GROWTH OF TEN SPECIES OF PREFERRED DEER BROWSE PLANTS UNDER VARIOUS CROWN DENSITIES

By

JOHN MARTIN CHRISTENSEN

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1968

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1976

GROWTH OF TEN SPECIES OF PREFERRED DEER BROWSE

PLANTS UNDER VARIOUS CROWN DENSITIES

Thesis Approved:

J. Lamar Teate
Thesis Adviser

J. E. Langwig

J. Steve Ownby

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

I wish to express my appreciation to Dr. J. Lamar Teate, who has been my thesis adviser. His patience and guidance have helped to lighten that burden of an unavoidably onerous task with which thesis-writers become most familiar.

My thanks are due also to the other two members of my advisory committee: Dr. J. E. Langwig and Mr. J. Steve Ownby. Their assistance was invaluable in the preparation of the final manuscript.

This feeling of gratitude extends also to the faculty and staff of the Oklahoma State University Forestry Department. Each member has added his or her individual touch which has enhanced my enjoyment and pride in association with them. The Forestry Department also made available the facilities for this project, and the McIntire-Stennis 1442 Compatibility of Game and Timber Production on Intensively Managed Lands research project provided the funds needed to carry out this study.

The greatest measure of my appreciation must go to my wife Sandra and to our family. Sandy's support and encouragement have been a special inspiration to me throughout this endeavor.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

A. Problem Basis

Increased production from all of America's land, including her forests, is needed by the growing population. Not only is the need for forest products increasing, but the demand for more recreational opportunities in the outdoors is increasing as well (9). America's southern forests harbor a recreation potential that can and should be enhanced by management for the production of deer food and cover along with forest products (1, 10, 22).

A conflict seems to arise in considering these two ideas in that intensified pine forest management tends to reduce the natural food resources for wildlife, at least on a given area during a part of the rotation. Thus as more land is put into tree production, sustenance of the wildlife, which is a facet of the public's growing needs and demands for recreation, may diminish (22, 33).

It is expected that by the year 2000 the southern forests will be the primary source for pulpwood, sawtimber, and plywood for the United States (10, 13). As the need for efficient forest management and harvesting techniques continues to develop, the naturally occurring browse and fruit species which support the white-tailed deer (Odocoileus virginiana) will be removed. Since the majority of the southern forests are privately-owned (8, 9), it becomes the responsibility of the many land managers to provide nutritious deer food which can be grown along with the trees (9).

There are numerous economic incentives that will encourage landowners to practice game management along with forest management to produce wildlife as a secondary crop (9, 13, 38). In several states, the capital value of the white-tailed deer ranges from half a billion to more than a billion dollars, varied by the numbers of deer present and by the known expenditures of sportsmen in the pursuit of deer (38). The white-tailed deer may be one of our most valuable wildlife species, not only in regard to dollars and cents but from the inspirational, recreational, and esthetic aspects as well. However, not everyone who hunts deer does so with a firearm; some people "shoot" pictures; others merely enjoy the sight of a deer bounding gracefully through the forest. These values placed on deer by the public make them a desirable element in our forests; the same forests which must be managed to produce wood products. Whatever the reasons for placing deer food in our growing forests, Lindzey (27) states that deer management is fully compatible with the timber production and forest recreation aspects of resource management.

There is an advantage to the effort of providing deer with food which will grow along with trees. The deer, with the fox, raccoon, possum, and coyote, has demonstrated its adaptive ability in a changing environment (38). It is often much simpler to list those species of plants in a given locality which are not eaten by deer rather than to list those which are used (19, 38). According to Dasmann (10) the foods which deer utilize have evolved along with the deer which feed upon them. Over the thousands of years that deer have existed in their present forms, those animals which could not adapt to changes have gone, as have those plants which couldn't withstand deer browsing (10, 32).

Despite the gourmet appetites of deer, it must be understood that all vegetation that grows within a deer range is not necessarily good deer food (10). Many deer have succumbed as a result of malnutrition rather than starvation. They have died with their stomachs full of food which was devoid of the proper nutrients which deer need to survive and prosper (9, 35). A number of studies has dealt with areas of seasonal variations of plant nutrients. Others have been made in the areas of deer preference for various plants, and those plants' nutrient contents (13, 17, 19, 33). There are certain times for most foods when they are most suitable for proper deer nutrition. Cushwa et al. (8) found that green material, fruits, mast, and mushrooms were all important foods at every season of the year. The least important were observed to be woody twigs; nearly all twig browsing took place when the twigs were succulent in spring and early summer.

B. Purpose of the Study

This study was designed to determine whether it is possible to introduce within a stand of trees deer browse plant species which will be productive enough to support a population of deer. The light intensities under which the plants grew were governed by the crown densities of the pine overstories in which they were placed. These particular study plants were selected because they occur naturally in the southern forests, are utilized by deer for browse and fruit, and do not impede forest management procedures, especially harvesting and regeneration.

An earlier study dealing with the response of plants to varying light intensities was made by G. H. Bessinger (3) at Oklahoma State University from 1971 through 1973. An effort was made in that study to control all factors as a constant other than light. Light intensity was governed by shrouding the various plots with different gauges of commercial shade fabric. The plants were established in pots and set out in an artificial medium consisting of sand and peat.

In the present study, ten species of preferred southern forest deer browse plants were established on plots located in actual pine forest conditions in southeast Oklahoma. These plots were begun one year prior to the beginning of the present growth study. Efforts were made, through the growing seasons of 1973 and 1974 to measure the growth of each plant on each plot.

C. Description of the Study Area

Study plots were located in McCurtain County, southeast of Idabel, Oklahoma, on land in the Tiak Ranger District administered by the U. S. Department of Agriculture, Forest Service, in the Ouachita National Forest (Figure 1). The twelve plots were scattered over the area, allowing each plot to be located on a site that had different degrees of light intensity reaching the plants on the ground. This was accomplished by locating the plots in loblolly pine (Pinus taeda) stands of different age classes and stand densities. Topography was flat to gently rolling with sandy loam soils. Average elevation above sea level was 460 feet.

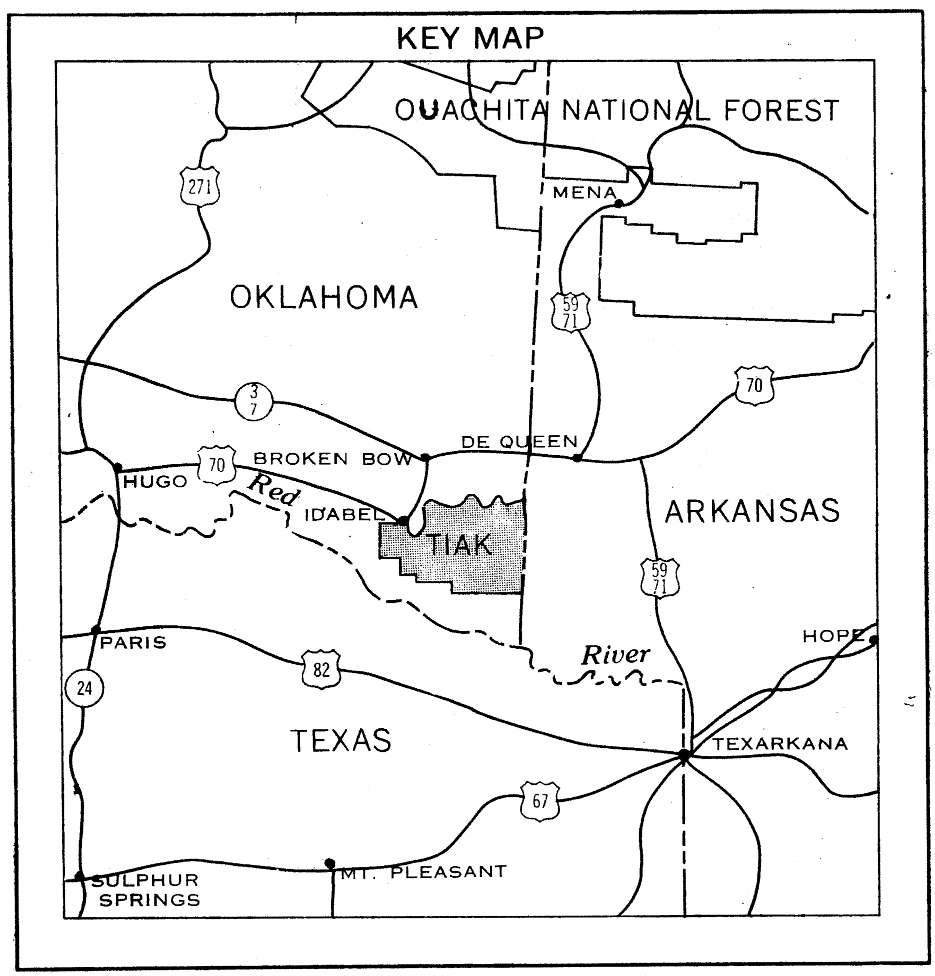

Figure 1. Map Showing Ouachita National Forest in Oklahoma, and Tiak Ranger District

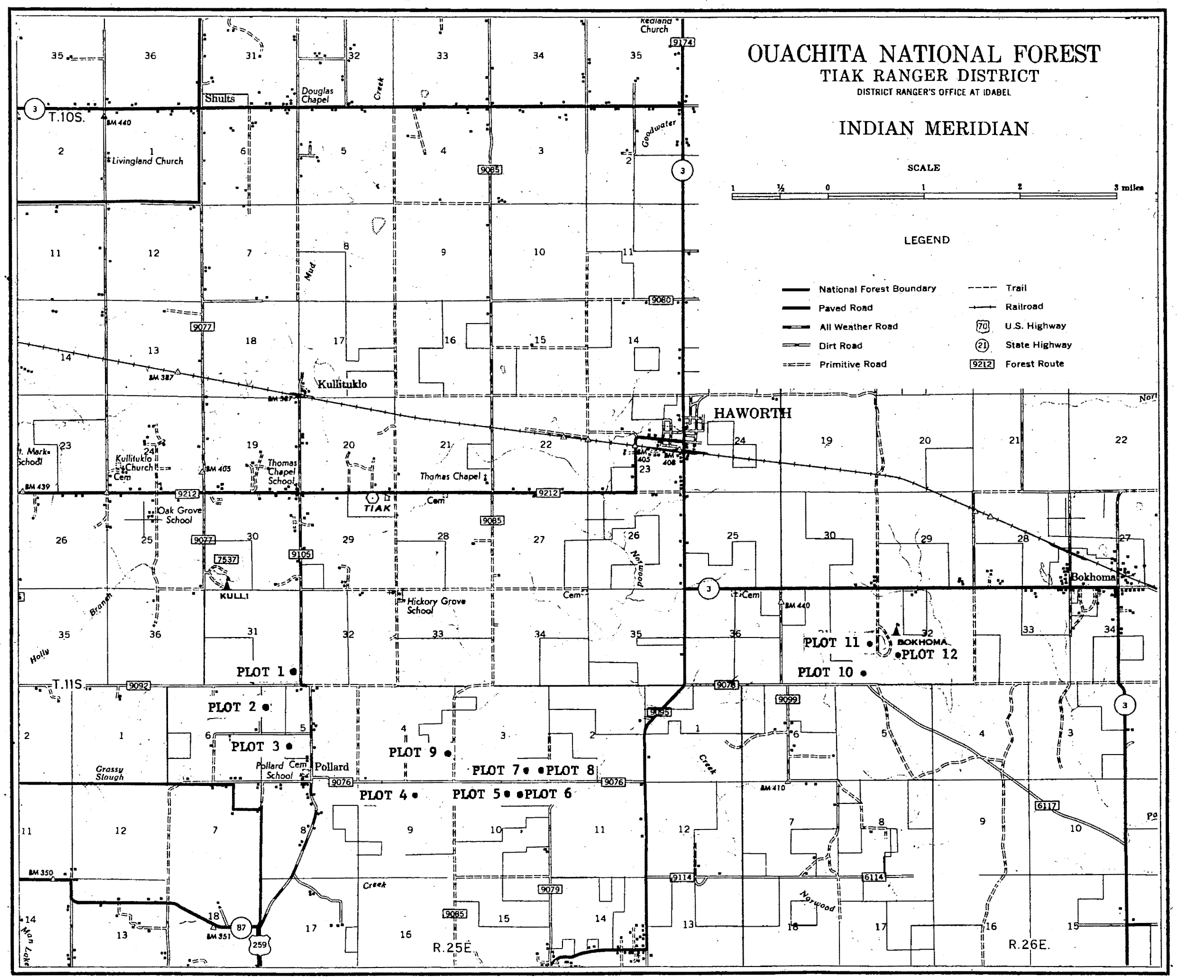

Figure 2. Map Showing Plot Locations on the Tiak Ranger District

CHAPTER II

PLANTS AND MEASUREMENTS

A. Plants

The plant species upon which this study was based are commonly found among the many plants available to deer for food in the southern forests. They produce fruit and browse material which is used throughout the year as it becomes available. These plants were selected because they were listed by a panel of wildlife biologists (18) as the most highly desired browse species among deer in the southern forests. An additional criteria used in selecting these plants was their lack of interference with timber harvesting and regeneration practices in the forests. They present a variety of browse material which will be available for deer use throughout the year. According to Lay (26) the greatest variety in habitat is the best insurance of good deer nutrition on any given forest range. This is true because most plants have certain times of the year when they are most nearly adequate for supplying proper nourishment. One or two good evergreen plants may provide the major support for deer on a range, bolstered by the varied production of several other species at different times throughout the year.

1. Description

The following pages contain as accurate and complete plant descriptions as was possible to obtain from the information available. Vast stores of information are available for some species, while few studies are available for others. The effort was made to present information for each plant which includes: common names and scientific names, growth habits, areas of geographic occurrence, and identifying characteristics.

a. American Beautyberry (*Callicarpa americana*). American Beautyberry is also known as: Spanish mulberry, French mulberry, and sourbush (18). Blair and Epps (5), and Halls and Alcaniz (16) describe the plant as a shade tolerant, low-growing deciduous shrub which can persist on very dry sites, and is abundant in pine stands which have a relatively high overstory. This is especially true on sites where fire or heavy browsing have reduced other woody plants (18). Its berrylike fruit is borne at an early age and is relished by deer; twigs and leaves are browsed by deer as well as cattle during the growing season and sometimes in early winter. According to Dasmann (10) up to 40 percent of the vegetative matter may be utilized without seriously harming the plant. In a study by Halls and Alcaniz (14), it was found that *C. americana* was the highest producer of browse forage on the basis of total twig growth of the plants they measured. It was also the earliest and most prolific fruit producer. This point is supported by Bailey (2), who observed that if American beautyberry is killed to the ground, young shoots spring up vigorously and the plant will produce flowers and fruit in the same season.

Bailey further describes American beautyberry as a shrub which averages from 3 to 6 feet in height, whose acuminate deciduous leaves are 3 to 6 inches long, opposite, and obtusely serrate. Its flowers are perfect with a bluish corolla. The violet fruits are a subglobose berry-like drupe with 2 to 4 stones. It occurs in wooded areas from Virginia to Texas (2), and offers no competition to commercial timber growth (18).

b. Strawberry Bush (Euonymus americana). Strawberry bush is an important deer browse species in the mountains, the Piedmont, and Coastal Plains sites (6). It is also called burning-bush, fishwood, bursting heart, and brook euonymus (3). Halls and Ripley (18) describe strawberry bush as a shade-tolerant, highly preferred deer browse species. It is an important indicator of the presence of deer; i.e., it virtually disappears on an overstocked range. Deer utilize both leaves and stems which are readily avaliable during all stages of growth. It is heavily browsed during late winter and early spring. E. americanus is increased by most logging operations and by protection from hot fires and over-browsing. It grows well on open sites and in the woods (14), and competes little with other browse species or commercial trees (18).

The shrub is upright, growing to eight feet in height. Its acuminate, crenately serrate leaves grow from 1 1/2 to 3 inches long. Flowers are yellowish or reddish green in color. The pink fruit with orange seeds is produced from September to October (2).

c. Smooth Hydrangea (Hydrangea arborescens). This plant, according to Dunkeson (11), should be used as an indicator of deer browse damage, because it has proven to be sensitive to repeated browsing, and deer browse it at all seasons (18). Also called hills-of-snow, mountain hydrangea, sevenbark, and wild hydrangea (3), the plant is described by Bailey (2) as an erect shrub which attains a height of 4 to 10 feet. The leaves grow from 3 to 6 inches long and are long-petioled, ovate, acute serrate, and rounded or cordate at the base. They are green and glabrous on both sides, or may have somewhat pubescent undersides. The plant has been observed to be most abundant in well-drained soils along steep road banks and in forest openings. It can tolerate up to 70 percent shade, although it responds quickly to an increase in light and will grow luxuriantly with less than 50 percent shade (18). Byrd and Holbrook (6) found that smooth hydrangea is an important deer browse species in the mountains.

d. Deciduous Holly (*Ilex decidua*). Deciduous holly was one of the five most frequently identified species in a fruit utilization study by Lay (23). Cushwa et al. (8) found that nearly all browsing of the plant's twigs occurs when they are most succulent in the spring or summer. Also known as possumhaw, swamp holly, bearberry, and winterberry (18), this plant is described as a shrub or small tree which may grow to thirty feet in height, with light gray, spreading branches. The leaves, which are dark green with impressed veins above and pale and pubescent beneath, grow from 1 1/2 to 3 inches in length. The orange or orange-scarlet globose fruit averages one-third of an inch in diameter (2).

Halls and Ripley (18) found that *I. decidua* occurs along streams or ponds, where deer and cattle often browse the leaves and tender twigs in the early spring. Since the plant often interferes with timber reproduction, recommendations are that it be controlled by slashing or burning the stems. This action results in sprouts which are readily utilized by deer (18).

e. Yaupon Holly (*Ilex vomitoria*). Yaupon is an evergreen shrub which Byrd and Holbrook (6) and Hosley (19) found to be an important deer browse species on the coastal plains. It inhabits a variety of sites, but grows best in moist sandy soils with permeable subsoils. This shrub, which grows well in the open and thrives without serious competition with pines in fully stocked stands, has spreading branches with oval or oblong leaves which are obtuse, crenate, glabrous, and usually 1/2 to 1 inch long. Flowers are clustered on branches of the previous year. The small scarlet fruits are globose (2, 16, 18, 19).

Halls and Alcaniz (16) have found that yaupon can withstand heavy grazing. It will provide succulent green forage early in the spring and late in the fall, especially when there are infrequent winter fires of moderate intensity which may serve to keep new growth near the ground and available to deer. Hosley (19) states that because of yaupon's high value to deer, efforts should be made to manage the shrub so that some plants produce fruit while others are kept in the sprout stage for browse and cover. On heavily-stocked ranges deer will readily eat the leaves and twigs all year. About 40 percent of the annual growth may be the highest allowable use of the plant (10, 18).

Yaupon was one of five most frequently identified species in a study by Lay (23) of fruit utilization by deer. Its other common names include: cassine, evergreen holly, and Christmas berry (3).

f. Japanese Honeysuckle - *Lonicera japonica*. Honeysuckle, southern honeysuckle, white honeysuckle, and Chinese honeysuckle are other names by which Japanese honeysuckle may be known. It thrives along streams, fence rows, and borders of woods. Its fragrant and beautiful spring flowers make this plant popular for use as an ornamental. It is also an effective binding for embankments, spreading as much as 15 feet per year on open moist sites (18).

Bailey (2) describes Japanese honeysuckle as a vine which may climb as high as 15 feet. The branchlets are usually pubescent when young, with roundish ovate to oblong leaves which are pubescent or almost glabrous beneath, and which grow to a length of 1 1/2 to 3 inches. The fragrant flowers are short-pedicelled, white changing to yellow, glandular-pubescent and often purplish outside, and attain a length of 1 1/2 to 2 inches.

Deer readily eat both old and new growth year round. Its great value as a game food may be offset by its climbing habit, which can make it a nuisance in timber management (18). Segelquist (33) states that Japanese honeysuckle is eaten by deer in every season of the year in the southeastern United States. In spite of the fact that it may make up as much as 38 percent of the total winter diet for deer in some areas, it has probably received more attention from foresters who try to control it than from wildlife biologists who try to propagate it. However, Sheldon and Causey (36) state that the vine has the potential for effecting a great increase in the carrying capacity for deer of southern pine forests. Since it is a shade tolerant species which can stand use of up to 65 percent of its annual growth (10), its occurrence should be encouraged in those pine areas where large numbers of white-tailed deer occur (36).

g. Zabel's Bush Honeysuckle - Lonicera korolkowii var. zabelii. As Bessinger (3) has stated, this variety of bush honeysuckle is the subject of differing opinions among authorities in the area of plant classification as to which species of honeysuckle it belongs (2, 42). For the sake of conformity in reference to plants in this study and to the same plants in Bessinger's work, this shrub will be regarded as

Lonicera korolkowii var. zabelii. Despite the probable difficulties to be expected in obtaining this variety when any degree of disagreement exists as to its proper classification, the plant's early foliage growth will encourage its use in deer habitat management. It has the potential for producing food for deer at a time of the year when there is normally a critical shortage. An added benefit is its marked hardiness (3).

Bush honeysuckle grows as a spreading branched shrub which may attain a height of twelve feet (2, 3, 42). The branchlets and light green to brownish twigs support alternate simple leaves which are ovate and 1 to 2 inches in length, rounded to subcordate at the base, with an acute apex.

The flowers, which appear in May or June, bear two-lipped petals which range in color from pink (rarely white) to red in color. The pulpy fruit is a bright red berry.

h. Elderberry - *Sambucus canadensis*. This plant is also called elder, sweet elder and blackberry elder (18). It occurs as a stoloniferous shrub, sometimes attaining heights up to 12 feet, on stream banks and in major bottoms, and on moist upland woods sites. In their study of several southern forest deer browse plants, Halls and Ripley (18) noted that elderberry does grow in full sunlight, but is more common in the understory wherever the canopy allows some direct sunlight to enter. Bailey (2) describes the plant as having bright green leaves which are borne on pale yellowish gray branches. There are usually seven short-stalked leaflets which are elliptic to lanceolate, and sharply serrate. They range in length from 2 to 5 inches, and are sometimes pubescent on the veins underneath. The shrub has foliage available from spring until frost, and bears fruit in September (2, 18).

i. Dryland Blueberry - *Vaccinium vacillans*. This shrub is often found in nearly pure stands on well-drained acid soils. Also known as blueridge blueberry, low bilberry, and sugar huckleberry, lowbush blueberry, and low blueberry, it occurs in dry, open pine or oak woods, along rocky ledges, and occasionally in abandoned fields (3, 18).

Dryland blueberry is erect, glabrous, widely branched, and grows from 1/2 to 3 feet high. Leaves are 1 to 2 inches long, obovate or oval, scarcely acute, with sparingly serrulate or entire margins. They are pale or dull glaucous on both sides. Flowers occur in dense clusters usually on the leafless pinnacles of twigs. The large, late ripening berries are of excellent flavor and are relished by men and beasts alike (2, 3).

In a deer range appriasal study, Dunkeson (11) stated that during winter browsing, indications are that dryland blueberry ranks rather low in palatability. He reported that the shrub was commonly winter-browsed only on those areas which supported the largest herds of deer. However, Cushwa (8) and Hosley (19) found that dryland blueberry provides green material which is important deer food during every season of the year, with greatest twig browsing occurring in the spring and summer when the twigs are most succulent. Lay (23), in a study of fruit utilization by deer in the southern forests, found dryland blueberry to be among five of the most frequently identified browse species.

j. Summer Grape - *Vitis aestivalis*. Summer grape is also known as pigeon grape and bunch grape. Its growth is common in woods, field borders, thickets and waysides, where it often burdens shrubs and climbs high into trees. The green material, fruits and woody twigs which are produced are important deer foods at every season of the year. Lay (23) found summer grape to be one of five species of deer browse most frequently identified in his study of fruit utilization by deer. Use of the woody twigs is confined almost entirely to the spring and summer when they are succulent (8, 37). This species is dioecious, and, according to Halls and Ripley (18), at least one staminate plant should be placed in the vicinity of 3 or 4 pistillate plants.

Bailey (2) describes summer grape as a strong, tall-climbing vine which has medium short internodes and often pubescent petioles. The leaves are mostly large, with a tendency to be thin at first, but thickening with maturity. Their outline is ovate-cordate to round-cordate with either 3 or 5 lobes, and sinuses which are either deep or open and broad. The upper surface of the leaves is dull and becomes glabrous, while the underside retains a generous covering of rusty or red-brown pubescence which clings to the veins in many small, tufty masses.

Fruits appear as small, black, glaucous berries, sporting a tough skin and a pulp which ranges from dryish and astringent to juicy and sweet in texture and flavor.

2. Preparation

As Bessinger's study was based on browse plants' response to light controlled by artificial means, this study was geared to measure the plants' response to light controlled by natural means; i.e., a loblolly pine (*Pinus taeda*) overstory in southeastern Oklahoma.

The twelve study plots were prepared following their establishment in the selected pine stands initially by marking the four corners of each plot. The corners were marked with six and one-half foot fence posts set approximately one and one-half feet into the ground. The plots were established within easy walking distance of main roads in the area. Different routes were taken by foot to and from the plots on each visit in order to avoid forming paths or trails to the plants. This was an effort to minimize the numbers of curious visitors to the plots who might have noticed signs of activity and inadvertantly or purposely damaged the study plants. The plots were not easily visible from the roads and their locations were noted on a map of the area to facilitate access by research personnel.

Two specimens of each study plant were set out on each plot in the spring of 1972. They were arranged in rows oriented north to south, in either 4 or 5 rows. Prior to planting, position of each plant on a given plot was determined by assigning each plant species a number between 1 and 10. Species numbers and position numbers were matched by using a table of random numbers. Plants on each plot were numbered from 1 through 20, beginning at the northwest corner of the plot, and running from north to south in each row.

The plants were allowed to grow for a year to establish themselves and overcome the shock of being transplanted. Those plants which died were replaced to preserve the numbers of plants desired on each plot. Plots numbered three, seven, eight, and nine, were fenced to prevent damage to the plants from cattle which were grazing on a portion of the national forest land on which these plots were located.

B. Measurements

1. Plant Growth

The same simple and efficient vegetative growth measurement techniques used by Bessinger (3) were employed in this study. These techniques were used not only for their ease of use and relative accuracy, but also because they did not cause physical damage to the plants which would have influenced their normal growth patterns. The techniques were the measurement of twig elongation and volume.

a. Twig Elongation. Prior to commencement of growth in the spring of 1973, the apparent dominant terminal twig and a randomly selected lateral twig were banded with bits of plastic tape. Yellow was placed on the terminal twig, and white was placed on the lateral twig. Initial measurements, to the nearest one-tenth inch, were recorded for each pair of twigs on each plant. Subsequent measurements through the 1973 and 1974 growing seasons were recorded. Growth was calculated from the initial measurement and each succeeding measurement through the two growing seasons.

b. Volume. A second growth parameter was measured because it is easily observed that some plants grow more in width, through tendrils or shoots, than in height. Also individual twigs do not necessarily maintain dominance, or remain as laterals, throughout the life of the plant. Therefore the volume increase of each plant was measured at the same time the terminal and lateral twig elongation was measured.

As the plants were banded and the twigs measured, an initial volume measurement was also taken. This was done by measuring the height (h) of each plant from ground level and two crown diameters, (a) through the long dimension and (b) at a right angle to the first. Calipers were used for these measurements which were recorded to the nearest one inch. The three readings were then applied to the formula for determining the volume of a cylindroid which is $\pi/4$ (abh). The resulting volume was converted to cubic feet, and rounded to the nearest one-hundredth cubic foot. All succeeding volume growth was determined from the initial volume.

The measuring techniques described above have been utilized in Texas by Halls and Alcaniz (13) and by Lyon (29, 30) in the western United States and by Bessinger (3) in Stillwater. The methods were found to be good means of measuring browse production and availability.

2. Light

Three parameters were considered to have an effect on the varying degrees of light which influenced the growth of the study plants on each plot. These were: percent light available, tree overstory density, and daylength.

a. Percent Light Available. Measurements were taken at each plot, both within the plot, and outside the plot in full sunlight. The measurements were taken with a light meter, calibrated in foot-candles. A check reading, taken in full sunlight near each plot, was divided into the corresponding plot reading, and converted to represent the percent of light available on each plot.

b. Overstory Density. As a means of correlating the various light percentages with the overstory conditions which produced them, measurements of the overstory trees on each plot were taken. One-fifth acre plots, concentric with the browse plant plots, were established, and a one-hundred percent tally of the overstory was made. Care was taken to derive an accurate average basal area, average height to the first green limb, and an average crown area, per acre.

Basal area was determined by measuring the diameter in inches at breast height (dbh) of each tree and then converting the diameters to square feet of basal area, and determining the average for each plot.

Heights to green limbs were measured with either a Suunto clinometer or a Haga altimeter. Both of these instruments have scales calibrated to enable the user to read heights in feet at a given distance from the object being measured.

Crown areas were determined by measuring the long diameter of the crown, within the drip line on the ground, and then measuring a second diameter at a right angle to the first measurement. This method is similar to the diameter measurements involved in determining the volume of the browse plants, described earlier. Mason and Hutchings (31) also utilized this technique in their study of juniper stands in Utah.

These measurements were used to determine an average square feet of crown area per tree per acre for each plot. The areas are shown with heights to the first green limbs, and basal areas per acre in comparison to the percent of shade readings in Table I.

c. Daylength. The World Almanac and Book of Facts (39, 40) for 1973 and 1974 was used to determine the average monthly daylengths for the study area in southeast Oklahoma. The daylengths for each month were recorded as they varied by degrees of latitude. A simple interpolation

TABLE I

COMPARISON OF PERCENT AVAILABLE LIGHT AS INFLUENCED BY FACTORS OF OVERSTORY DENSITY ON EACH PLOT

Plot No.	% Light Available	Overstory Density		
		Avg. Basal Area/Ac (Ft^2)	Avg. Height to First Green Limb (Ft)	Avg. Crown Area/Ac (Ft^2)
1	3.3	180	20	61,850
2	2.3	140	19	61,725
3	1.3	230	25	74,915
4	12.3	155	19	65,300
5	10.1	125	15	57,845
6	7.1	125	15	53,665
7	12.4	75	8	24,255
8	8.5	65	7	21,095
9	25.8	95	9	39,945
10	18.6	160	37	46,910
11	30.1	170	34	41,495
12	10.8	175	34	46,890

was used to derive the daylengths for latitudes 35° N, in which the study area lies. These data are presented in Table II.

3. Temperature

Temperature records for 1973 and 1974 were available from U. S. Forest Service weather observations at the Jadie Lookout Tower, which is located near the study area. Average monthly maximum and minimum temperatures for the study area were calculated from this information, and are presented with data from Curry's "Freezing Temperatures in Oklahoma" (7) in Table III. These sources were also used to determine the beginning and end of the growing seasons in 1973 and 1974, and actual and area average freeze-free days.

4. Soils

Efforts were made to locate the plots where the slope and exposure were similar for each. Samples of the soil on each plot were taken from 1 to 3 inch and 9 to 13 inch levels. The samples were tested by the Soil and Water Service Laboratory of the Agronomy Department at Oklahoma State University. Determinations were made as to soil pH, and pounds per acre of various nutrients found in the soil The samples were also designated as to the soil class in which they occurred. Several variations were found in amounts of different elements occurring in the soils on each plot. The seemingly extreme variations in calcium, from 290 pounds per acre, to 1180 pounds per acre, are not uncommon in forest conditions. Lutz and Chandler (28) state that exchangeable forms of calcium in the mineral soils of humid regions may be six to eight times greater than that of potassium. This demonstrates the difficulty of

TABLE II

AVERAGE DAYLENGTH/MONTH FOR LATITUDES 35° N**
(1973, 1974)

Month	'73, '74 Average Daylength (Hours*)
January	10.00
February	11.00
March	12.00
April	13.00
May	14.00
June	14.50
July	14.25
August	13.50
September	12.50
October	11.50
November	10.25
December	10.00

* Rounded to nearest one-quarter hour.

** Computed from tables in World Almanac and Book of Facts (39, 40).

TABLE III

AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURES, LAST AND FIRST FREEZE DATES, NUMBER OF FREEZE-FREE DAYS, 1973, 1974

Month	1973 Max.	1973 Min.	1974 Max.	1974 Min.
Jan.	51*	32	51	38
Feb.	58	34	59	39
Mar.	69	49	73	52
Apr.	70	52	77	53
May	81	59	85	66
June	86	67	85	65
Jul.	91	72	94	70
Aug.	93	69	89	68
Sep.	86	68	76	60
Oct.	79	59	76	54
Nov.	67	50	63	44
Dec.	56	36	55	38
Last freeze, spring:	Apr. 10		Mar. 24	
First freeze, fall:	Dec. 6		Nov. 15	
Freeze-free days:	239		235	
Area average freeze-free days:		220**		

* All average temperatures rounded to nearest degree, Fahrenheit.

** From Curry, Billy R., "Freezing Temperatures in Oklahoma" OSU Extension (7).

accurately determining the influence of one factor in plant development, such as light, when so many factors interact to influence growth and production. A comparison of the soil test results and plant growth per plot is presented in Table IV. To save space it was necessary to abbreviate the plant names as follows: American Beautyberry = AB; Strawberry Bush = SB; Smooth Hydrangea = SH; Deciduous Holly = DH; Yaupon = YO; Japanese Honeysuckle = JH; Zabel's Bush Honeysuckle = BH; Elderberry = EB; Dryland Blueberry = DB; and Summer Grape = SG.

5. Precipitation

Weather records from the U. S. Forest Service Jadie Lookout Tower also provided data for the monthly rainfall amounts in the study area. Although there is a difference between the rainfall of the two years in excess of 20 inches, both totals are greater than the average annual rainfall in the area which is 45 inches (41). These accumulations are presented in Table V, as monthly totals for the years 1973 and 1974.

TABLE IV

COMPARISON OF SOIL TEST RESULTS ON EACH STUDY PLOT TO AVERAGE PLANT GROWTH, LENGTH IN INCHES, AND VOLUME IN CUBIC FEET

Plot	Sample Level	pH	N	P	Lbs/Acre: K	Ca	Mg	Soil Class	Growth (L = Length, V = Volume)	AB	SB	SH	DH	YO	JH	BH	EB	DB	SG*
1	1-3"	5.1	10-	5	45	1050	140	Loam	L	13.2	9.6	2.6	2.2	12.8	17.2	4.1	16.2	4.9	11.4
	9-13"	5.4	10-	5	42	1030	100	Silt & Loam	V	2.88	0.10	-0.76	-0.13	12.23	-2.53	-0.29	-1.10	-0.55	-1.42
2	1-3"	5.2	10-	17	59	510	70	Loamy Sand	L	9.0	11.3	4.8	4.0	2.7	9.3	9.2	0.1	-0.3	11.9
	9-13"	5.8	10-	54	76	520	60	Sandy Loam	V	2.65	1.05	0.57	1.11	0.35	-1.49	0.64	-0.99	-0.45	-2.70
3	1-3"	5.6	10-	7	87	730	80	Sandy Loam	L	15.9	10.8	4.1	2.9	5.2	7.5	12.0	2.1	1.9	25.8
	9-13"	6.4	10-	5	58	840	40	Sandy Loam	V	6.54	1.38	1.63	0.14	1.61	4.00	-0.52	-0.69	-0.40	0.22
4	1-3"	5.4	10-	5	52	660	80	Sandy Loam	L	9.6	11.8	5.9	6.2	4.8	15.1	9.0	3.6	2.6	8.8
	9-13"	5.7	10-	5	72	590	60	Loam	V	5.77	0.26	-1.21	0.40	1.31	-6.60	1.35	-0.64	-0.23	0.15
5	1-3"	5.3	10-	5	72	360	50	Sandy Loam	L	18.8	10.3	4.0	5.2	4.7	2.6	7.1	-7.1	1.7	21.1
	9-13"	5.4	10-	5	66	480	50	Loam	V	4.66	0.02	-0.10	0.22	3.04	-2.98	1.47	-1.31	0.19	2.55
6	1-3"	5.1	10-	5	69	290	30	Sandy Loam	L	14.9	13.4	4.4	1.2	9.0	14.4	5.2	-0.6	2.1	-5.7
	9-13"	5.5	10-	2	47	310	30	Sandy Loam	V	6.19	0.78	-1.30	-0.61	10.60	-2.28	2.98	-1.73	0.66	0.15
7	1-3"	5.2	10-	5	52	460	50	Sandy Loam	L	20.4	22.6	5.5	8.6	20.4	12.9	8.7	0.4	0.9	56.8
	9-13"	5.1	10-	5	64	560	120	Loam	V	19.28	2.30	0.03	2.46	20.88	1.45	6.20	1.04	0.69	6.25
8	1-3"	5.5	10-	5	89	450	70	Sandy Loam	L	15.9	18.5	16.4	10.0	20.9	16.6	20.8	1.7	1.9	40.8
	9-13"	5.6	10-	5	71	810	90	Loam	V	2.53	0.39	2.32	1.77	21.81	28.14	3.17	-1.51	-0.08	3.30
9	1-3"	5.2	10-	2	46	770	90	Sandy Loam	L	24.3	19.5	12.7	8.2	14.5	50.6	8.6	7.9	1.6	64.9
	9-13"	5.4	10-	5	58	1180	120	Loam	V	13.68	0.42	0.51	1.96	19.32	7.41	3.73	-1.23	1.77	17.17
10	1-3"	4.7	10-	5	94	990	140	Sandy Loam	L	10.3	7.0	8.1	6.4	8.4	5.9	3.9	-4.6	1.9	-10.6
	9-13"	4.5	10-	5	62	440	150	Sandy Loam	V	1.77	-0.03	3.72	0.67	1.66	-0.62	2.92	-3.88	0.49	0.22
11	1-3"	4.5	10-	2	57	600	80	Sandy Loam	L	7.8	19.9	-2.9	0.1	1.1	14.0	5.7	1.7	2.9	7.3
	9-13"	4.5	10-	7	78	430	130	Sandy Loam	V	0.73	0.26	-0.91	-0.10	0.26	-0.48	0.38	-0.71	0.43	0.00
12	1-3"	4.7	10-	5	110	680	140	Sandy Loam	L	-0.2	10.2	0.7	2.9	1.9	2.1	4.4	1.3	-0.2	2.3
	9-13"	4.7	10-	5	120	750	270	Sandy Loam	V	7.20	0.15	-0.06	0.71	0.02	0.54	-0.30	-0.80	0.15	-0.50

* KEY TO SYMBOLS: AB = American Beautyberry; SB = Strawberry Bush; SH = Smooth Hydrangea; DH = Deciduous Holly; YO = Yaupon; JH = Japanese Honeysuckle; BH = Bush Honeysuckle; EB = Elderberry; DB = Dryland Blueberry; SG = Summer Grape

TABLE V

MONTHLY RAINFALL IN STUDY AREA (INCHES)

Month	1973	1974
January	4.12	5.76
February	3.35	1.31
March	7.32	.70
April	10.21	4.49
May	.44	4.20
June	13.21	1.36
July	3.69	1.29
August	.89	1.35
September	12.78	16.72
October	10.70	5.01
November	7.51	7.20
December	4.70	3.84
Annual Total	78.92	53.23

CHAPTER III

RESULTS

The data presented herein are derived from the measurements and observations accumulated during the 1973 and 1974 growing seasons.

A. Growth

Data has been gathered and processed in such a manner as to make possible the consideration and comparison of total vegetative increase of the study plants over a period of two consecutive growing seasons. This manner is preferred over the presentation of growth patterns exhibited by individual plants under given circumstances. It is easily observed from previous studies that each plant has a certain mode of growth behavior which is typical of that plant and which is influenced by the various factors of its environment. The object here is to make a comparison of each study plant's growth and the varying percentages of available light under which it grew in each plot.

Measurements for the two specimens of each plant were combined in order to present an average figure for its response on each plot. This data, along with the percent of light available, tree basal area per acre, heights to the first green limb, and average crown areas per acre from Table I, are presented in Table VI. Twig elongation and volume growth figures are both presented. The volume figures seem to illustrate best the growth of each plant, except in the cases of Japanese

TABLE VI

STUDY PLANT GROWTH COMPARED TO: PERCENT LIGHT AVAILABLE, AVERAGE BASAL AREA/ACRE, AVERAGE HEIGHT TO FIRST GREEN LIMB, AND AVERAGE CROWN AREA/ACRE

Plant	Growth: T = Twig Elongation; V= Volume Increase																							
	T*	V*	T	V	T	V	T	V	T	V	T	V	T	V	T	V	T	V	T	V	T	V	T	V
American Beautyberry	13.2	2.88	9.0	2.65	15.9	6.54	9.6	5.77	18.8	4.66	14.9	6.19	20.4	19.28	15.9	2.53	24.3	13.68	10.3	1.77	7.8	0.73	-0.2	7.20
Strawberry Bush	9.6	0.10	11.3	1.05	10.8	1.38	11.8	0.26	10.3	0.02	13.4	0.78	22.6	2.30	18.5	0.39	19.5	0.42	7.0	-0.03	19.9	0.26	10.2	0.15
Smooth Hydrangea	2.6	-0.76	4.8	0.57	4.1	1.63	5.9	-1.21	4.0	-0.10	4.4	-1.30	5.5	0.03	16.4	2.32	12.7	0.51	8.1	3.72	-2.9	-0.91	0.7	-0.06
Deciduous Holly	2.2	-0.13	4.0	1.11	2.9	0.14	6.2	0.40	5.2	0.22	1.2	-0.61	8.6	2.46	10.0	1.77	8.2	1.96	6.4	0.67	0.1	-0.10	2.9	0.71
Yaupon	12.8	12.23	2.7	0.35	5.2	1.61	4.8	1.31	4.7	3.04	9.0	10.60	20.4	20.88	20.9	21.81	14.5	19.32	8.4	1.66	1.1	0.26	1.9	0.02
Japanese Honeysuckle	17.2	-2.53	9.3	-1.49	7.5	4.00	15.1	-6.60	2.6	-2.48	14.4	-2.28	12.4	1.45	16.6	28.14	50.6	7.41	5.9	-0.62	14.0	-0.48	2.1	0.54
Zabel's Bush Honeysuckle	4.1	-0.29	9.2	0.64	12.0	-0.52	9.0	1.35	7.1	1.47	5.2	2.98	8.7	6.20	20.8	3.17	8.6	3.73	3.9	2.92	5.7	0.38	4.4	-0.30
Elderberry	16.2	-1.10	0.1	-0.99	2.1	-0.69	3.6	-0.64	-7.1	-1.31	-0.6	-1.73	0.4	1.04	1.7	-1.51	7.9	-1.23	-4.6	-3.88	1.7	-0.71	1.3	-0.80
Dryland Blueberry	4.9	-0.55	-0.3	-0.45	1.9	-0.04	2.6	-0.23	1.7	0.19	2.1	0.66	0.9	0.69	1.9	-0.08	1.6	1.77	1.9	0.49	2.9	0.43	-0.2	0.15
Summer Grape	11.4	-1.92	11.9	-2.70	25.8	0.22	8.8	0.15	21.1	2.55	-5.7	0.15	56.8	6.25	40.8	3.30	64.9	17.17	-10.6	-0.22	7.3	0.00	2.3	-0.50
Plot Number	1		2		3		4		5		6		7		8		9		10		11		12	
** % Light Available	3.3		2.3		1.3		12.3		10.1		7.1		12.4		8.5		25.8		18.6		30.1		10.8	
** Average B.A./AC (FT^2)	180		140		230		155		125		125		75		65		95		160		170		175	
** Average Height First Green Limb(FT)	20		19		25		19		15		15		8		7		9		37		34		34	
** Average Crown Area/Acre (FT^2)	61,850		61,725		74,915		65,300		57,845		53,665		24,255		21,095		39,945		46,910		41,495		46,890	

* Twig elongations in inches, rounded to nearest .1"; Volumes in cubic feet, rounded to nearest .01 FT^3

** From Table I

honeysuckle and summer grape. These two plants tend to be low-growing with extensive vines which are difficult to measure accurately by the volume method.

Some inconsistencies seem apparent in Table VI among some of the data for percent of available light, average square feet of basal area per acre, and average square feet of crown area per acre. For example, on plots 1, 2, and 3, plot 2 appears to have the smallest basal area of the three plots, less light available than on plot 1, and nearly the same number of square feet of crown area per acre as plot 1. Ordinarily it would be expected that the data for plot 2 would follow the trend set by the decreasing percentages of available light from plot 1 to plot 2, and to plot 3. This difference in plot 2 can be attributed to the presence of several large, very limby trees (commonly called "wolf-trees") which reduce the basal area as compared to plots 1 and 3, but caused the crown area to be nearly the same as that found on plot 1.

Another discrepancy seems to emerge when plot 8 is compared to plot 11. Plot 8 has a lower light percentage, a lower basal area per acre, and a lower average square footage of crown area per acre than plot 11. It would seem reasonable in view of the lower available light percentage on plot 8 to expect higher basal area and higher crown area figures. The key to this inconsistency lies in the figure for the average height to the first green limb on both plots. The average height to the first green limb on plot 8 is seven feet, while on plot 11 the average height to the first green limb is 34 feet. Despite the lower figures for basal area and crown area on plot 8, the shorter height to the first green limb on this plot reduces the amount of reflected light which reaches the ground on plot 8. On plot 11 the greater volume of space below the first green limb on which light can be reflected accounts for the higher percentage of available light as compared to plot 8.

Other discrepancies which seem to occur are treated in the following discussions of each plant. In these discussions each plant species will be presented in alphabetical order by its scientific name.

1. American Beautyberry - Callicarpa americana

The best responses by American beautyberry occurred in plots 7, 9, 3, and 6, in that order. Growth ranged from approximately six cubic feet (FT^3) on plot 6 up to 19 FT^3 on plot 7. Overstory in plot 7 was one of the thinnest with 75 feet of basal area/acre, and with 12.4 percent light available. Plot 9, which was a plantation thinned prior to the time of this study, had more light available, but a higher basal area than plot 7. This was likely due to the arrangement of the trees in rows with alternate rows having been lopped in the thinning operation. This allowed a greater number of trees to grow on the site, while their alignment with open areas between rows permitted greater intensities of light to enter. This situation also enhanced the entry, and subsequent competition of briars and brush with the study plants and trees on the plot. Since a similar response was noted by Halls and Ripley (18), this observation supports their statement that American beautyberry does best in pine stands which have relatively high light intensities available, and where competition from other woody plants has been reduced by fire or heavy browsing. The conditions which existed on plot 6, which had over seven percent light available and tended to be one of the more heavily-stocked plots in the overstory, would seem to indicate a lower limit below which American beautyberry tends to exhibit a markedly diminishing response.

2. Strawberry Bush - Euonymus americanus

Strawberry bush exhibited the best growth in plots 7, 11, 9, and 8, in descending order. It will be noted from Table VI that the twig elongation responses tended to be greater than the volume growth. The plant does have a natural tendency for an upright growth form, as noted by Bailey (2). It has been observed that strawberry bush is an important indicator of the presence of deer, and that the shrub will virtually disappear on an overstocked range (18). The shrub showed a general growth increase on all 12 plots. Its poorest response occurred on plot 10, where some browsing evidence was observed, and on plot 1, which had one of the lowest percentages of light available. One of the greater basal area/acre and one of the greatest crown area/acre of all 12 plots occurred here, also.

3. Smooth Hydrangea - Hydrangea arborescens

The conditions on plots 8, 9, and 10 seem to represent the descending order of smooth hydrangea's best performance. Overall, this plant's production was fairly low on all the plots. A contrast in observed response between this study and that of Halls and Ripley (18) was noted on plot 11, which had large overstory trees with the highest percentage of light available, the shrub's production was lowest of all the plots. According to Halls' and Ripley's deer browse plant study the light conditions on plot 11 were the lower limits of those conditions in which smooth hydrangea would grow. However, in this study better response was noted at all the lower light intensities. This is possibly due to a combination of several factors on the study site other than those of light. This seems to be supported in Byrd and Holbrook's (6) observation that smooth hydrangea tends to fare better on mountainous sites. This would suggest an important interplay of environmental factors other than light, such as soil and moisture, and would serve to illustrate further the difficulty involved in an attempt to measure the effect of one environmental factor on the growth of a given plant species.

4. Deciduous Holly - Ilex decidua

Deciduous holly showed the best performance on plots 8, 7, and 9, respectively. The volume measurements seemed to be a more consistent and accurate means of observation than did the twig elongation measurements. In some instances, such as on plots 7, 8, and 9, the twig growth seemed to be unusually great as compared to the other plots. This shrub tends to sprout vigorously and certain twigs may attain dominancy through a growing season, when indications were at the beginning that the particular twig measured would tend to be a less active lateral. This twig growth behavior would tend to support Lay (23) and Cushwa (8) in their observations that, as a sprouter whose twigs would provide browse in the early spring, deciduous holly could be controlled by slashing or burning the stems to provide browse which is readily utilizable by deer at a time when it is needed.

5. Yaupon - Ilex vomitoria

This shrub produced the best increase in vegetative growth on plots 8, 7, and 9, in descending order. This observation seems a bit odd in that plot 8 had the lower percent of light available, and plot 9 had the highest. However, these plots were located in previously-thinned plantations in situations described previously for American beautyberry. Again, when the basal areas and crown areas are compared to the shrub's growth measurements, plot 8, with the lowest basal area and crown area, and the lowest light reading, had the best shrub response. It would seem that other factors, such as competition from other plants, would tend to offset the advantages of increased light availability. This supports Bailey's (2) contention that yaupon will grow well in the open and can thrive without serious competition with pines in fully stocked stands. This would be further illustrated by one of yaupon's lesser responses observed in this study. On plot 2, which had one of the lower available light percentages and one of the higher basal areas and crown areas, yaupon's production was one of the lower of those observed on the twelve plots.

Halls and Alcaniz (16) have reported that yaupon can withstand heavy grazing. It seems to provide optimum forage when provided in areas where controlled burning may be used to reduce competition from other woody plants, and which would serve to keep yaupon's new growth near the ground and available to deer. The shrub's observed response in this study, which was demonstrated on each of the 12 plots would tend to support Halls' and Alcaniz's findings.

6. Japanese Honeysuckle - Lonicera japonica

Japanese honeysuckle's growth was observed better by the twig elongation measurements. This was due to the plant's growth habit as a vine. Long, low-lying branchlets meandered under and through the forest litter, presenting a growth form whose diameters were difficult to ascertain and measure accurately by the volume method. An exception to this case would seem to occur on plot 8. This particular specimen exhibited a tendency to produce upright branchlets which tended not to be as low-lying and prone to intermingle with the forest litter as did the other specimens.

The observation by Halls and Ripley (18) that Japanese honeysuckle may spread as much as 15 feet per year was not matched on any of the plots in this study. The best growth was just over four feet in twig elongation on plot 9. Responses on other plots ranged downward to about two inches on plot 12. Although the plants did not proliferate abundantly on any of the plots, each plant remained apparently healthy, and made some progress in growth. The best examples were found on plot 9, as stated earlier, with plots 1, 8, 4, and 6 respectively showing noticeable increases. Even though the best responses of Japanese honeysuckle were far below those observed by Halls and Ripley, these plants were located in a different geographic site from the open, moist sites to which Halls and Ripley referred.

7. Zabel's Bush Honeysuckle - Lonicera korolkowii var. zabelii

This species' response ranged from its best on plot 7 to its smallest production on plot 3, where an actual reduction in volume was noted. The available light on plot 7 was 12 percent and on plot 3 was one percent; differences were greatest in basal area. Plot 7 had 75 FT^2 basal area/acre, and 230 FT^2 of basal area occurred on plot 3. Large differences in crown area were also noted on the two plots, with

24,255 FT^2/acre on plot 7 and 74,915 FT^2/acre on plot 3. The differences in basal area and crown area, along with the dissimilar percentages of available light, are due to plot 7 having been one of the thinned plantation sites mentioned previously, while plot 3 was a naturally dense stand. The difference in stand density is illustrated by the heights to the first green limb. On plot 7, the average height was eight feet while on plot 3 the average was 25 feet. Plot 7, due to the regularly spaced and alined trees could allow fewer trees to develop denser crowns. Plot 3 had relatively close spacing with crowns dense enough that the lower limbs were naturally pruned to an average height of 25 feet.

The spreading-branched growth habit of this shrub, also noted by Bessinger (3), and Wyman (42), contributed to the volume growth measurements seeming to be more consistent between plots for the purpose of comparison of production.

8. Elderberry - Sambucus canadensis

It would seem that the optimum percentage of available light for elderberry ranges from about three percent, as was observed on plot 1, to 12 percent on plot 7. However, the plant had its best response on plot 7; production on all the other plots fell far below that observed in this case. Several of the other plots on which elderberry responded poorly had light intensities which fell within the range from three percent to 12 percent.

It has been stated in other studies (2, 18) that elderberry will grow in full sunlight but is more common in understory conditions which allow some direct sunlight to enter. Considering this statement in relation to elderberry's response as observed in this study, it is found that the statement holds true for plot 7 which had 75 FT^2/acre basal area, and 24,255 FT^2/acre crown area. The alinement of the trees in rows on this plantation site would allow dense crown development of the trees, while providing access for direct sunlight between the rows. However, other factors than light could be responsible for elderberry's response on plot 1. This site had one of the lower available light percentages, a and one of the larger basal areas and crown areas.

9. Dryland Blueberry - Vaccinium vacillans

The best of dryland blueberry's comparatively meager responses occurred on plots 9 and 6. The volume measurements seem to represent more accuratley the actual growth of this shrub. For instance, on plot 1 the twig elongation averaged 4.9 inches, while the actual volume of the plant as a whole actually decreased.

The shrub responded best on plot 9, which had a higher available light percentage and lower basal area/acre, height to the first green limb, and average crown area/acre than those observed on plot 6.

As observed and described by Bessinger (3) and Halls and Ripley (18), dryland blueberry's natural tendency to occur voluntarily in dry, open woods, along rocky ledges, and occasionally in abandoned fields might account for the shurb's generally low response in this study. Indications are, again, that factors other than varied light intensity may have a greater and more consistent effect on this plant's growth.

10. Summer Grape - Vitis aestivalis

The twig elongation measurements would seem to be a better representation of this plant's growth on the 12 study plots. The reasons are similar to those described earlier concerning the growth of Japanese honeysuckle.

The greatest growth occurred on plots 9, 7, and 8, respectively. It would appear that percentages of available light would have a pronounced effect on summer grape's production; plot 9 had the highest percentage of available light, plot 8 had the lowest of the three plots. Basal areas and crown areas/acre also follow in order from the highest, plot 9, to the lowest of the three, plot 7.

However, the comparison of the poorest plant response of the 12 plots to the conditions on the plot where the low response occurred do not follow the trend described above. It would seem apparent that the light conditions on plots 9, 7, and 8 are optimum for the growth of summer grape, while the site factors other than light on the other plots would have a greater effect on the growth of this species.

B. Statistical Analysis

An analysis of variance was made on the twig elongation and on the volume growth data accumulated over the two growing seasons of 1973 and 1974. Oklahoma State University's computer center was utilized with the aid of Dr. Ronald McNew of the Department of Statistics. A statistical analysis system designed and implemented by A. J. Barr and J. H. Goodnight of the Department of Statistics, North Carolina State University was used for the analyses.

The two analyses showed that there are no statistically significant differences in growth response of any species under the various percentages of available light. Physical differences of plant growth occurred among plots, there were physical differences among species, and physical differences in growth among times of observations. There was interaction of species with time, but no interaction of plots with species.

Interaction of species and times of observation substantiates findings in previous work, such as Bessinger's (3), that different plants produce at different rates at any given time during a growing season. The absence of interaction of plots and species means that the difference in response between any two species for the two growing seasons is constant over the plots. Those species which produced best over all the plots did best on each plot regardless of the percent of light available. Differences in production did occur, but they were not great enough to be statistically significant so that it could be predicted that the same response would occur under the same conditions if the study were repeated.

Figures 3-12 in the Appendix, are a graphical portrayal of the means of the production for each species on each plot and therefore at each light intensity. For the sake of insuring adequate room on each graph to show patterns of response, the values shown on the graphs are one-fifth of the mean growth for each species over the two growing seasons. In Figure 13, plots and their corresponding light intensities were grouped to form four ranges of intensity. The plant responses for those plots involved were averaged to show the plants' response in each group. The patterns ran the same for Figures 3-12 and for Figure 13. These results serve to illustrate the results of the analyses which show that those plants which produced best over all the plots and light intensities did best on each plot.

The overstory measurements were made in addition to the light readings on each plot. These serve to show the conditions on each plot which governed the light intensities. Standard deviations were computed for the overstory measurements on each plot. It was found that each plot contained a stand of overstory trees with the measurements of approximately two-thirds of each stand occurring within one standard deviation above or below the mean for each plot. Thus each plot was located in a stand of overstory trees whose measurements were normally distributed about the mean of the trees on each plot.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine whether it is possible to introduce within a stand of trees deer browse plant species which will be productive enough to support a population of deer. The light intensity was varied by different overstory conditions in the loblolly pine stands in which the plots were located. There were no means by which the other environmental factors such as moisture, temperature, and soil could be controlled and held constant for all the plots. These factors were monitored and recorded to determine area averages for the two growing seasons for rainfall and temperatures. These averages were compared to area averages compiled over a 42-year period at the National Weather Service Station at Idabel, Oklahoma (7). Soil samples were collected from each plot and were tested by the Soil and Water Service Laboratory of the Agronomy Department at Oklahoma State University.

A. Measurement Methods

1. Vegetative Plant Growth

Measurements of the vegetative growth of the plants were taken by determining twig elongation and volume increases. Both methods had inherent advantages and disadvantages. The twig elongation figures could be misleading in that an apparent dominant terminal twig could have turned out to be a lateral twig as the plant grew and developed.

Likewise, the lateral twig might have attained dominance. In order to offset the occurrence of this possibility, the two measurements were combined to show an average figure for twig elongation. There was also the possibility that both twigs might grow or lag while the majority of the remainder of the twigs would do the opposite. In this respect the volume measurement would give a better picture of the actual growth, or lack of growth, of a given plant. A disadvantage arises with plants such as japanese honeysuckle or summer grape, where the growth habit of the plant is that of a low-lying, wide-spreading vine. In this situation an accurate volume measurement is difficult because the vines tend to grow over, under, around, and through the forest litter and other vegetation. This condition makes even the more desirable elongation measurement tedious at best, especially in the presence of mosquitoes, ticks, poison ivy, high humidity, and high temperatures.

The most accurate reading of growth should be attained by considering the twig elongation and the volume data together. Thus a given plant which may provide a misleading high twig elongation figure might be brought into better focus when the decrease in volume makes apparent the overall lack of vigor of the plant.

2. Overstory Density and Percent of Available Light

Overstory measurements were taken in addition to light readings. Averages were determined for the overstory in the parameters of: square feet of basal area per acre, height to the first green limb, and square feet of crown area per acre. All of these figures are presented along with the percent of available light on each plot in Table VI.

B. Plant Production

Observed production of the plants showed summer grape, Japanese honeysuckle, strawberry bush, and American beautyberry to be the best producers as far as overall growth is concerned. The statistical analysis showed the same results, with yaupon making a good showing, also. As was pointed out in the statistical discussion, these plants did best over all the plots in the study, and can be considered the best producers on any given plot.

The best plant production occurred on plots 7, 8, and 9; the poorest production was on plots 10, 11, and 12. This is a good illustration of the importance of factors other than light which determine plant growth. On plots 10, 11, and 12, which had a much greater area of open space below the canopy and above the study plants, production was much less than that on plots 1, 2, and 3, which had the most dense overstory of all 12 plots.

Production over all the plots left much to be desired in regard to supporting a deer population. Few deer signs were observed in the study area, although some protective measures were necessary to prevent the study plants from being utilized by cattle and rabbits. Barbed wire fences were constructed to serve as cattle exclosures around plots 3, 7, 8, and 9. The area in which these plots were located is part of a grazing allotment administered by the Tiak Ranger District. Wire cages were placed around all the strawberry bush plants on each plot in order to prevent clipping of the stems by rabbits. It seems that rabbits' preference for this plant is as great as that of deer, which seem to have a particular liking for the plant, as noted by Halls and Ripley (18).

The observed production on plots 7, 8, and 9 would seem to indicate that the best deer browse production might be attained by combining browse introduction with some method(s) of stand treatment. For example, plots 7, 8, and 9 were located in previously thinned plantations, in which the trees were alined in rows with every other row having been lopped in the thinning treatment. It would seem that browse plants could be introduced in similarly thinned areas, or in clear cut blocks along with the trees planted in the reforestation process. Particular efforts would be needed to avoid introduction of a browse plant, such as Japanese honeysuckle, which reportedly has a tendency to climb and hamper young trees (33), when growing under optimum conditions. Other treatments, such as fertilization, or controlled burns to reduce competetive nonbrowse plants would seem to be in order for the forest manager who is conscientious about providing food for deer while he boosts his forest products yield. It must be stressed, however that no one environmental factor such as light can be regarded as the sole or most important influence on the vegetative production of a group of plants. The interaction of many factors, including: light, soil type, and nutrient content, available moisture, temperature, and competition from other plants will determine the final production of a given plant. This production is also governed by the plant itself, in regard to genetic makeup, stress and disease resistance, and reaction to being browsed.

Future studies in this area of consideration should be concerned with a determination of the types of stand treatments in which browse plants may be introduced. Concern should be given to the browse plants themselves, in regard to use of fertilizers and methods of reduction of competing species (i.e., slashing of stems, herbicides, or controlled burning) which are undesirable for deer browse.

BIBLIOGRAPHY

(1) Bailey, L. H. The Holy Earth. New York: Scribner's 1915.

(2) _____________. The Standard Cyclopedia of Horticulture. New York: The MacMillan Co., 1942.

(3) Bessinger, Glenn H. "The Influence of Varying Light Intensities on the vegetative Growth of Ten Southern Forest Deer Browse Species." (Unpub. M.S. thesis, Oklahoma State University, 1973.)

(4) Blair, Robert M. "Keep Forage Low to Improve Deer Habitat." Forest Farmer, 27, 11 (Nov., 1968), 8-9, 22-23.

(5) _____________ and E. A. Epps, Jr. Seasonal Distribution of Nutrients in Plants of Seven Browse Species in Louisiana. New Orleans: USDA Forest Service Southern Forest Experiment Station, Research Paper SO-51, 1969.

(6) Byrd, Nathan A. and H. L. Holbrook. "How to Attract More Wildlife." Forest Farmer, 33, 10 (Oct., 1974), 15.

(7) Curry, Billy R. Freezing Temperatures in Oklahoma. Stillwater, Oklahoma: Oklahoma State University Extension, 1970.

(8) Cushwa, Charles T., R. L. Downing, R. F. Harlow and D. F. Urbston. The Importance of Woody Twig Ends to Deer in the Southeast. Asheville, North Carolina: USDA Forest Service Southeast Forest Experiment Station, Research Paper SE-67, 1970.

(9) Dasmann, Raymond F. Wildlife Biology. New York: John Wiley and Sons, Inc., 1966, pp. 59-64, 207-215.

(10) Dasmann, William. If Deer Are to Survive. Harrisburg, Pennsylvania: Stackpole Books, 1971.

(11) Dunkeson, Robert L. "Deer Range Appraisal for the Missouri Ozarks." Journal of Wildlife Management, 19, 3 (Mar., 1955), 358-364.

(12) Goodrum, Phil D. and V. H. Reid. "Deer Browsing in the Longleaf Pine Belt." Proceedings, Society of American Foresters, (1958), pp. 139-143.

(13) Halls, Lowell K. "Growing Deer Food Amidst Southern Timber." Journal of Range Management, 23, 3 (Mar., 1970), 213-215.

(14) ______________ and R. Alcaniz. "Browse Plants Yield Best in Forest Openings." Journal of Wildlife Management, 32, 1 (Jan., 1968), 185.

(15) ______________ and R. Alcaniz. "Forage Yields in an East Texas Pine-Hardwood Forest." Journal of Forestry, 69, 1 (Jan. 1971), 25-26.

(16) ______________ and R. Alcaniz. Growth Patterns of Deer Browse Plants in Southern Forests. New Orleans: USDA Forest Service Southern Forest Experiment Station, Research Paper SO-75, 1972.

(17) ______________ and E. A. Epps, Jr. "Browse Quality Influenced by Tree Overstory in the South." Journal of Wildlife Management, 33, 4 (Apr., 1969), 1028-1031.

(18) ______________ and T. H. Ripley. Deer Browse Plants of Southern Forests. New Orleans: USDA Forest Service Southern and Southeastern Forest Experiment Stations, 1961.

(19) Hosley, Neil W. "Management of the White-Tailed Deer in Its Environment." The Deer of North America. Ed. W. P. Taylor. Harrisburg, Pennsylvania: Stackpole Books, and Washington, D.C.: Wildlife Management Institute, 1956, pp. 187-260.

(20) Knierem, Philip G., K. L. Carvell, and J. D. Gill. "Browse in Thinned Oak and Cove Hardwood Stands." Journal of Wildlife Management, 35, 1 (Jan., 1971), 163-167.

(21) Korschgen, Leroy J. "Foods of Missouri Deer, With Some Management Implications." Journal of Wildlife Management, 26, 2 (Feb., 1962), 164-172.

(22) Lay, Daniel W. "Browse Quality and the Effects of Prescribed Burning in Southern Pine Forests." Journal of Forestry, 55, 5 (May, 1957), 342-347.

(23) ______________. "Fruit Utilization by Deer in Southern Forests." Journal of Wildlife Management, 29, 2 (Feb., 1965), 370-375.

(24) ______________. "Forest Clearings for Browse and Fruit Plants." Journal of Forestry, 64, 10 (Oct., 1966), 680-683.

(25) ______________. "Browse Palatability and the Effect of Burning in Southern Pine Forests." Journal of Forestry, 65, 11 (Nov., 1967), 826-828.

(26) Lay, Daniel W. "Foods and Feeding Habits of White-Tailed Deer." Proceedings of a Symposium, USDA Forest Service Southern Forest Experiment Stations; Forest Game Committee, Southeast Section of the Wildlife Society; and the School of Forestry, Stephen F. Austin State University, (1969).

(27) Lindzey, James S. "The White-Tailed Deer in Oklahoma: Ecology, Management, and Production." (Unpub. Ph.D. thesis, Oklahoma A. & M. College, 1951.)

(28) Lutz, Harold J. and R. F. Chandler. Forest Soils, New York: John Wiley and Sons, Inc., 1959. p. 355.

(29) Lyon, L. Jack. "Estimating Twig Production of Serviceberry from Crown Volumes." Journal of Wildlife Management, 32, 1 (Jan., 1968), 115.

(30) ______________. "Length-and-Weight-Diameter Relations of Serviceberry Twigs." Journal of Wildlife Management, 34, 2 (Feb., 1970), 456-460.

(31) Mason, Lamar R. and S. S. Hutchings. "Estimating Foliage Yields on Utah Juniper from Measurements of Crown Diameter." Journal of Range Management, 20, 3 (Mar., 1967), 161-166.

(32) Osgood, Wilfred H. The White-Tailed Deer. Chicago: Field Museum of Natural History, Department of Zoology, 1922.

(33) Segelquist, Charles A. "Evaluation of Wildlife Forage Clearings for White-Tailed Deer Habitat Management in a 600-acre Arkansas Ozark Enclosure." (Unpub. Ph.D. thesis, Oklahoma State University, 1974.)

(34) ______________. and W. A. Green. "Deer Food Yields in Four Ozark Deer Types." Journal of Wildlife Management, 32, 2 (Feb., 1968), 330-337.

(35) Shaw, Samuel P. and T. H. Ripley. "Managing the Forests for Sustained Yield of Woody Browse for Deer." Proceedings: Society of American Foresters Meeting, (1965), 229-233.

(36) Sheldon, John J. and Keith Causey. "Deer Habitat Management: Use of Japanese Honeysuckle by White-Tailed Deer." Journal of Forestry, 72, 5 (May, 1974), 286-287.

(37) Snider, Carl C. and J. M. Asplund. "In Vitro Digestibility of Deer Foods from the Missouri Ozarks." Journal of Wildlife Management, 38, 1 (Jan., 1974), 20-31.

(38) Taylor, Walter P. "The White-Tailed Deer of North America." Symposium: Ecology and Management of Wild Grazing Animals in Temperate Zones, Eighth Technical Meeting (1969), 203-220.

(39) The Newspaper Enterprise Association, Inc. (Editors) The World Almanac and Book of Facts. New York: Doubleday and Co., Inc., 1973, pp. 224-235, 719.

(40) The Newspaper Enterprise Association, Inc. (Editors) The World Almanac and Book of Facts. New York: Doubleday and Co., Inc., 1974, pp. 238-249, 705.

(41) U. S. Department of Agriculture. Yearbook of Agriculture. Washington: U. S. Government Printing Office, 1967.

(42) Wyman, Donald. Shrubs and Vines for American Gardens. New York: MacMillan Company, 1969.

APPENDIX

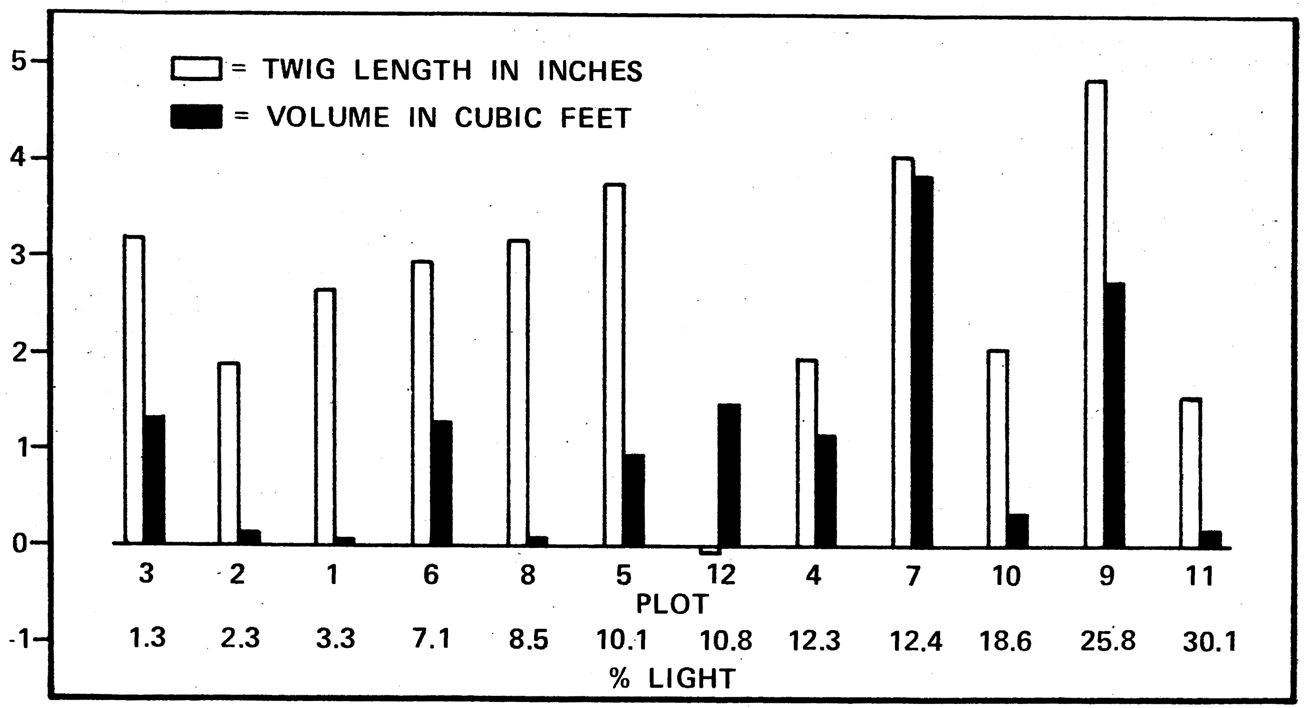

Figure 3. Graph of Average Twig Length and Average Cubic Volume of American Beautyberry

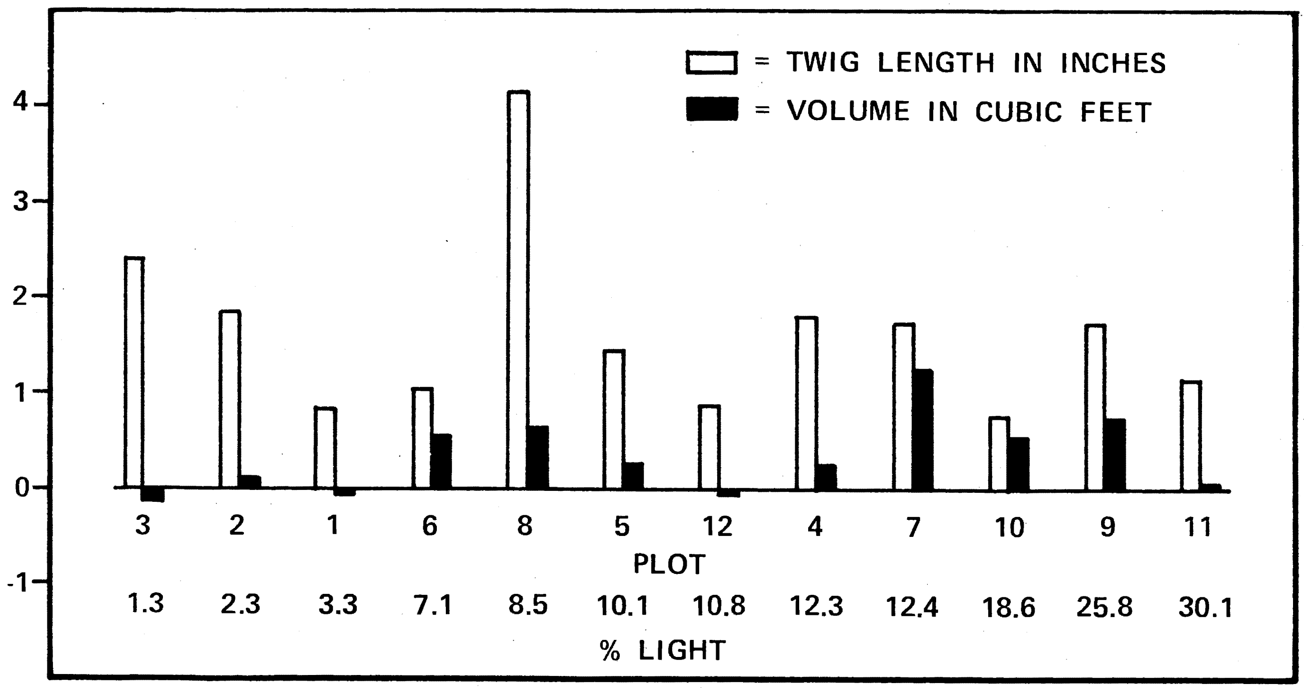

Figure 4. Graph of Average Twig Length and Average Cubic Volume of Bush Honeysuckle

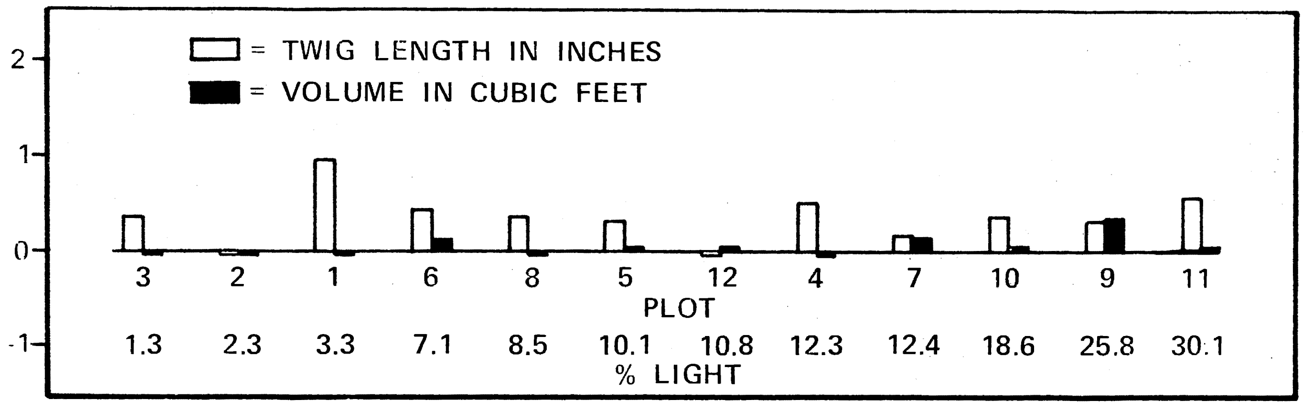

Figure 5. Graph of Average Twig Length and Average Cubic Volume of Dryland Blueberry

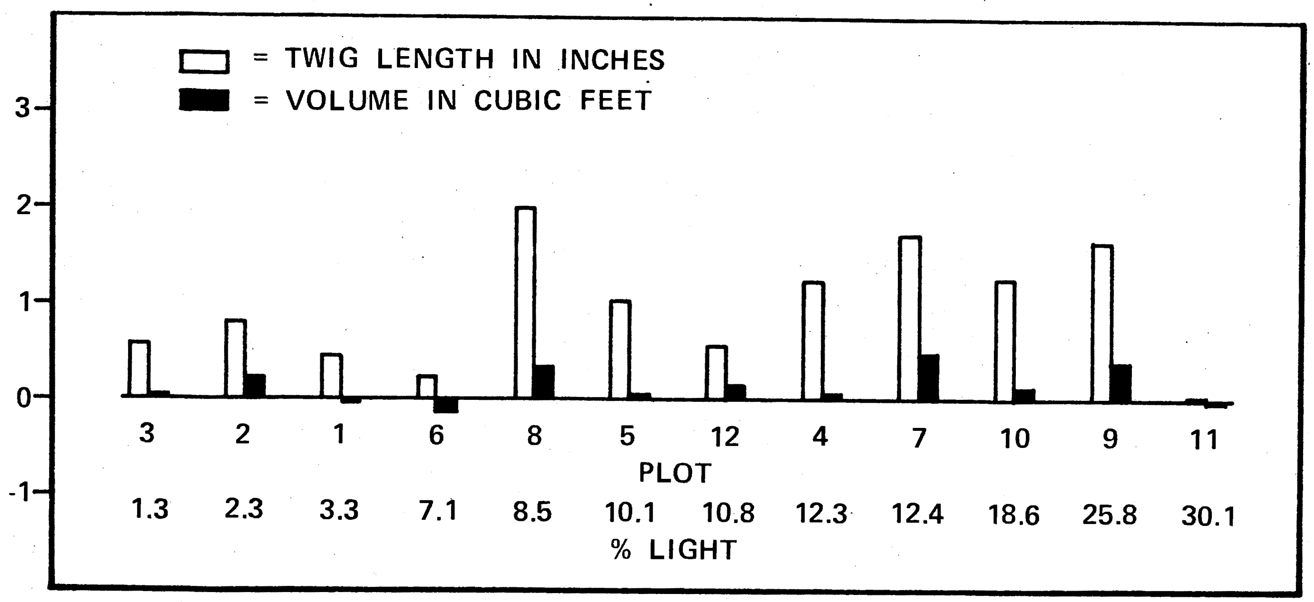

Figure 6. Graph of Average Twig Length and Average Cubic Volume of Deciduous Holly

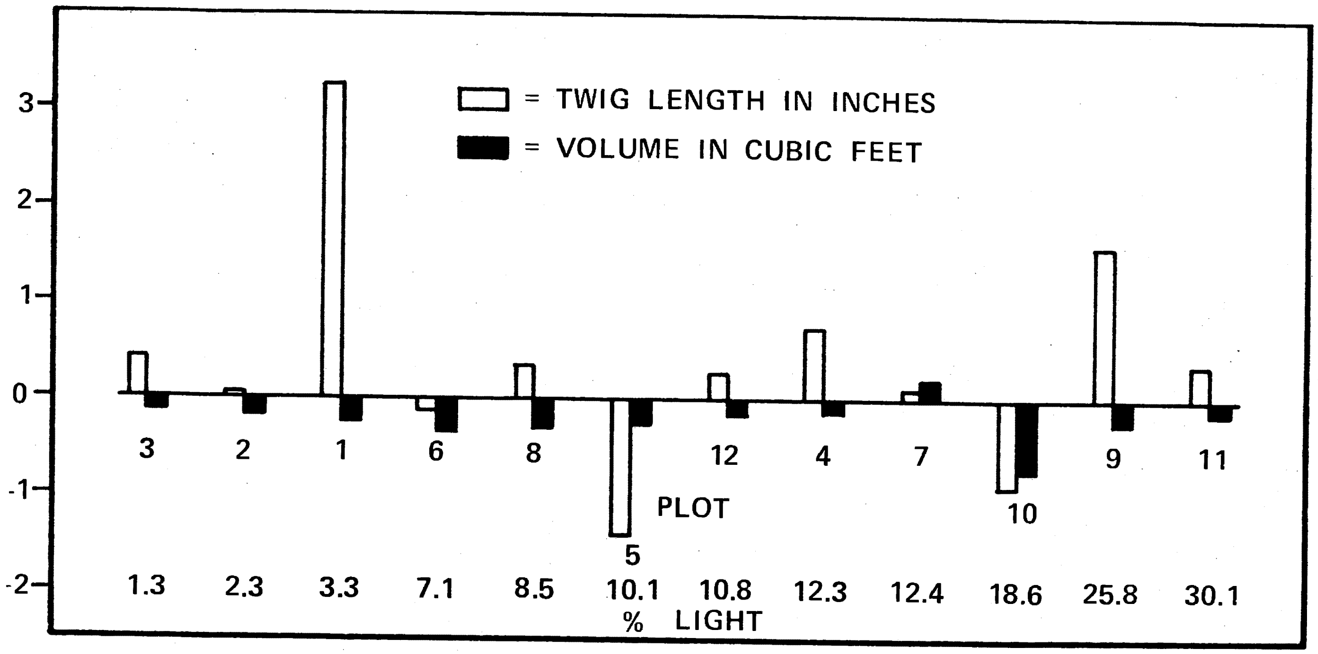

Figure 7. Graph of Average Twig Length and Average Cubic Volume of Elderberry

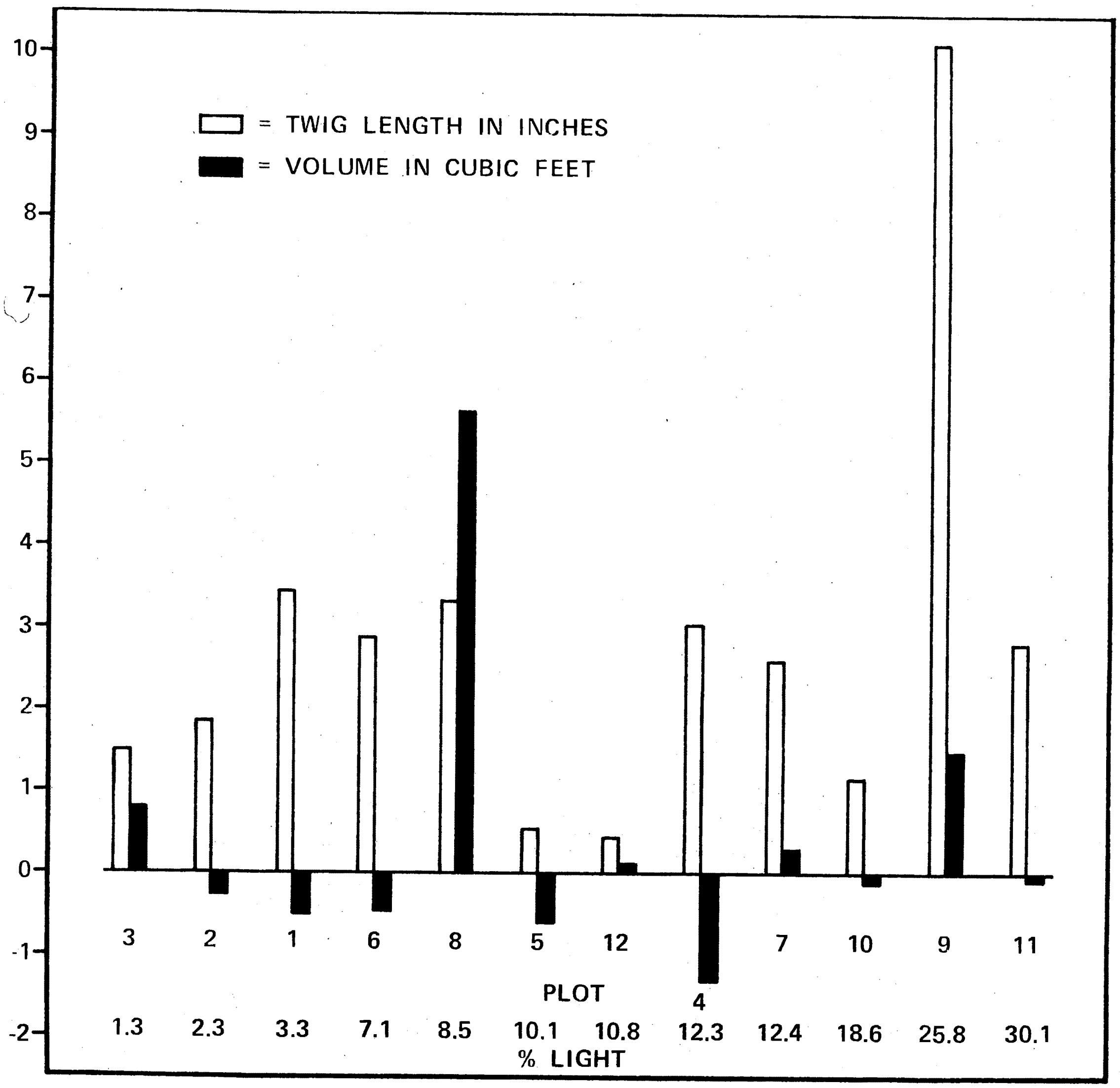

Figure 8. Graph of Average Twig Length and Average Cubic Volume of Japanese Honeysuckle

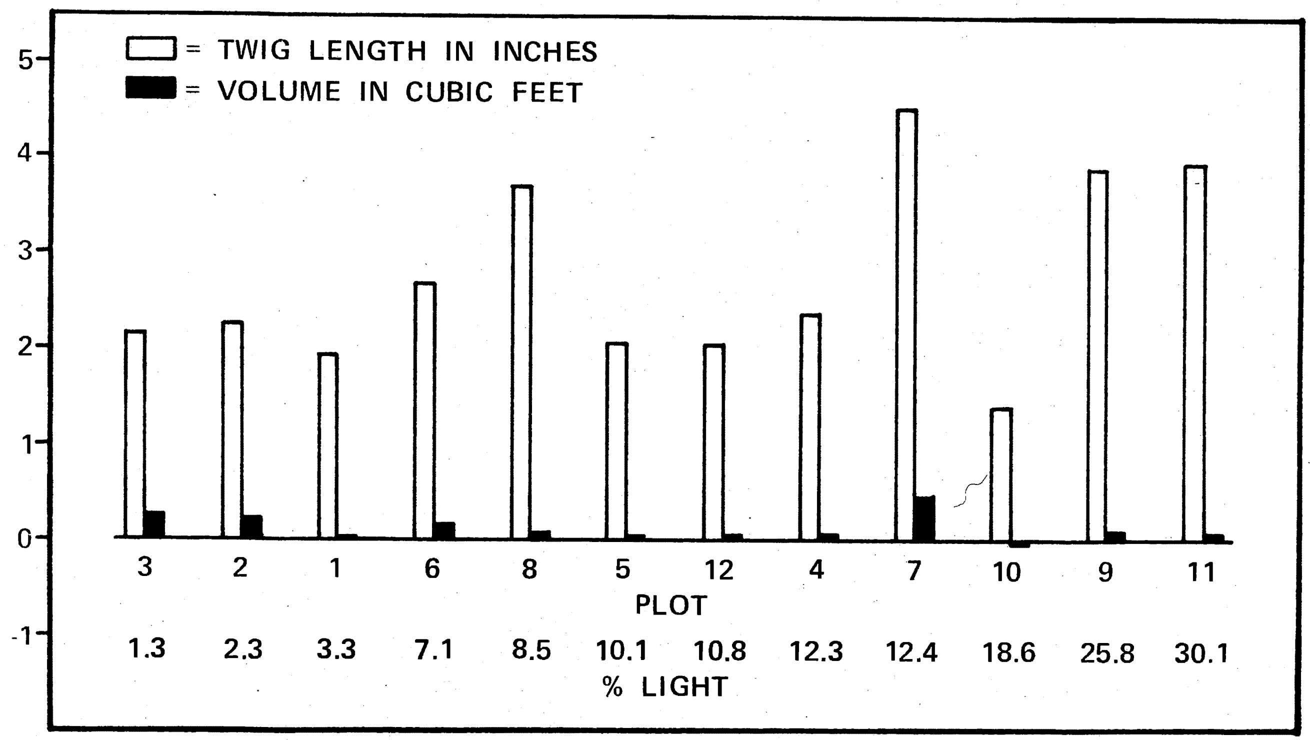

Figure 9. Graph of Average Twig Length and Average Cubic Volume of Strawberry Bush

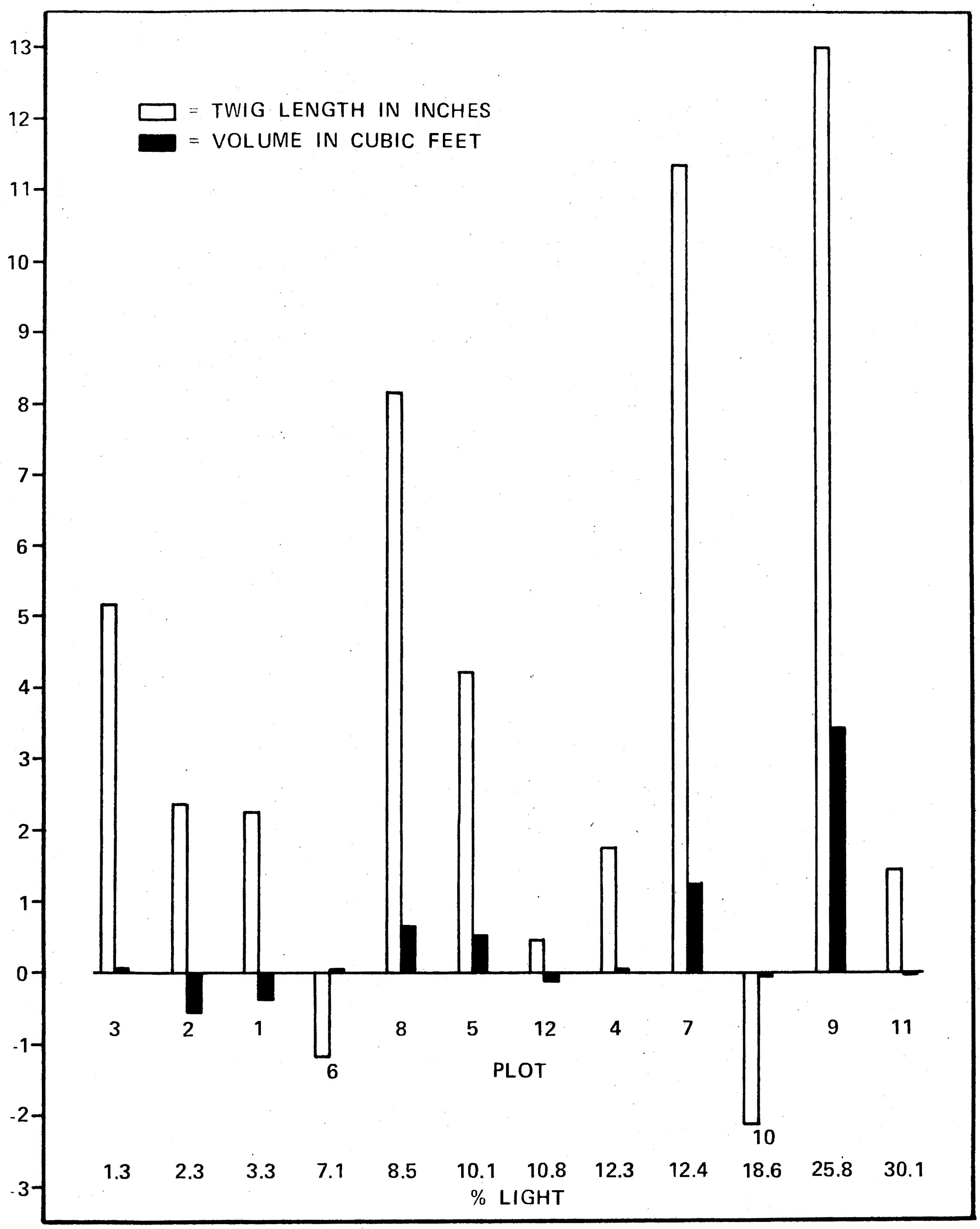

Figure 10. Graph of Average Twig Length and Average Cubic Volume of Summer Grape

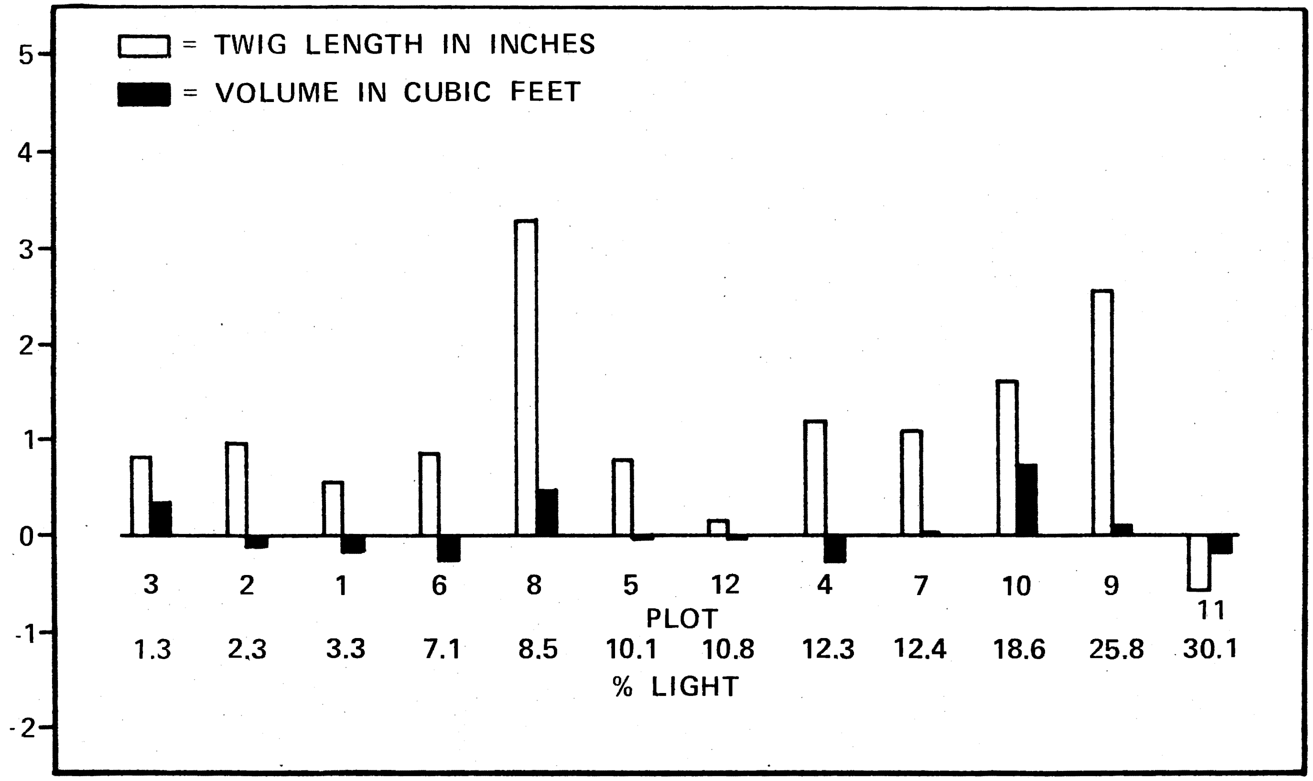

Figure 11. Graph of Average Twig Length and Average Cubic Volume of Smooth Hydrangea

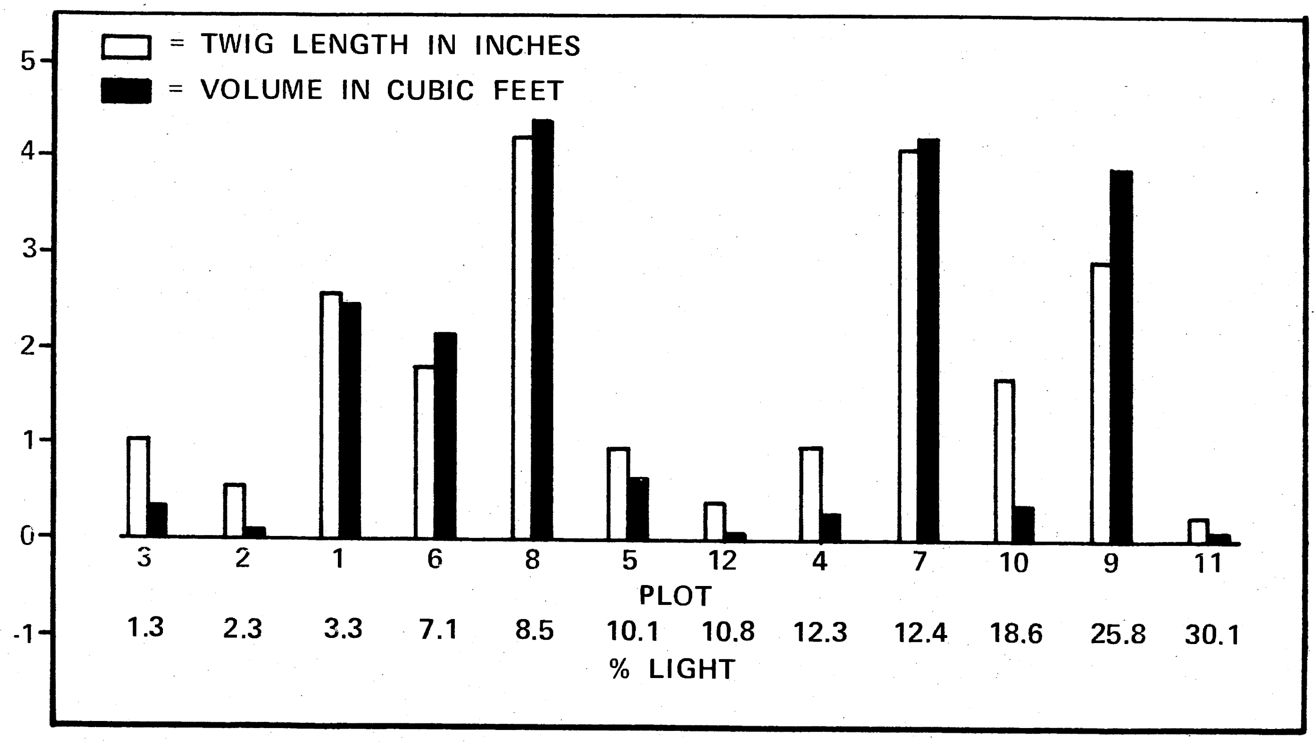

Figure 12. Graph of Average Twig Length and Average Cubic Volume of Yaupon

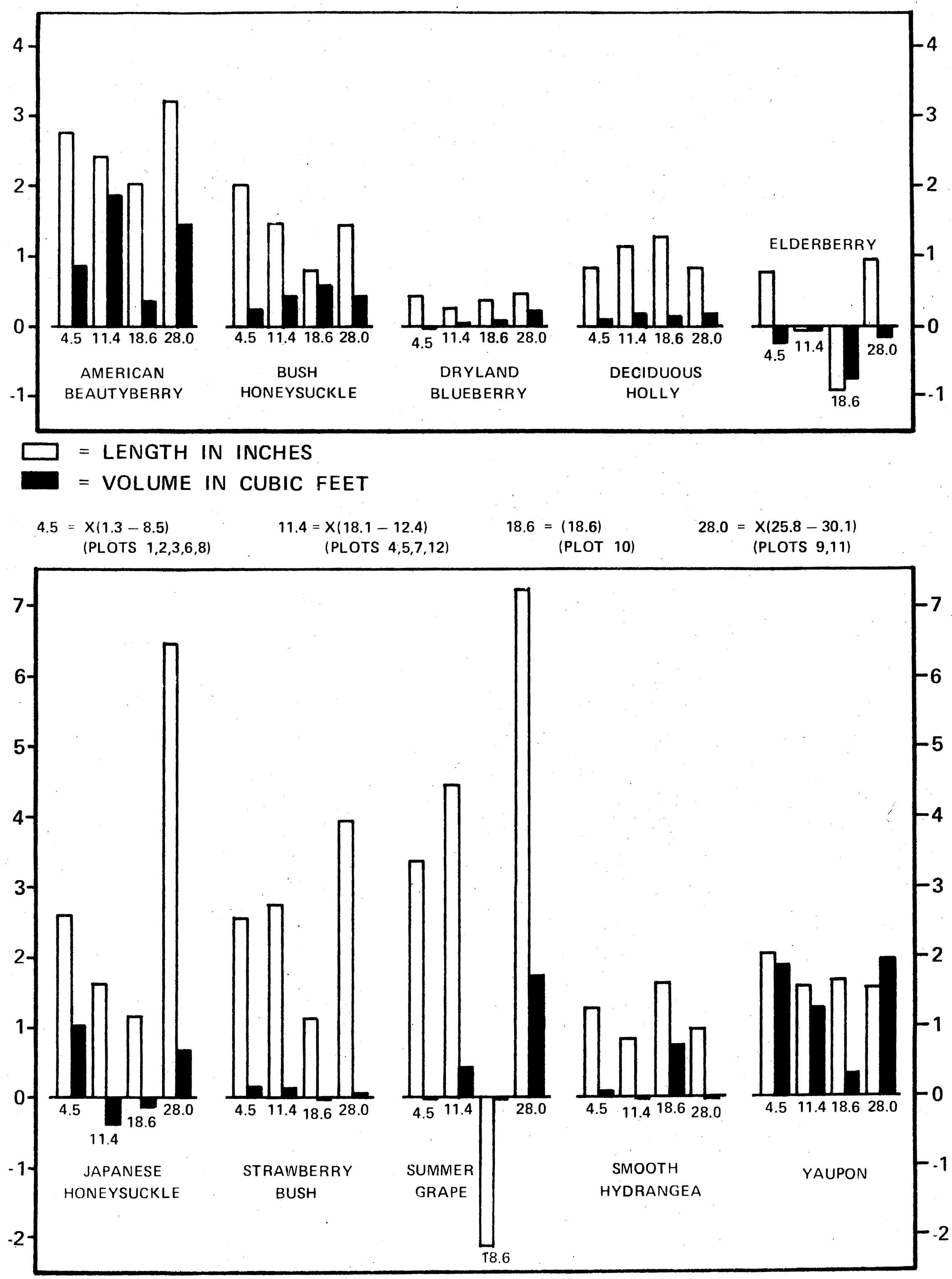

Figure 13. Graph of Average Twig Length and Average Cubic Volume of All Species, With Plots Grouped Into Four Ranges of Light Intensities

VITA

John Martin Christensen

Candidate for the Degree of

Master of Science

Thesis: GROWTH OF TEN SPECIES OF PREFERRED DEER BROWSE PLANTS UNDER VARIOUS CROWN DENSITIES

Major Field: Forest Resources

Biographical:

Personal Data: Born in Ponca City, Oklahoma, June 28, 1944, the son of Edward W. and Luella C. Christensen.

Education: Graduated from Ponca City Senior High School in May, 1962; received Associate in Arts degree from Northern Oklahoma College in May, 1964; received Bachelor of Science degree in Agriculture, with a major in Forestry, from Oklahoma State University in May, 1968; completed requirements for the Master of Science degree at Oklahoma State University in July, 1976.

Professional Experience: Timber Marker, Dierks' Forests, Incorporated, 1965-66; Technician, Oklahoma State University, Department of Forestry, at the Kiamichi Forest Research Station, summer of 1967; District Culturist, Timber Sale Preparation Assistant, Project Sales Officer, U. S. Forest Service, 1968-72; Graduate Teaching Assistant and Graduate Research Assistant, Oklahoma State University, Department of Forestry, 1972-74; presently employed, since 1974, as Forestry Foreman, Department of Parks and Recreation, City of Stillwater, Oklahoma.