint of the total forest environment. This consideration should have precedence in all land management decisions; but before it does, an ethic must be developed that acknowledges that man is simply a part of the ecosystem and not its conqueror.

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APPENDIX

TABLE XXXVI

FERTILIZATION RATES FOR ANNUAL CROPS ON CANEY FORAGE CLEARINGS

Date	Fertilizer Applied	
	Kind	Quantity
4-68	0-20-10	250 lb/ac
9-68	10-20-20	250 lb/ac
2-69	16-0-0	25 lb/ac
8-69	10-20-20	250 lb/ac
9-70	10-20-20	250 lb/ac
9-71	10-20-20	250 lb/ac

TABLE XXXVII

FERTILIZATION RATES FOR HONEYSUCKLE
ON CANEY FORAGE CLEARINGS

Date	Clearing No.	Fertilizer Applied	
		Kind	Quantity
4-68	1,2,3,4	33-0-0	120 lb/ac
8-68	1,2,3,4	33-0-0	50 lb/ac
3-69	1,2,3,4	12-12-12 33-0-0	100 lb/ac 100 lb/ac
4-70	1,2,3,4	45-0-0	100 lb/ac
8-70	1,2,3,4	33-0-0	100 lb/ac
3-71	3,4	10-20-10 33-0-0	100 lb/ac 100 lb/ac

TABLE XXXVIII

FERTILIZATION TREATMENTS THAT WERE RANDOMLY DISTRIBUTED OVER EQUAL PORTIONS OF HONEYSUCKLE CLEARINGS NO. 1 AND 2 IN THE SUMMER OF 1971[1]

Treatment Combinations
N_0 P_0 K_0
N_0 P_0 K_1
N_0 P_1 K_0
N_0 P_1 K_1
N_1 P_0 K_0
N_1 P_0 K_1
N_1 P_1 K_0
N_1 P_1 K_1
N_2 P_0 K_0
N_2 P_0 K_1
N_2 P_1 K_0
N_2 P_1 K_1

[1] N_0 = 0 lb of N per acre
N_1 = 200 lb of N per acre
N_2 = 400 lb of N per acre

P_0 = 0 lb of PO_5 per acre
P_1 = 40 lb of PO_5 per acre

K_0 = 0 lb of K_2O per acre
K_1 = 40 lb of K_2O per acre

TABLE XXXIX

ANNUAL RAINFALL IN INCHES FROM AUGUST 1, 1957, TO JULY 31, 1970, AT CALICO ROCK, ARKANSAS, ABOUT 8 MILES NORTH OF THE STUDY AREA

Year	Rainfall	Departure from Normal
1957-58	45	0
1958-59	43	- 2
1959-60	46	+ 1
1960-61	54	+ 9
1961-62	31	- 14
1962-63	34	- 11
1963-64	33	- 12
1964-65	44	- 1
1965-66	40	- 5
1966-67	34	- 11
1967-68	50	+ 5
1968-69	55	+ 10
1969-70	39	- 6

TABLE XL

AVERAGE SUMMER BROWSE YIELDS BY SPECIES IN OVENDRY LB PER ACRE FROM 1968 THROUGH 1971[1]

Species	Habitat Type Upland Hardwood	Upland Pine-Hwd.	Cedar Glade	Streambottom Hardwood	All Types Combined
Preferred Browse					
Acer rubra	1.20	3.61	0.02	6.31	2.39
Amelanchier canadensis	0.23	0.06	1.79	0.50	0.33
Ascyrum spp.	0	0.01	0.20	0	0.02
Berchemia scandens	0	0.10	0	0	0.04
Cornus florida	14.98	18.38	0.81	18.59	15.23
Fraxinus americana pennsylvanica	0.02	0.07	0.02	4.54	0.47
Juniperus virginiana	0.16	0.09	0.09	0.21	0.13
Lonicera spp.	0.03	0	0	0.17	0.03
Nyssa sylvatica	0.37	0.35	0	0.58	0.35
Rhus aromatica	0	0	6.82	0	0.57
Robinia pseudo-acacia	0.03	0.01	0.94	0	0.10
Rosa spp.	0	0	0.05	0	0
Rubus spp.	0.24	0.14	0.02	0	0.17
Sassafras albidum	3.89	6.12	0.29	1.25	4.08
Smilax spp.	0.02	2.18	14.51	3.41	2.43
Symphoricarpos orbiculatus	0.02	0	0	0	0.01
Ulmus alata	0.02	0	10.16	0.06	0.85
Vaccinium stamineum	1.99	6.10	0.81	0.06	3.04
V. vacillans	3.51	16.56	1.15	2.36	7.51

TABLE XL (continued)

Species	Habitat Type Upland Hardwood	Upland Pine-Hwd.	Cedar Glade	Streambottom Hardwood	All Types Combined
Viburnum rufidulum	0.03	0	1.73	0.33	0.19
Vitis spp.	5.91	0.98	0.48	0.29	3.23
Total Preferred Browse	32.64	54.76	39.89	38.65	41.17
Nonpreferred Browse					
Bumelia lanuginosa	0.02	0	1.03	0.19	0.11
Carpinus caroliniana	0.14	0.14	0	0	0.11
Carya spp.	6.99	14.38	6.01	6.57	9.38
Castanea ozarkensis	0.13	1.25	0	1.74	0.64
Ceanothus americanus	0.03	0	0.89	0.15	0.25
Celtis laevigata & *occidentalis*	0.15	0.02	2.09	0.16	0.25
Cercis canadensis	0	0.01	0	0	0
Diospyros virginiana	0.70	0.10	0	0	0.37
Hamamelis virginiana	0	0	0	0.25	0.02
Liquidambar styraciflua	0	0	0	0.73	0.06
Morus rubra	0.01	0	0	0	0
Ostrya virginiana	0.96	0.47	9.06	14.14	2.73
Parthenocissus quinquefolia	0.49	0.04	0.59	0.43	0.34
Pinus echinata	0.04	1.88	3.60	0	0.74
Prunus americana	0.17	0.06	1.22	0.12	0.21
P. serotina	0.29	0.04	0	0.17	0.19
Quercus alba	8.95	9.20	2.39	6.60	8.29
Q. marilandica	0.89	0.48	0	0	0.59

TABLE XL (continued)

Species	Habitat Type: Upland Hardwood	Upland Pine-Hwd.	Cedar Glade	Streambottom Hardwood	All Types Combined
Q. muehlenbergii	0.09	0	0	0	0.04
Q. rubra	0.12	0.45	0.55	1.49	0.40
Q. stellata	2.25	1.29	29.26	0	3.95
Q. velutina	1.34	5.34	1.46	1.29	2.70
Rhamnus caroliniana	0	0.01	0	0.06	0.01
Rhododendron spp.	0.10	0.01	0	0	0.05
Rhus radicans	0.19	0.11	0.64	0.30	0.18
Ulmus americana & *fulva*	0.07	0	0	0	0.01
Vaccinium arboreum	0	0.79	6.27	0	0.84
Miscellaneous Browse	0.08	0.07	0.06	0.24	0.08
Total Nonpreferred Browse	24.20	36.12	65.12	34.57	32.45
Total Browse	56.84	90.88	105.01	73.22	73.62

[1]Differences between mean browse yield in this table and tables IV & V are due to rounding.

TABLE XLI

AVERAGE SUMMER BROWSE YIELDS BY SPECIES IN OVENDRY LB PER ACRE FOR THE SIX EXCLOSURES IN 1969 AND 1971[1]

Species	Exclosure Habitat Type			
	Upland Hardwood Exc. 3 & 11	Upland Pine-Hwd. Exc. 1 & 4	Cedar Glade Exc. 2 & 12	All Exclosures Combined
Preferred Browse				
Acer rubra	3.62	1.02	0.02	1.55
A. saccharum	0	0	0.70	0.23
Amelanchier canadensis	0.65	0.14	0.14	0.31
Ascyrum spp.	0	0	0.79	0.26
Berchemia scandens	0	0	0.14	0.05
Cornus florida	37.43	33.35	5.76	25.51
Fraxinus americana & pennsylvanica	0	0	1.81	0.60
Juniperus virginiana	0	0.35	9.30	3.22
Lonicera spp.	0	0.12	0	0.04
Nyssa sylvatica	0.45	9.16	0.02	3.21
Rhus aromatica	0	0	0.24	0.08
Robinia pseudo-acacia	0	0.41	0	0.14
Rubus spp.	0.02	0	0	0
Sassafras albidum	3.72	4.87	0	2.86
Smilax spp.	0	0.25	13.68	4.64
Ulmus alata	0	0	0.45	0.15
Vaccinium stamineum	2.64	3.35	0.22	2.07
V. vacillans	1.08	14.43	2.10	5.87
Viburnum rufidulum	0.54	0	0.04	0.19

TABLE XLI (continued)

Species	Exclosure Habitat Type: Upland Hardwood Exc. 3 & 11	Upland Pine-Hwd. Exc. 1 & 4	Cedar Glade Exc. 2 & 12	All Exclosures Combined
Vitis spp.	1.12	0.10	1.30	0.84
Total Preferred Browse	51.27	67.55	36.71	51.82
Nonpreferred Browse				
Asimina triloba	0.06	0	0	0.02
Carya spp.	7.06	4.33	18.24	9.88
Castanea ozarkensis	1.91	1.75	0	1.22
Celtis laevigata & occidentalis	0.06	0	1.95	0.67
Cercis canadensis	0	0	1.83	0.61
Diospyros virginiana	0.39	0	0	0.13
Morus rubra	0.02	0	0.72	0.25
Ostrya virginiana	0	0	12.32	4.11
Parthenocissus & quinquefolia	1.68	0.02	4.93	2.21
Pinus echinata	0.29	0.58	2.47	1.11
Prunus americana	0.06	0.35	1.22	0.54
P. serotina	0.51	0.57	0.27	0.45
Quercus alba	3.53	5.14	0.10	2.92
Q. marilandica	0	0	0.18	0.06
Q. rubra	0	0	1.74	0.58
Q. stellata	0	0.33	0.54	0.29
Q. velutina	2.68	12.29	2.49	5.82
Rhamnus caroliniana	0	0	0.26	0.09
Rhododendron spp.	0.04	1.87	0	0.64

TABLE XLI (continued)

Species	Exclosure Habitat Type: Upland Hardwood Exc. 3 & 11	Upland Pine-Hwd. Exc. 1 & 4	Cedar Glade Exc. 2 & 12	All Exclosures Combined
Rhus copallina	0	0	1.01	0.34
R. radicans	0.49	0.58	0.76	0.61
Vaccinium arboreum	0	0	1.24	0.41
Miscellaneous Browse	0.02	0.04	0.02	0.03
Total Nonpreferred Browse	18.80	27.85	52.29	32.99
Total Browse	70.07	95.40	89.00	84.81

[1]Differences between mean browse yields in this table and Table X are due to rounding.

TABLE XLII

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN AUGUST 1969

Species	Cell Contents	Cell Wall Contents		
		Hemi-cellulose	Lignocellulose	
			Cellulose	Lignin[1]
Honeysuckle Leaves	68.7	10.4	10.5	10.5
Honeysuckle Twigs	35.1	13.9	36.5	14.5
Lespedeza & Clover	66.3	5.0	22.1	6.7
Dogwood Leaves	76.1	-[2]	-[2]	3.6
Dogwood Twigs	50.4	7.5	32.4	9.8
Eastern Redcedar	61.6	5.5	21.2	11.8
Panic Grasses	37.6	26.5	31.8	4.0
Pussytoes	62.1	4.8	29.5	4.6

[1]72 percent sulfuric acid determination.

[2]Acid detergent fiber greater than neutral detergent fiber.

TABLE XLIII

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN NOVEMBER 1969

Species	Cell Contents	Cell Wall Contents: Hemi-cellulose	Cell Wall Contents: Lignocellulose: Cellulose	Cell Wall Contents: Lignocellulose: Lignin[1]
Honeysuckle Leaves	74.8	4.0	10.8	10.3
Honeysuckle Twigs	32.7	15.4	34.4	17.5
Elbon Rye	63.5	18.4	16.4	1.8
Dogwood Leaves	78.0	-[2]	-[2]	3.6
Dogwood Twigs	49.5	6.9	30.2	13.3
Eastern Redcedar	60.6	5.4	18.4	15.7
Panic Grasses	33.2	28.2	30.1	8.5
Pussytoes	63.1	1.0	30.2	5.7

[1]72 percent sulfuric determination.

[2]Acid detergent fiber greater than neutral detergent fiber.

TABLE XLIV

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN MARCH 1970

Species	Cell Contents	Cell Wall Contents		
		Hemi-cellulose	Lignocellulose	
			Cellulose	Lignin[1]
Honeysuckle Leaves	71.4	9.5	10.3	8.8
Honeysuckle Twigs	23.7	16.9	20.4	39.0
Elbon Rye	39.9	27.6	28.6	3.9
Dogwood Leaves	72.3	-[2]	-[2]	18.3
Dogwood Twigs	56.5	4.7	25.8	13.1
Eastern Redcedar	56.3	11.9	9.0	22.8
Panic Grasses	23.5	39.0	30.9	6.7
Pussytoes	53.1	5.1	31.4	10.5

[1]72 percent sulfuric acid determination.

[2]Acid detergent fiber greater than neutral detergent fiber.

TABLE XLV

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN MAY 1970

Species	Cell Contents	Cell Wall Contents		
		Hemi-cellulose	Lignocellulose	
			Cellulose	Lignin[1]
Honeysuckle Leaves	62.3	14.2	11.4	12.1
Honeysuckle Twigs	34.0	14.6	34.1	17.3
Elbon Rye	29.9	28.1	34.2	7.8
Dogwood Leaves	71.4	2.3	19.4	7.4
Dogwood Twigs	55.9	5.3	28.6	10.2
Eastern Redcedar	56.8	8.4	15.1	19.8
Panic Grasses	24.8	31.6	37.8	5.9
Pussytoes	51.4	3.6	37.5	7.5

[1]72 percent sulfuric acid determination.

TABLE XLVI

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN AUGUST 1970

Species	Cell Contents	Cell Wall Contents			Silica
		Hemi-cellulose	Lignocellulose		
			Cellulose	Lignin[1]	
Honeysuckle Leaves	59.8	14.4	14.8	14.0	0.3
Honeysuckle Twigs	28.6	19.2	38.4	14.1	0.1
Lespedeza & Clover	58.4	9.9	23.9	7.9	0.2
Dogwood Leaves	71.7	1.3	22.7	4.3	0.6
Dogwood Twigs	50.8	7.6	30.7	10.9	0.1
Eastern Redcedar	55.6	10.6	19.7	14.1	0.6
Panic Grasses	25.3	37.8	29.5	7.4	6.0
Pussytoes	53.2	6.8	33.5	6.5	1.0

[1]Permanganate determination.

TABLE XLVII

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN OCTOBER 1970

Species	Cell Contents	Cell Wall Contents			Silica
		Hemi-cellulose	Lignocellulose		
			Cellulose	Lignin[1]	
Honeysuckle Leaves	65.8	14.4	14.8	5.3	0.3
Honeysuckle Twigs	29.0	15.9	44.0	11.1	0.3
Elbon Rye	58.3	25.2	9.7	6.8	1.0
Dogwood Leaves	74.1	-	-	13.6	0.4
Dogwood Twigs	55.5	6.4	28.0	10.0	0.4
Eastern Redcedar	56.4	8.4	28.0	7.2	0.4
Panic Grasses	32.7	26.4	31.7	12.5	7.1
Pussytoes	55.1	7.7	25.1	11.8	1.5

[1]Permanganate determination.

TABLE XLVIII

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN FEBRUARY 1971

Species	Cell Contents	Cell Wall Contents			Silica
		Hemi-cellulose	Lignocellulose		
			Cellulose	Lignin[1]	
Honeysuckle Leaves	73.2	6.9	13.8	6.2	0.6
Honeysuckle Twigs	26.4	15.7	44.8	13.0	0.1
Elbon Rye	48.7	30.7	13.8	6.8	1.1
Dogwood Leaves	67.0	-[2]	-[2]	14.9	1.1
Dogwood Twigs	57.4	6.2	28.8	7.7	0.3
Eastern Redcedar	57.8	3.7	28.3	20.2	0.2
Panic Grasses	24.8	37.4	23.7	14.0	4.9
Pussytoes	58.9	41.1	29.0	8.9	0.7

[1]Permanganate determination.

[2]Acid detergent fiber greater than neutral detergent fiber.

TABLE XLIX

RESULTS OF CHEMICAL ANALYSES, IN PERCENT DRY MATTER, OF FORAGES GROWN ON FORAGE CLEARINGS AND OF SELECTED NATIVE FORAGES IN MAY 1971

Species	Cell Contents	Cell Wall Contents			Silica
		Hemi-cellulose	Lignocellulose		
			Cellulose	Lignin[1]	
Honeysuckle Leaves	73.5	10.6	13.4	2.4	0.4
Honeysuckle Twigs	42.0	14.8	39.0	4.2	0.3
Elbon Rye	52.5	17.1	26.3	4.0	1.1
Dogwood Leaves	70.0	6.8	19.4	3.7	0.4
Dogwood Twigs	57.5	8.3	28.4	5.8	0.3
Eastern Redcedar	65.1	8.3	21.6	4.9	0.3
Panic Grasses	35.9	27.4	32.4	4.4	2.6
Pussytoes	51.5	7.8	35.6	5.2	0.5

[1]Permanganate determination.

VITA

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