

THE INFLUENCE OF VARYING LIGHT INTENSITIES  
ON THE VEGETATIVE GROWTH OF TEN SOUTHERN  
FOREST DEER BROWSE SPECIES

By

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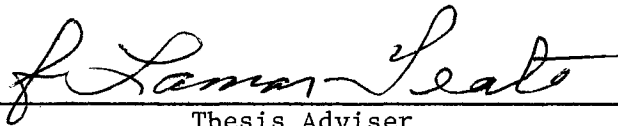
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## CHAPTER I

### INTRODUCTION

#### A. The Problem

The southern forests are contained in an area extending from Virginia to eastern Texas and Oklahoma. By the year 2000, these forests are expected to be the number one source of pulpwood, saw-timber and plywood for the United States (35). Since the majority of the more than 200 million acres of commercial forest land contained in this area are in private ownership, economics and the need for more efficient management and harvesting have dictated an ever increasing dependence on even-aged pine plantation management. This trend will continue to economically justify the removal of hardwood browse and fruit species that are presently available to the white-tailed deer (Odocoileus virginianus). Deer contributes both to the economics and recreational values of a timber stand. Blair (5) points out that although commercial forests are generally managed to provide a favorable environment for tree growth and regeneration, they also can and should be managed for the production of deer food and cover.

White-tailed deer are primarily browsing ruminants except in late winter and early spring when they utilize large amounts of grasses and forbs. Korschgen (24) found that individual food habits vary widely within the deer range in relation to differences in ecological types,

plant associations, land use patterns and the density of the deer population. According to Lay (29), principal foods utilized include browse plants, fruits, succulent herbage, mushrooms and agricultural crops. Although browse generally contributes less than one half of the total diet, it is important in that it is usually available on a year-around basis as either green leaves and twigs or as fruit producing plants.

Browse consists primarily of tender shoots, twigs and leaves as well as certain fruits. Results of a study conducted by Cushwa, Downing, Harlow and Urbston (8) indicated that nearly all browsing of twigs occurs during the spring when they are growing rapidly and are therefore succulent and palatable. Young tender tips are taken when available but with maturity they become hard for the deer to digest due to the high lignin content and are therefore used less frequently.

Blair and Epps (5) found that in the spring leaves and young twigs contain sufficient protein for deer body maintenance and some growth. After maturity only leaves contain a maintenance level of protein. During the spring and summer seasons, Cushwa, Downing, Harlow and Urbston (8) found fast growing leaves to be major food items for deer while some evergreens are taken the year-around making them especially valuable as a part of habitat management.

Most browse plants produce fruits that are eaten by deer. Lay (27) reports that fruits are important since they are available in late summer and fall when other nutritious food is scarce. While individual species of soft fruits may be limited in their period of availability, collectively they are available the year-around and, although limited in quantity, they have a high rate of digestibility and are a good

source of energy for the deer.

As stated by Blair (4), southern forest pine plantations can, depending on their age and management, provide sizable amounts of browse. According to Halls (12), the suitability of a plantation for deer habitat is directly related to the kinds and amounts of forage in the understory which is inversely related to the timber stand density and the corresponding amount of light reaching the understory plants. As the trees develop from regeneration to harvest, they and the plants beneath compete for light, moisture, mineral nutrients and growing space. The availability of these factors and the physiological tolerance level of the understory plants determines the ecological development of the timber stand which, in turn, regulates the suitability of an area for deer habitat.

Blair (4) reports that timber stand development and structure of a pine plantation affects habitat potential by influencing browse plant production. In the early reproduction stage of about three to five years, the timber stand increases in size and density which causes the crowns to close, thus excluding most of the understory by intercepting the light available for plant growth. During this time the plantation serves the deer mainly as cover if food is nearby. After the first thinning at an age of approximately fifteen to twenty years, forage is again produced due to the increased light energy reaching the understory. Since woody browse brought in by thinning is not permanent, the stand must be thinned again at four to five year intervals to keep the canopy open. At the same time, a midstory must be kept from forming since it usually grows above the deer's normal browse limit and it also serves to keep light from reaching the understory browse plants.

Silvicultural methods such as deadening, thinning and burning not only reduce the midstory but also serve to keep browse plants low while improving their nutritional quality.

According to Carter and Dow (7), the primary concern today of forest and wildlife managers is the effect various methods of timber management have on wildlife habitat. Duvall (10) and Hall and Alcaniz (16) report that techniques used in forest management to improve deer habitat include alteration of the overstory density and understory species composition to increase the quantity or improve the seasonal distribution, palatability and quality of browse plant tissue. To achieve such a management goal, the manager must have knowledge of the attributes and shortcomings of browse plants acceptable to deer and the effects of environmental factors on the establishment and growth of such plants (20).

Environmental influences on growth of browse plants are important because the use of browse plants by deer depends on the condition of the plant itself. As reported by Halls and Alcaniz (16) rapidly growing plants and newly formed plant tissues are more nutritional and palatable which, according to Dietz (4), results in high feed intake.

Blair (5) states that the major environmental factors influencing browse composition, growth and vigor are moisture, soil, temperature and light. Of these factors, light can be the most easily modified and controlled by the forest manager through stand manipulation. Likewise modification and control of light influences soil moisture and temperature. Adequate deer food and cover can generally be produced beneath dominant canopies if there is enough light since many species can grow and reproduce at low light intensities, they can be managed as a

component of the forest understory. To accomplish this, timber owners must manage their stands at a minimum density that will yield acceptable economic returns and, at the same time, provide a favorable environment for the growth of palatable deer food.

#### B. Purpose of the Study

The determination of a minimum stand density that allows for both the production of deer food and cover plus an acceptable rate of timber growth must be evaluated on the basis of understory plant performance under varying timber stand densities. The purpose of this study was to evaluate the vegetative growth and seasonal growth patterns as influenced by varying intensities of light.

Other studies, including those reported by Blair (3, 4), Carter and Dow (7), Halls and Alcaniz (13, 14, 15) and Halls and Epps (18), have been conducted on southern browse species to determine growth and fruit production under open-grown conditions compared to woods-grown. Generally, the results have been that influences imposed by tree overstory densities vary regionally but open sites generally sustain plants with greater productivity and nutrition. According to Halls and Alcaniz (14), this greater and prompter growth under open-grown conditions helps explain the common observation that browse is most abundant during those periods of the timber cycle when overstory competition is lowest.

As reiterated by Halls and Epps (18) and Laycock and Price (31), plants grown under shaded conditions generally have less herbage production, lower percentage of nitrogen-free extract, higher lignin content and a higher protein content. Shade retards plant development and

maturation, therefore, plants remain succulent longer during the summer and are available for a longer period of time for deer utilization. For these reasons it is important to know the time of year browse plants grow and mature under differing light conditions. Such differences in growth patterns between species offers possibilities for combining plants within a deer's home range in order to provide young green browse throughout most of the year. During their study of the growth patterns of several browse plants, Halls and Alcaniz (13, 16) found that the plants generally have a rapid flush of growth in the spring and then a leveling off in the summer.

#### C. Advantages of the Procedure Used

All previously reported light and growth studies concerned with southern browse plants were carried out in natural field conditions. Each revealed that growth was stimulated by other environmental factors such as varying moisture, soil and temperature conditions which compounded the influence of light upon growth.

The procedures used in this study, reported in the following text, were designed to control the major environmental growth factors of soil and moisture. Therefore, plant response to varying light conditions will be considered as the only influencing factor.

## CHAPTER II

### MATERIALS AND METHODS

#### A. Plant Materials

##### 1. Selection

The ten plant species used in this study represent only a small portion of the total number of plants utilized by the white-tailed deer in the southern forest habitat. They were selected because they are indigenous to the southern forests, are producers of browse and fruit that is utilized by deer, do not interfere with forest management and are available as commercial nursery stock.

##### 2. General Description

The plant descriptions which follow contain information such as identifying features, natural ranges, deer preferences and taxonomical and physiological information. Previous intensive studies have been reported for some of these species while little or no information is available on others. Therefore, consistency in presentation was not attainable.

For an area to sustain a herd of white-tailed deer there must be a variety of browse plants and other foodstuffs to supply a balanced year-around diet. So as not to infer in the discussion that any one

plant is more important or valuable than another, the plants presented below have been arranged alphabetically according to scientific names.

a. American Beautyberry - *Callicarpa*  
*americana* (Figure 1)

American beautyberry is a common understory shrub that grows throughout the South. Its natural range is eastern Texas and Oklahoma, east to southern Missouri and Maryland and south to Florida. While the leaves may wilt during a drought, it can persist on very dry sites but grows best on moist soils beneath high, fairly thin, pine canopies or in open areas. Halls and Epps (18) reported that due to a shorter life span in the open compared to growth beneath a canopy, American beautyberry is less prevalent in the open. On ranges that have been subjected to heavy browsing or fire which has reduced other woody plants, it is very common and sometimes dominates the area.

This multi-branched shrub ranges in height from two to eight feet. The brittle mainstem grows from three to six feet tall.

Deer and cattle eat the twigs and leaves during the growing season and occasionally in early winter. As a deer preference food it is ranked low during the spring but as the season progresses use increases. Overall it is considered a medium preference. That is, it is life sustaining, providing a large part of the deer's diet when first choice feeds are scarce.

Twigs are round or four-sided, star shaped, and are covered with densely matted hairs.

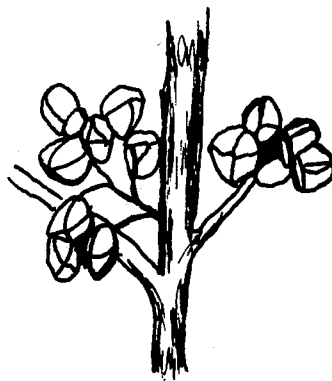
The deciduous aromatic leaves are simple, opposite or sometimes ternate. The soft-textured blades are ovate to elliptic in shape.

Verbenacea-Vervain Family  
Callicarpa americana - American  
Beautyberry



Foliage and Flowers XI

Also commonly called:  
Spanish mulberry  
French mulberry  
Sourbrush



Fruit XI

Figure 1. Morphology of American Beautyberry.

The apex is acute to acuminate while the base is acute. Margins are coarsely serrate to dentate. Leaf length ranges from three to nine inches with widths varying from one and one-half to five inches. The lower surface, the veins of the upper surface and the petiole are covered with yellow-brown to white matted hairs.

Flowers appear on the new growth mostly during June but may occur up to November. The small one-eighth inch long perfect flowers are borne on axillary dichotomous cymes. The petals are rose to pale pink or pale blue in color and are rarely white.

American beautyberry bears fruit at a very early age. These fruits are brilliantly colored violet to reddish purple (rarely white) and become noticeable in July, maturing on the stem from August to November. They form dense spherical clusters that encircle the stem at regular intervals. Each berry-like drupe is from one-eighth to one-fourth inch in diameter and contains four seeds, each about one-sixteenth inch long. According to Halls and Ripley (21), there are approximately 30 fruits per cluster and about 7,300 per pound. They may persist through early winter and a few on the lower stems until early spring. Deer frequently eat the fruits from August through October and lesser amounts at other times. Since the fruits are readily available in August and September when other wild fruits are scarce, it is an important item in the deer's habitat. Also, because of its high water content of about 80 percent, it can be important to the deer during the dry late summer months.

Halls and Alcaniz (14), reporting on an east Texas study, found that while American beautyberry has a reasonable fruiting capacity in stands of timber, the highest fruit production occurs in open fields.

The comparative growth ratio of open-grown to woods-grown production was as high as 26:1.

Lay (28) reported that deer find and take these prolifically produced fruits seven to nine months of the year although the fresh fruit is available for less than four months.

Halls and Oefinger (19) report that the fruits are relatively high in energy value with fat content ranging from six to eleven percent while the crude protein, phosphorous and calcium contents are generally marginal or deficient for most game animals.

The growth pattern of this plant was studied in east Texas by Halls and Alcaniz (12, 15). Their findings were that growth was initiated by a spring flush after which the stems ceased to elongate and terminal buds were formed. Spring temperatures and moisture had the strongest effect on forage yields and quantities which were available later in the year. Yields are relatively unaffected by low rainfall and high temperatures which occur during the summer and fall. Average twig lengths were longer for open-grown compared to those grown in the woods. Woods-grown plants were smaller and healthier.

Another east Texas study conducted by Halls and Alcaniz (14) found that, for the first two growing seasons after a timber thinning, forage yields did not increase. During the third season small responses occurred but mainly because of a fire which had killed the tops of the plants. Yields and initial responses to thinning and burning were found to be most effective at four to five year intervals.

Blair (2), working in central Louisiana, reported a marked increased production of palatable American beautyberry deer browse in both winter and summer seasons with corresponding heavier degrees of

thinnings in a pine plantation.

Heavy use seldom kills this plant but often reduces browse and fruit yields. Lay (26) found that when plants were clipped to simulate deer use in southeastern Texas, American beautyberry had an intermediate level of survival and productivity rate. When all new growth was removed, monthly production decreased in the spring from 146.3 to 2.4 grams of air dry weight in three years.

Under moderate deer use pressure in east Texas, Halls and Ripley (20) reported about one-quarter of the available forage was taken under heavy deer and cattle utilization. In six years browse production decreased from twenty-one to six pounds per acre under a fully stocked pine stand. On open sites, American beautyberry was able to withstand 40 percent utilization.

Investigating leaf and twig tissue nutrient variances as influenced by maturation, Blair and Epps (5) reported that American beautyberry exhibited the following characteristics:

- 1). As indicated by dry matter content, the leaves and twigs contained the most palatable and digestible tissue in the spring. After the tissues have matured, leaves are the better source of succulent forage;
- 2). In the spring, the twig tips and bases and the leaves contained the required excess protein necessary for deer growth. The leaf tissues contained a maintenance level at all times while twigs contained this level only during the spring;
- 3). Crude fat is relatively low in all tissue. While the content increases in leaf tissues with maturation, the twig experiences very little seasonal change. Leaf tissues are the better source of crude fat especially in summer and fall when the deer is storing body fat;

- 4). The content of crude fiber changes very little in leaf tissues. Crude fiber content of twigs is lowest in the spring and increases substantially by mid-summer and remains high the remainder of the year;
- 5). Nitrogen-free extract, or soluble carbohydrates, increases with maturation. Leaves contain more soluble carbohydrates than twigs and twig tips have higher levels than twig bases;
- 6). Leaves contain less ash than twigs in the spring but contain more in the other seasons;
- 7). Calcium content increases in the leaves with maturation but varies very little in the twigs. Compared to twigs, leaves contain more calcium in all seasons;
- 8). Only in the spring do the leaves and twigs provide enough phosphorus for deer body maintenance. During this time, twig tips contain more phosphorus than the leaves while the leaves contain more than the twig bases. With maturation, leaf and twig tissue contents equalize;
- 9). The calcium-phosphorus ratio is lowest in the spring and widens with maturation. There is little variance during the remaining portion of the year. The ratio for twig tips is more desirable than leaves and twig bases.

Lay (25) reports that the nutritional value and palatability of American beautyberry leaves and twigs is improved with fires and are maintained with properly spaced repeated burns.

Halls and Epps (17) report that the nutrient content of open-grown American beautyberry plant is much higher than woods-grown plants.

Natural propagation is accomplished through seeds which are widely distributed by birds and mammals of many kinds. This plant can also be artificially propagated by man through collection of seeds in fall and

sowing in the next spring. Cuttings can also be made, the best time being in September.

b. Fringetree - *Chionanthus virginicus*

(Figure 2)

Fringetree is most abundant in the understory of pine-hardwood forests especially on moist, acid, sandy loam soil in thickets or along stream and river banks. Natural distribution of this plant is from eastern Texas, Oklahoma and Kansas, east to southern Missouri and Kentucky, Ohio and Pennsylvania and south to Florida. Although its range is wide, it is usually a minor component of the total vegetation of an area and is among the shorter lived plants. In its northern range fringetree is usually a shrub but in the South it may develop into a tree 18 feet and occasionally 35 feet tall with a diameter of eight to twelve inches. The short ascending branches form a narrow oblong crown. Best development is reached in semi-open areas but the plant is moderately shade tolerant and is sometimes found under dense overstories.

The bark is umber in color, nearly smooth above and deeply scored below into narrow short confluent ridges and is sometimes used as a source of a tonic for a diuretic and fever remedy. The wood is close grained, strong and light brown in color and has no commercial value.

Deer and cattle utilize this plant as browse. Ripley and McClure (34) classed fringetree as a staple according to a preference for deer food. It constitutes the bulk of the diet on good ranges and is of high nutritive value, thus providing for normal deer weight gain and reproduction. Halls and Ripley (21) reported that in the Gulf Coast

Oleaceae-Olive Family  
Chionanthus virginicus -  
Fringetree



**Foliage and Flowers XI**

Also commonly called:  
White fringetree  
Old man's beard  
Flowering ash  
Grandfather-gray-beard



**Fruit XI**

Figure 2. Morphology of Fringetree.

Plains, it is a preferred deer browse but in the Piedmont and mountains it is grazed lightly. Greater use occurs in the spring, summer and fall. It is moderately intolerant to browsing and often dies when over one-third of the annual growth is removed.

Twigs are stout, slightly angled and more or less covered with fine hairs especially when young. They are ashy gray to reddish brown at the tips. The large warty lenticles are round or shield shaped. Terminal buds are broadly ovoid, acute tipped, brown colored and about one-third inch long with smaller lateral buds. Winter buds are covered with several outer acute scales. Leaf scars are elevated and semicircular with numerous bundle scars arranged in a u-shaped pattern. The pith is homogeneous and white in color.

The opposite deciduous leaves are singular and narrow elliptic to oblong or obovate in shape. The apex is acuminate or acute while the base is wedge shaped or cuneate. The margin is entire but oftentimes wavy. Leaf lengths range from three to eight inches and widths vary from one to four inches. Veins form a prominent net-like pattern. The upper surface is dark green and glabrous. Lower surfaces are a paler green and pubescent at least on the veins. Petioles are stout and about three-fourths of an inch long.

The fragrant greenish-white to white flowers appear with the leaves from March to June. They are borne from lateral buds near the ends of year-old branches in five to ten inch long, loose, drooping pendants of three flower clusters from four to six inches long subtended by bracts. Although practically dioecious due to imperfect development of either the stamen or pistil, occasional perfect flowers appear. The four linear petals are nearly one inch long with deeply four-lobed

calyx. Fringetree usually flowers at the age of from five to eight years.

The fruit is a dark blue-black to purple berry-like drupe occasionally covered with a whitish bloom. They are borne in loose clusters from August to October. The drupe is from one-half to one inch long and contains three ovoid seed each one-third inch long. These fruits and seeds are taken by many birds and animals including turkey, quail and deer. Lay (28) reported that deer take the fruit from seven to nine months out of the year in east Texas.

From an investigation of growth patterns, Halls and Alcaniz (13) reported that fringetree followed a pattern of a rapid spring growth flush succeeded by cessation of stem elongation and the formation of terminal buds. Spring temperatures and soil moisture conditions apparently strongly influenced the rapid early growth which in turn determined the forage yields for the remaining portion of the year.

Observations in Mississippi, Louisiana and eastern Texas, as reported by Halls and Ripley (21), indicate that hot fires will root kill most specimens but light fires induce sprouting and help keep forage available to deer.

c. Strawberry Bush - *Euonymus americanus*

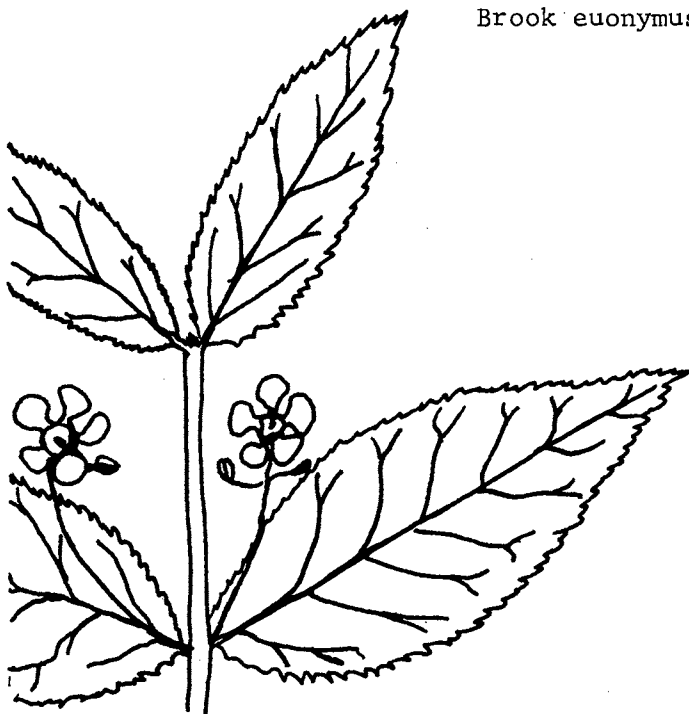
(Figure 3)

The shade tolerant strawberry bush is generally found on fertile, well drained, moist sites with a definite humus layer. It is most abundant on the borders of woods, northern aspects of ravines, along stream edges, in coves and on rich bottom land. Optimum growth is obtained in mature hardwood stands. The natural range of this plant

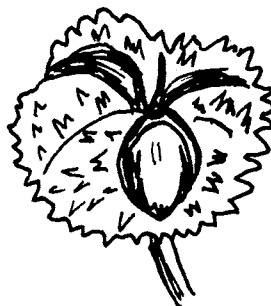
Celastraceae - Staff Tree Family  
Euonymus americanus - Strawberry Bush

Also commonly called:

Burning bush  
Fish wood  
Bursting heart  
Brook euonymus



Foliage and Flowers XI



Fruit XI

Figure 3. Morphology of Strawberry Bush.

is eastern Texas, Oklahoma and Kansas, southeastern Nebraska, east through southern Missouri to New York and south to Florida. With the exception of some fringe areas of this distribution, Ripley and McClure (34) classes this plant as a highly preferred deer browse species that constitutes a delicacy or "candy" species which is taken first and is high in crude protein. Even when animal density is low, deer take this plant although other species may be taken more heavily as herd pressure increases. Due to its natural sporadic occurrence, it seldom contributes more than two percent to the total diet of a deer.

Strawberry bush grows in an upright or semierect shrub form ranging in height from two to seven feet. The bark is a gray-brown color. The plant is available to deer during all stages of growth and is heavily browsed during late winter and early spring. Both the twigs and leaves are utilized.

Twigs are slightly four-sided, olive green in color and oftentimes spreading and horizontal.

The leaves are thick and dark green, turning a pale green or scarlet in the fall. Blades are lance-ovate to lanceolate in shape, one to four inches long. Leaf apexes are acuminate while the bases are cuneate. Margins are slightly serrate. Although deciduous, leaves often persist in the southern range.

The solitary flowers are borne on slender stalks in May or June. The one-half inch broad flowers contain five rounded clawed petals.

The capsule fruit forms from September to October and is covered with sharp tubercles. This pink to purple-red capsule splits at maturity revealing three to five reddish-orange to crimson-red pulpy seed.

Best growth is attained where understory is sparse to moderate. Halls and Alcaniz (16) reported that growth normally begins with a rapid spring elongation in east Texas. About 80 to 90 percent of the total growth has been attained by the last of April or early May. Due to nominal continued summer growth, little influence is brought to bear due to summer rains.

Comparing plant growth in open and woods-grown conditions in east Texas, Halls and Alcaniz (14) found that there was little growth difference between the two conditions. Later, Halls and Alcaniz (16) reported that woods-grown plants, when compared to open-grown, attained longer twig elongations and appeared more healthy.

Strawberry bush is increased by logging operations and by protection from overbrowsing and hot fires. The species disappear from overstocked ranges. Natural propagation is through seeds scattered by birds. Artificially, stem cuttings can be rooted in the fall.

d. Smooth Hydrangea - *Hydrangea arborescens*

(Figure 4)

Smooth hydrangea grows in well-drained soils along steep road banks, rocky stream banks and in forest openings at elevations ranging from 2,000 feet to over 4,000 feet in the mountains of North Carolina. The natural range of this plant is Louisiana north to Iowa, east through Michigan and New York and south to Florida. Deer browse this plant during all seasons. As a deer preference food, Ripley and McClure (8) class it as a desirable staple forming the foundations or "bread and butter" species that constitutes the bulk of the deer's diet on good range. It is high in nutritional value providing for normal

Saxifragaceae-Saxifrage Family  
Hydrangea arborescens - Smooth  
Hydrangea

Also commonly called:

Hills-of-snow  
Mountain hydrangea  
Sevenbark  
Wild hydrangea

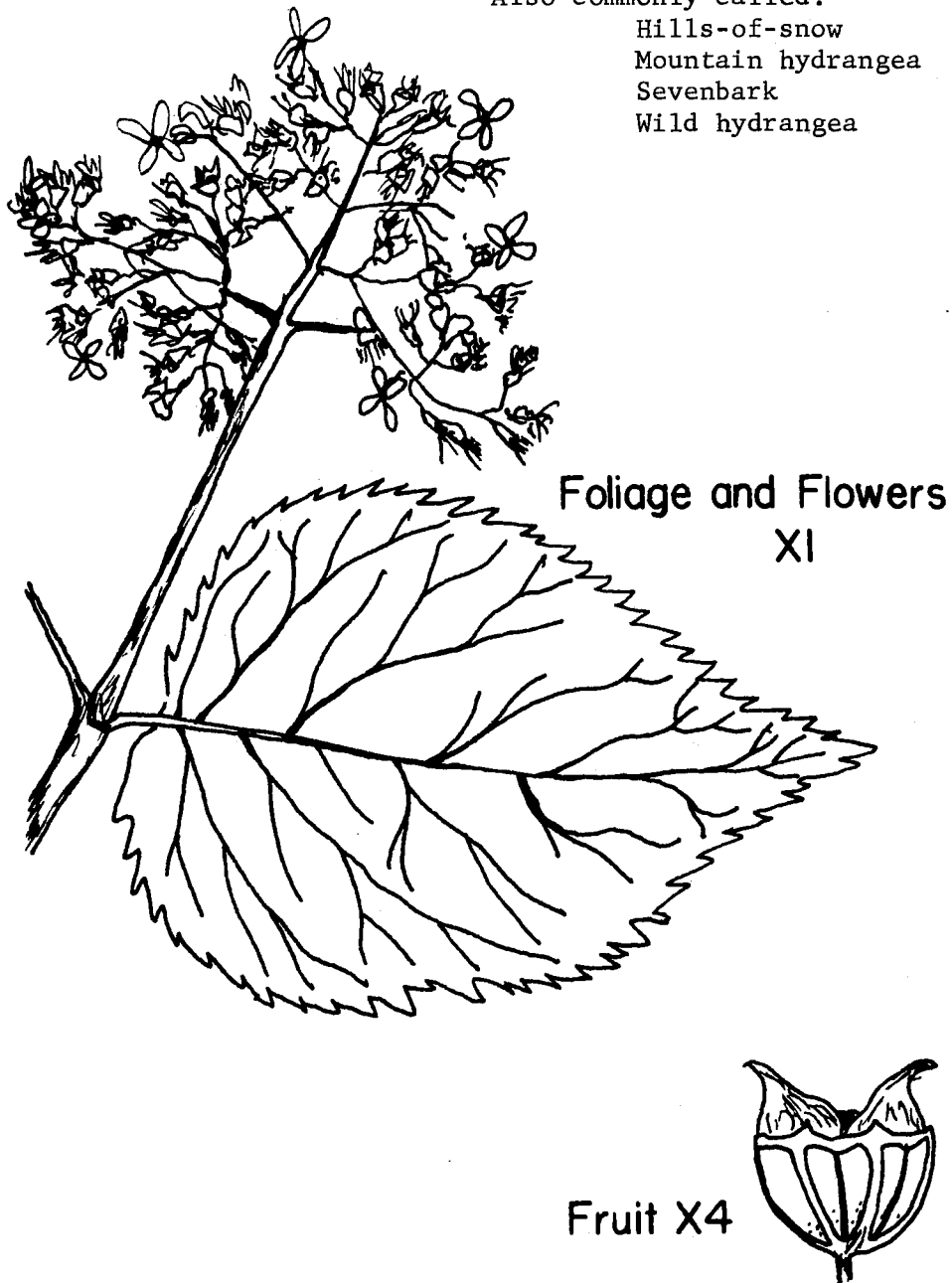


Figure 4. Morphology of Smooth Hydrangea.

deer weight gain and reproduction. In relatively good range it is taken after the more preferred buffalo-nut and strawberry bush. Intensive use of this plant indicates an overpopulation of the deer range. Spring and summer use of leaves, shoots and twigs has been heavy with high deer populations in the mountains of North Carolina and Georgia.

This wide branched shrub grows in clumps and reaches heights of from two to ten feet tall. Twigs are sparingly puberulous when young, turning light green and shaggy barked when mature.

The simple deciduous leaves are opposite and range in length from two to six inches. The blade shape is ovate to elliptic. The apex is acute or acuminate while the base is rounded or cordate. The upper surface is dark green, glabrous and deeply corrugated. The lower surface is a paler green, veiny and rarely downy. The margins are serrate to sharply dentate. When crushed, an unpleasant odor and bitter taste is given off.

Flowers and fruits of this plant are eaten by deer, turkey and other wildlife. Flowers form in June or July and are borne in creamy-white, two to six inch long cymes. Both the small fertile and the sterile flowers are borne together in terminal corymbose clusters. The exterior flowers of the cluster are often without petals, stamens or pistils but with enlarged and conspicuous calyx lobes. Sometimes the sterile flowers are abundant and sometimes absent.

The many seeded fruit develops in October to December. The approximately one-tenth inch two-celled capsule is membranous, two-horned and prominently ten-ribbed.

Halls and Ripley (21) report that smooth hydrangea can tolerate approximately 70 percent shade and grows well with less than 50 percent.

Under thin canopies, growth is in the form of long shoots coming out from the roots of old growth, thus forming a thick brush. Under heavy shade it forms a strong straggly growth with shoots growing from higher branches. The plant responds to increased light very quickly. In West Virginia, approximately 30 to 40 percent of the total annual growth can be taken off without plant damage. When the plant is repeatedly browsed during the growing season in Missouri over 35 percent of the plants studied were either killed or severely damaged.

e. Deciduous Holly - *Ilex decidua*

(Figure 5)

Deciduous holly occurs on the heavier soils in low moist locations such as the flat alluvial areas along streams and ponds. Its natural range is eastern Texas and Oklahoma, southeast Kansas and central Missouri, east to Virginia and south to Florida. Deer and cattle eat the leaves and tender twigs in the early spring and the fruit in the winter.

Its growth habit varies from individual plants and small clumps to extensive thickets. While the growth form is most often a tall shrub, it attains tree form with heights of 20 to 30 feet and diameters of six to ten inches. The spreading branches are light gray in color. The slender twigs are silver-gray with warty appearing lenticels.

The deciduous leaves range in size from one and one-fourth to three inches long and one-half to one and one-half inches wide. They occur in crowded groups at the end of short branchlets. In the early spring the leaves become thick and firm. The partly fascicled leaves are obovate-oblong shaped. The apex is obtuse and the base is cuneate.

Aquifoliaceae-Holly Family  
Ilex decidua - Deciduous Holly

Also commonly called:

Possumhaw  
Swamp holly  
Bearberry  
Winterberry

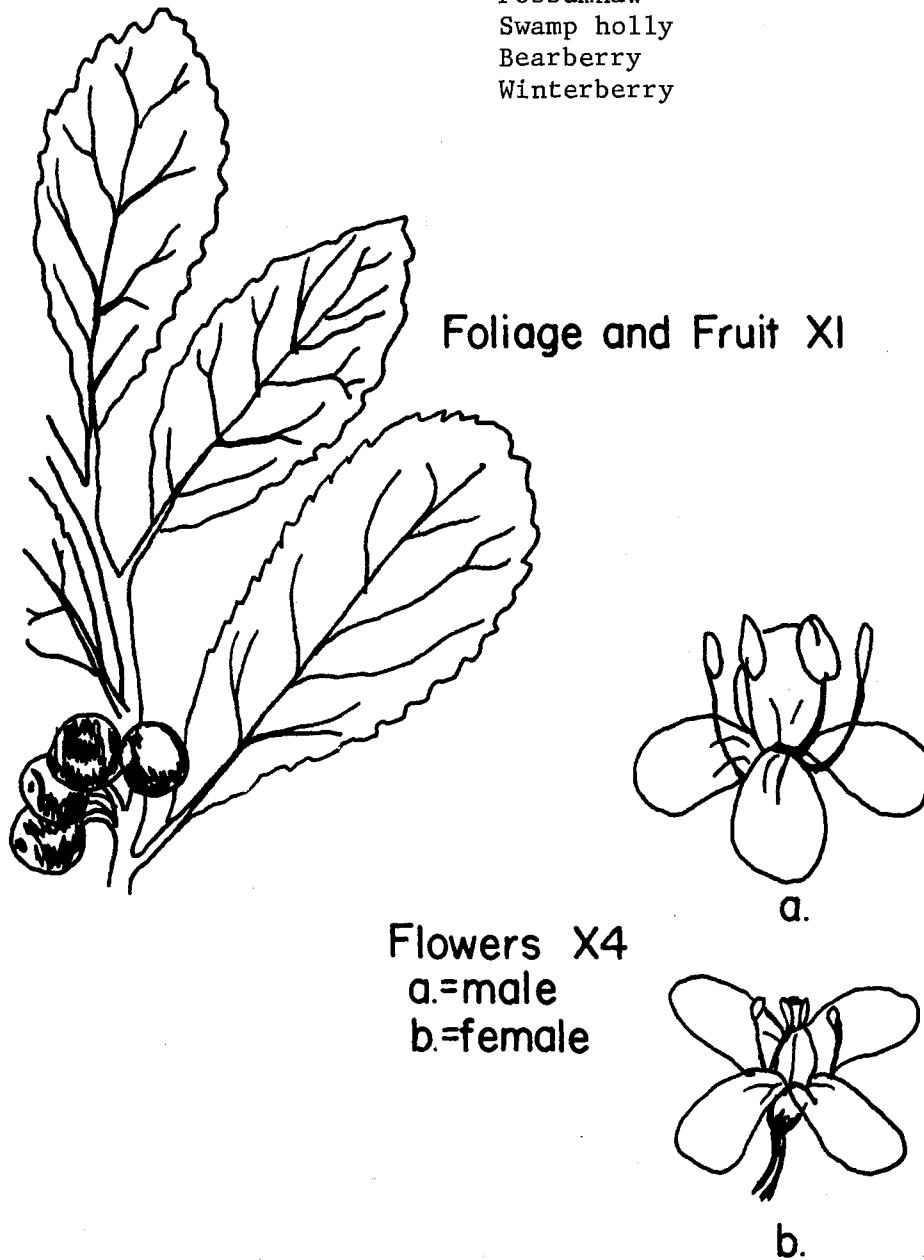


Figure 5. Morphology of Deciduous Holly.

Margins are obtusely serrate. The upper surface is dark green and lustrous with impressed veins. The lower surface is pale green and pubescent on the midrib.

The small white inconspicuous flowers appear from March to May. They are crowded at the ends of the lateral branches of the previous season but occasionally develop solitarily on the branches of the current year's growth.

The scarlet red to orange fruit is a globosed shaped drupe approximately one-fourth inch in diameter. It frequently persists until after the new leaves appear in the spring.

When this plant interferes with timber reproduction it can be controlled with a basal spray of 2,4,5-T in diesel oil which kills the tops and reduces sprouting after treatment. Slashing or burning is preferred by wildlife managers when control is necessary. These methods produce sprouts which are readily eaten by deer.

f. Youpon - *Ilex vomitoria*

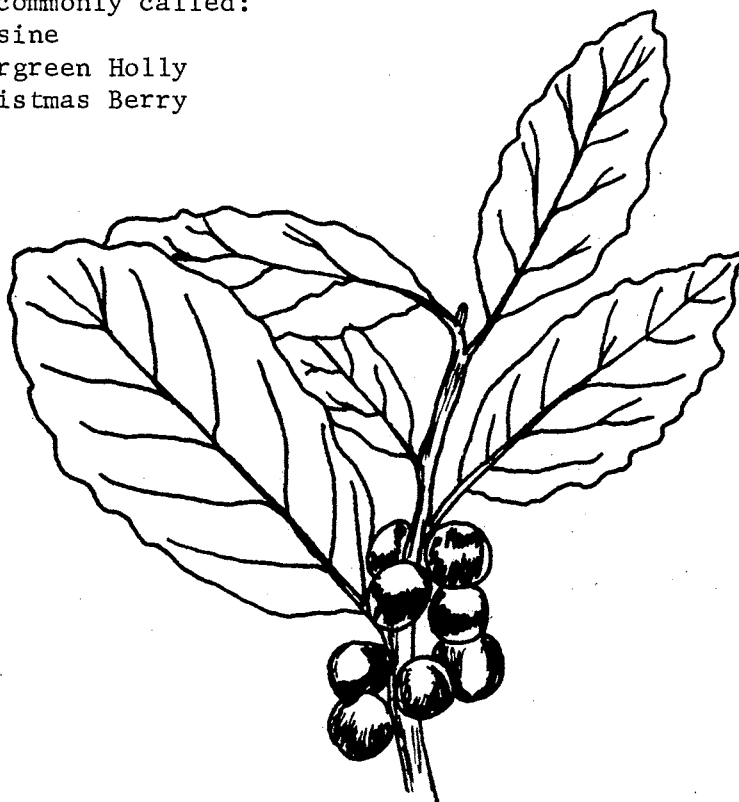
(Figure 6)

Youpon inhabits a wide variety of sites but is usually most abundant on moist sandy soils with permeable subsoils. Its range is from eastcentral Texas, southeast Oklahoma, southern Arkansas, northeast to Virginia and south to Florida. It is most abundant in the Coastal Plains forests of Louisiana, Texas and Arkansas. For deer, youpon is an excellent browse plant. They readily eat the leaves, twigs and fruit in the fall and winter and on heavily stocked ranges, they use the plant all year. On some central Texas ranges Halls and Ripley (20) reports that it is the only evergreen deer food and can

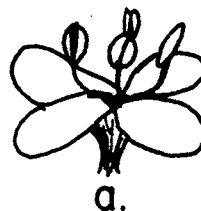
Aquifoliaceae-Holly Family  
Ilex vomitoria - Youpon

Also commonly called:

Cassine  
Evergreen Holly  
Christmas Berry



Foliage and Fruit X1



Flowers X4  
a.=male  
b.=female

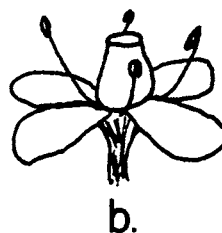


Figure 6. Morphology of Youpon.

support one deer to four acres or less. It offers no serious competition to pine but often competes with forage grasses for moisture and is regarded as a weed species on some ranges.

Halls and Oefinger (19) report that in east Texas up to 150 pounds per acre of youpon browse have been grown beneath pine stands while plants in the open have produced five to fifty-seven times this amount. Likewise, fruit yields of 200 pounds per acre in the open have greatly exceeded yields under woods-grown conditions.

When heavily browsed, youpon tends to hedge and the short stiff branches protect enough leaves inside the crown to keep the plant alive and thus allowing for survival on overstocked ranges. This shrub form reaches heights up to 25 feet. On unburned areas it also grows in small tree form 10 to 30 feet tall and 14 inches in diameter, although few plants reach these dimensions. The bark of this many-branched plant is smooth and whitish gray. The twigs are stiff, divergent and puberulous when young.

Leaves are a reliable source of green forage for deer in late winter and are of special significance because they contain sufficient protein for deer body maintenance. These short-stalked evergreen leaves are simple, and alternate. The shape is elliptic to ovate-oblong. Apexes are slightly rounded and the bases are acute. The margins are shallow cernate with blunt teeth which lend a wavy appearance to the blade margins. They range in size from one-half to two inches long and about one-half their length in width. The shiny upper surface of this rather thick leaf is dark green and glabrous. The lower surface of this rather thick leaf is dark green and glabrous, the lower surface being pale green. They persist for two growing

seasons and usually fall as new growth begins in the third season. The leaves possess a medicinal or emetic property and are made into a high caffeine content tea by the people of the South.

Small flowers appear during April and May and are arranged in nearly sessile clusters at leaf bases on branches of the previous year. These flowers are unisexual with male and female flowers usually borne on separate plants. Both sexes are about one-fourth inch in diameter. The four to five small white petals are subtended by an equal number of green sepals.

Fruits are taken by deer, quail, turkey, squirrel, raccoon and many song-birds all of which help distribute the seeds. The glossy red berry-like globose drupe matures in October and November. The one-fourth inch diameter fruit contains four pale amber one-sixteenth inch nutlets. Most plants with stems two inches or more in diameter bear some fruit each year although production varies. Halls and Ripley (21) report that in a series of study plots 10.8 pounds of fruit per acre were produced during one year and 4.2 pounds the next year. Lay (28), working in east Texas, found that deer utilized the fruit every month out of the year even though they were most abundant and available in fall and winter seasons.

Growth patterns in east Texas as reported by Halls and Alcaniz (13, 16) begin slowly in mid-March and accelerate to a rapid flush during May and June. Most of the growth was new twigs formed from lateral buds rather than lengthening of previously formed buds. Growth continues into late summer and fall whenever moisture and temperature are favorable. Open-grown plants elongate for a more extended time than those grown under woods conditions.

Halls and Ripley (21) report that infrequent winter burns at moderate intensities usually kill the tops and promote sprouting, thus is beneficial in keeping foliage within reach of deer. Summer burns, hot or frequent fires tend to eliminate the plant. Full development of a youpon understory in an unburned pine forest takes from 10 to 15 years. Burning also increases the nutritional value of youpon. On an unburned east Texas range the crude protein content of browse varied from nine percent in the spring to seven percent in the winter. Phosphoric acid content ranged from .25 percent in the spring to .16 percent in the winter. Burned ranges contained 11 to 15 percent crude protein and .43 to .19 percent phosphoric acid.

Studies of the effect of burning and clipping on browse yields in southeastern Texas reported by Lay (27) revealed that burned plants with a 25 percent rate of clipping increased in production. The 50 percent clipping held production at a level rate while 100 percent eliminated most of the plants. Burning increased production.

Natural reproduction is carried out through seeds which are taken and scattered by various wildlife. Nursery seedlings have been used for deer food plantings between pine rows. Halls and Oefinger (19) report that good results from seed propagation have been obtained in east Texas through fall collection, two years of controlled overwintering, germination and a field planting of one year old stock. Results of cutting were not as favorable with only a 14 percent rooting rate. The highest rooting rate was obtained from May cuttings.

g. Zabels' Bush Honeysuckle - *Lonicera*  
*korolkowii* var *zabelii* (Figure 7)

Authorities differ as to what genus this variety of honeysuckle belongs. Wyman (38) includes this variety in the genus *tartarica*, while Bailey (1) includes it in the genus *korolkowii*. For discussion, this plant will be referred to as *Lonicera korolkowii* var *zabelii* in the text which follows. This discordance in species type is an indication of many possible problems that could be created with the introduction of exotic deer browse plant species to southern forests.

Use of Zabels' Bush Honeysuckle by deer has not been substantiated although it is known that deer utilize *Lonicera tartarica*, tartarian bush-honeysuckle, and *Lonicera japonica*, Japanese honeysuckle, both closely related to this plant. Due to its early leafing habit in the spring, this plant offers great potential in deer habitat management since this is a critical food shortage time for deer. It is also a very hardy plant being able to survive as far north as Pennsylvania.

The growth form of this plant is a spreading branched shrub, eight to ten feet tall and as wide or wider in diameter. Twigs are light green to brownish.

The alternate simple leaves are broadly ovate and one to two inches long and approximately the same width. The apex is acute, while the bases are rounded to subcordate. Margins are smooth. The upper surface is dark green and glabrous. Lower surfaces are a pale green color.

Flowers appear in May or June. The two-lipped petals are pink to bright red in color.

The non-persisted fruit is a bright red pulpy berry.

Caprifoliacea-Honeysuckle Family  
Lonicera korolkowii var zabelii - Zabels' Bush Honeysuckle



Foliage and Flowers X1



Fruit X2

Figure 7. Morphology of Zabels' Bush Honeysuckle.

h. Dryland Blueberry - Vaccinium

vacillans (Figure 8)

Dryland blueberry is usually found in colonies, often in nearly pure stands. It generally grows in sandy soils that are dry, well drained and acid. Best growth is obtained on the fringe of pine or oak woods, or high rocky ledges and occasionally in old abandoned fields. The range of this plant is eastern Oklahoma, northeast to Michigan and Maine and south to Georgia.

This stiff shrub grows from six inches to four feet in height. The often crooked glabrous twigs are somewhat four angled and range in color from yellow-green to brown. The two to three inch flowering twigs are mostly without leaves in the fruiting season.

The deciduous leaves are obovate. Apexes are oval or broadly oblong with a small bristle at the apex. Bases are obtuse or acutish while the margins are entire or sparingly or minutely serrulate. Their length varies from three-fourths to two and one-half inches. When they emerge from the bud their color is a dull green tinged with red; this coloring is retained for some time. With maturity the leathery leaf becomes a dull light green and glabrous on the upper surface and a pale or glaucous beneath. Their autumnal color is a tint scarlet and crimson.

Even before the leaves are fully formed in May or June, drooping and somewhat bell-shaped flowers appear. These small one-fourth inch flowers are borne in dense racemose clusters usually at the ends of the branchlets.

The very sweet fruits ripen from June to September and are taken

Ericaceae-Huckleberry Family  
Vaccinium vacillans - Dryland Blueberry

Also commonly called:

Blueridge blueberry

Sugar huckleberry

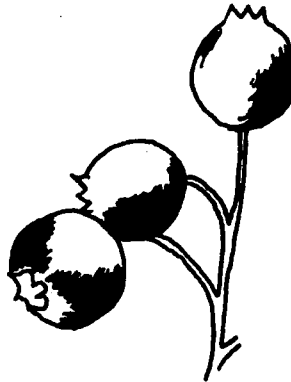
Low blueberry

Blue huckleberry

Late blueberry



Foliage and Flowers  
XI



Fruit X2

Figure 8. Morphology of Dryland Blueberry.

by many birds and animals including deer and man. The two-tenth to three-tenth inch fruit is a globose berry containing four or five seeds. It is covered with a blue bloom and has a persistent calyx on the flattened end. Although it is usually found colored blue or black, a variety of white fruit is known.

Deer utilization and growth response to outside influences vary with geography. Halls and Ripley (21) report that in some areas it is considered unpalatable while in others such as the western Gulf Coast, Wisconsin and Pennsylvania it is ranked as a second or third choice. In Alabama, leaf use is made of this plant especially during April and May. In the flat-wood and pine-oak sites of Florida utilization ranges from 10 to 38 percent. Growth responses also vary with location. Fire in the Coastal Plains increases growth but in other areas it decreases the growth rate. Sparse overstories apparently increase palatability as indicated by heavy shoot utilization in recently cut stands of timber.

Halls and Crawford (17) and Segelquist and Green (35) report that in northern Arkansas, Dryland blueberry is browsed wherever available but is utilized greatest on the upland pine-hardwood timber types.

i. Mapleleaf Viburnum - Viburnum  
acerifolium (Figure 9)

This upright shrub varies in height from two to six feet and often grows in clumps which form thickets. It generally occurs on exposed dry ground or on the margins of rocky mountain woodlands. Its natural range is east of a line from east Texas extending north to Minnesota. Mapleleaf viburnum is valuable in deer management due to the production

Caprifoliaceae-Honeysuckle Family  
Viburnum acerifolium - Mapleleaf Viburnum

Also commonly called:

Arrowwood  
Possumhaw  
Squashberry  
Dockmackie



Foliage and Fruit X1



Flower X4

Figure 9. Morphology of Mapleleaf Viburnum.

of leaves, twigs and fruit that is utilized. It sprouts and layers readily and normally thrives under moderate browsing and seeds prolifically in the open.

The smooth gray or dull brown ascending twigs are somewhat pubescent when young. The terminal buds are acute and covered with two or three pairs of visible scales.

The simple maple-like leaves evolve from the buds involute, reddish and densely hairy. When full grown the opposite leaves are suborbicular or broad-oval in shape. Apexes are multi-acuminate and bases are rounded to cordate. Widths and lengths vary from one and one-fourth to five inches. The three-lobed dentations are coarsely and unequally toothed diverging at the apex. Some upper leaves have very shallow lobes. The upper surface is slightly pubescent and green while the lower surface is more densely pubescent, a paler green and covered with black dots.

The white to yellowish-white flower appears in June. They are borne on long stalked terminal cymes three-fourths to three and one-half inches broad. The one-quarter inch flowers are all perfect with prominent stamens.

The nearly black ellipsoid to broadly ovoid fruit ripens from July to October. The flattened drupe is faintly double ridged on one side and double grooved on the other side with a nipple-like tip. It clings to the branch throughout the winter.

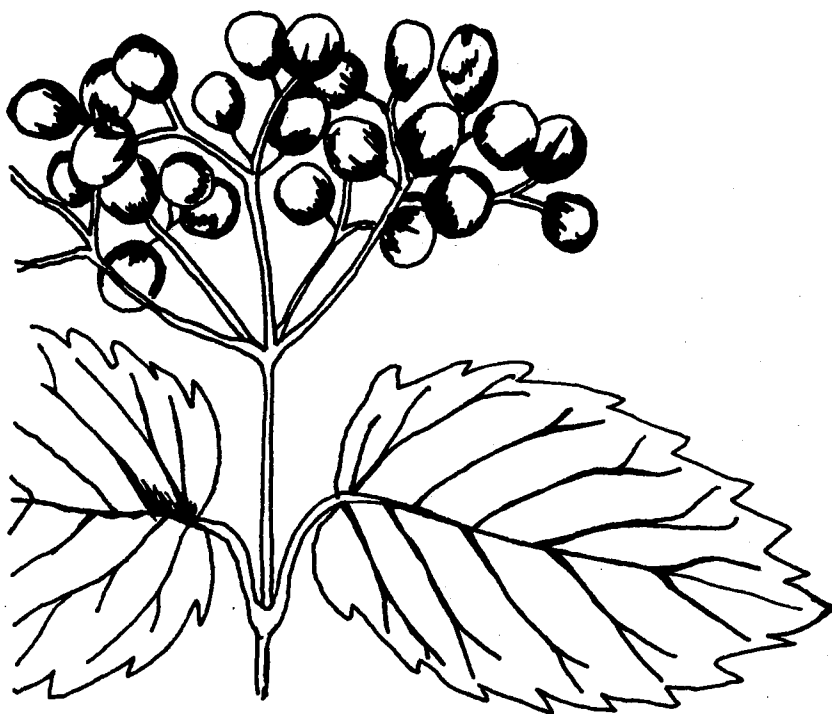
j. Southern Arrowwood - Viburnum

dentatum (Figure 10)

This upright bushy shrub is common in low moist ground and on the

Caprifoliaceae-Honeysuckle Family  
Viburnum dentatum - Southern Arrowwood

Also commonly called:  
Arrowwood viburnum  
Mealy tree  
Withewood



Foliage and Fruit XI



Flower XI

Figure 10. Morphology of Southern Arrowwood.

borders of rivers. It reaches heights of three to fifteen feet and often forms thickets. The natural range of this plant extends from eastern Texas to southern Illinois, northeast to Maine and south to Florida.

The ash colored bark is smooth. Twigs are obtusely angular, smooth and often straight and arrow-like. Terminal buds are acute with two or three pairs of visible scales.

Leaves come out of the buds involute, green with a reddish brown tinge, shining and downy. With maturity the opposite leaves become deep green on the upper surface and a paler green beneath. They are shaped broadly ovate or round-ovate and one to four and one-half inches long. Bases are rounded or cordate. Apexes are acute. The veins of this simple leaf are strongly pinnate, continuous to the margins and depressed on the upper surface and prominent below. Margins are coarsely and sharply serrate. In the axils of the veins there are many single or tufted hairs. The autumnal tint is a dark bronze red.

Flowers appear in June on long slender-stalked cymes one and one-fourth to four and one-half inches wide. These perfect flowers are white in color with conspicuous long stamens.

The nearly black fruit is about one-fourth inch long. This ovoid-spherical drupe appears from August to November. The flesh is thin with dry and somewhat acid center. Stone grooves appear on one side while it is rounded on the other side.

### 3. Preparation

The plant materials used were obtained from commercial nurseries located in Tennessee. As these plants were received they were pruned

to uniform sizes within species and placed in one-gallon capacity plastic pots in which they remained throughout the study. These pots were filled first with approximately one inch of well-decomposed peat and then to within one inch of the top with potting medium consisting of a mixture of:

- 11 bushels of well-decomposed peat
- 11 bushels of coarse grained sand
- 11 bushels of sterilized mineral soil
- 1 pound of 20 percent superphosphate fertilizer
- 5 pounds of ground limestone
- 5 pounds of 5-10-5 fertilizer

These potted plants were then placed in a pre-constructed lath house (Figure 11) for a period ranging from one-half to one and one-half years depending on the availability of the nursery stock.

## B. Methods

### 1. Controlled Light Enclosures

Four light enclosures with dimensions of 12x12x8 feet were built. Three of these enclosures were covered with green colored commercial shade fabric of differing shade producing capabilities. Green colored fabric was used to correlate the enclosures to the natural green foliage conditions of a forested environment (Figure 12).

Each plot enclosure was assigned a plot number ranging from 1, the open or no shaded condition, to 4, the highest percentage of shade. During the course of the study each plot was calibrated for actual shade producing percentage by the use of a Weston Illumination Meter

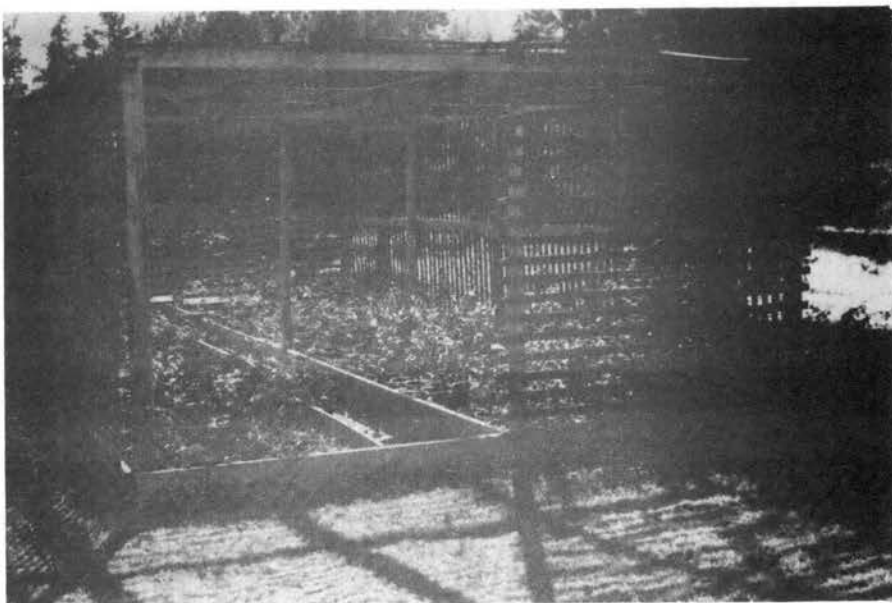


Figure 11. Lath House Used for Temporary Plant Storage.

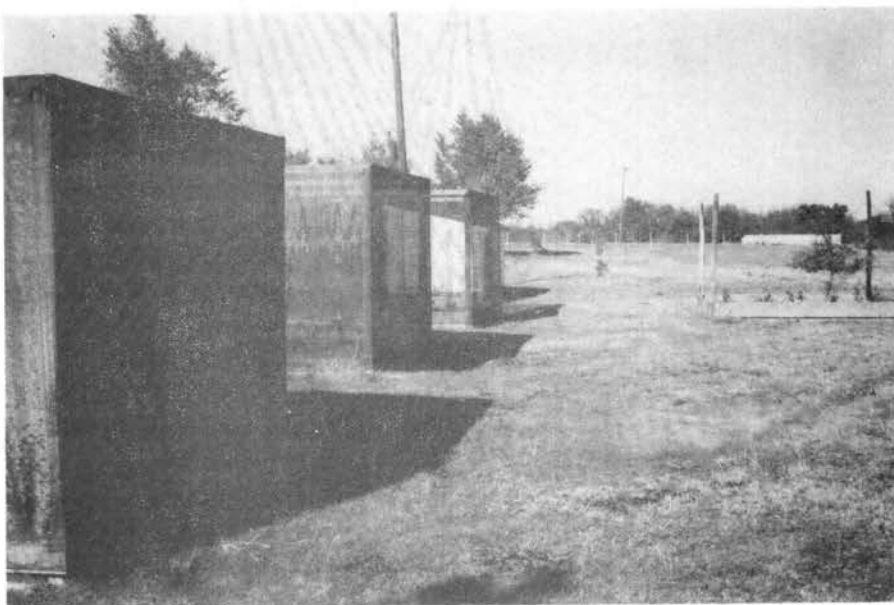


Figure 12. View Looking North With Plot 4 Shown in the Left Foreground, Plot 3 in the Center and Plot 2 in the Background. Plot 1 Is Located in the Right Center.

Model 756 which indicates light intensities in foot candles (Figure 13). From these random readings the following shade conditions were determined:

<u>Plot</u>	<u>Manufacturers Represented Shade Percent</u>	<u>Calibrated Shade Percent</u>
1.	None	None
2.	30	37
3.	55	56
4.	73	77



Figure 13. Taking Light Readings From a Weston Illumination Meter With Wane Placed on Center Positioned Thermometer Stand.

To accommodate two plants of each species or 20 plants per plot, equally spaced positions were created by subdividing each plot into quadrangles (Figure 14). Extending east to west, four rows three feet apart in the interior and one and one-half feet along the exterior edges were formed. Five north to south rows were established with two and four-tenths feet between interior rows and one-and two-tenths feet from the edge to the exterior rows. These dimensions gave each plant seven and two tenths square feet of growing space. Each position was then assigned a number between one and twenty.

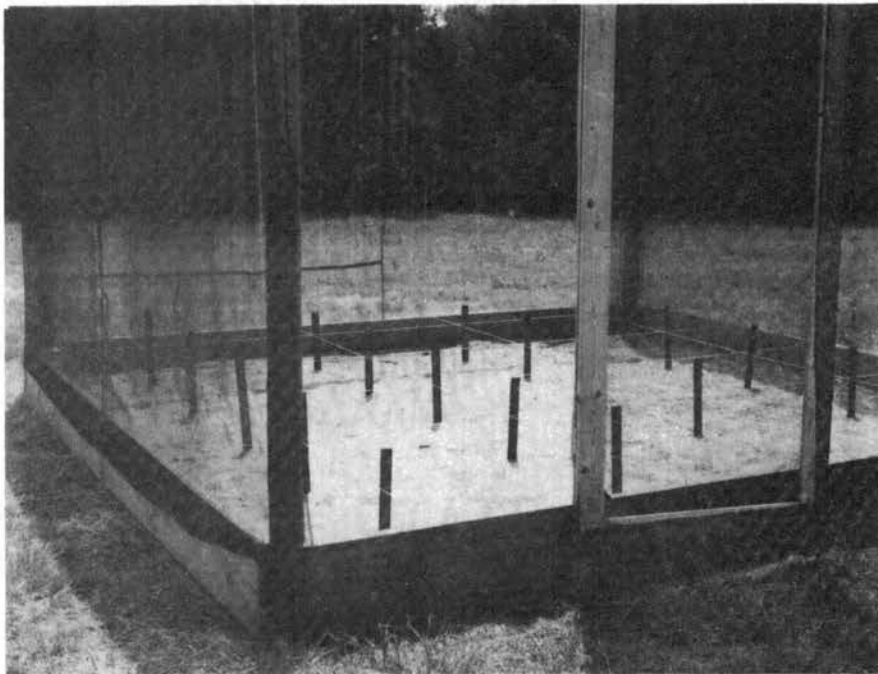


Figure 14. Plot 2 Subdivided Into Quadrangle for Plant Positioning.

## 2. Plant Positioning

In July 1971 eight plants from each of the ten species were removed from the lath house for placement in the four study plots. In selecting plants within each species, an attempt was made to choose plants of as near the same size and vigor as possible. Actual position in the plots was determined by assigning each species a number between one and ten and, by using a table of random numbers, species numbers and position numbers were correlated.

Two plants of each of ten species were then placed on a bed of two to three inches of sand within each plot. The interspaces were filled to within one inch of the top of the pots with a mixture of equal volumes of partially decomposed sawdust, well-decomposed peat and coarse grained sand (Figure 15).



Figure 15. Plot 2 With Positioned Potted  
Plants and Filled Inter-Spaces.

The growth habits of these plants were observed weekly for the remainder of the 1971 growing season.

### 3. Vegetative Growth Measurement Procedures

In order to quantify vegetative growth, simple and efficient measurement techniques were sought; techniques which would not cause physical plant damage and adversely influence normal growth. Using this criteria, two methods were selected:

#### a. Measuring Twig Elongation

Measuring seasonal elongation or lengthening of twigs that are within the reach of deer has proved to be useful in estimating browse production and in determining growth patterns. Elongation, as taken from the context of this report, is defined as all terminal growth measured from the dormant position of the terminal bud of the stem. This growth is made up from the combined increments attributed by the three zones of growth which are the zone of differentiation and maturation, zone of cell elongation and the meristematic zone. This method has been successfully utilized in east Texas by Hall and Alcaniz (12, 13, 15) and in California by Bedell and Heady (1).

In December 1971, two strips of plastic tape, one colored yellow and the other white, were banded on two different twigs of each dormant plant. The yellow band was placed on the apparent terminal twig. Although Halls and Alcaniz (12) found that there was no significant growth difference between terminal and lateral twig growth, this method allowed for a uniform measurement position for each plant species. Randomly picked lateral branches were banded with white tape.

From the outer edge of the tape to the tip of the bud an initial measurement, taken to the nearest one-tenth inch, was taken from which all subsequent elongation measurements were calculated (Figure 16).



Figure 16. Measuring Twig Elongation.

b. Cubic Volume Measurement

From prior observations of the growth habits of the study plants,

it became evident that some plants put on the majority of their total production in the form of lateral or basal sprouts. Such growth would not be detected by measuring twig elongation as discussed above.

Therefore, another method using the cubic volume increase was utilized.

At the same time that the plants were banded, their cubic volume was measured. The technique used was to measure the height (h) of each plant, from the lip of the plastic container, and two crown diameters, one through the long dimension and the other at right angle to the first (a and b). Measurements were taken with a caliper and recorded to the nearest one inch (Figure 17). The readings were then inserted in the formula for determining the cubic volume of a cylindroid which is  $(\pi/4) \times (abh)$ . This total was then converted from cubic inches to cubic feet and read to the nearest one one-hundredth cubic foot. From this initial volume, all succeeding measurements were computed.

This method for determining forage production has been used in the western United States by Evans and Jones (10), Lyon (31, 32), Kinsinger and Strickler (22) and Watkins and De Forest (35) who found it to be a good indicator of vegetative production and availability.

Observations and measurements were taken during the 1972 growing season. These readings were made bi-weekly until such time that all plants had leafed out or otherwise shown the beginning of growth activities. From this time until June, bi-monthly readings were taken. Those plants which showed an exceptional amount of spring growth were measured weekly. From July to October monthly measurements were recorded. By October, further measurable growth activities had obviously ceased.



Figure 17. Measuring Cubic Volume.

#### 4. Environmental Factors

The major environmental factor that was considered in evaluating growth was light intensities. Geography, light duration and temperature were also considered so as to be able to correlate any major differences in these as influencers on plant growth.

##### a. Geography

The study plots were situated near Stillwater which is located in northcentral Oklahoma about 70 miles north of Oklahoma City. The geodetic location of this area is approximately 36 degrees north latitude and 97 degrees west longitude, at an elevation of approximately 880 feet.

### b. Light

The major light characteristics that were of concern as factors influencing plant growth were intensity, duration and the accompanying temperature resulting from these two factors.

1). Intensity. Since current information was not available for the Stillwater area, average daily solar radiation values for 1972 were obtained for Oklahoma City from the National Weather Service in Oklahoma City. These radiation values were recorded in Langleys, one of which is equal to one calorie of energy produced per square centimeter per day as measured by a pyrometer. From this information, values for the Stillwater area were determined by comparing 1950 through 1967 average percentage differences as recorded by simultaneous light intensity readings in Oklahoma City and Stillwater. From this computation, average daily readings by months were derived as shown in Table I.

2). Duration. From the tables entitled "Sunrise and Sunset at Oklahoma City, Oklahoma" as prepared by the National Almanac Office, United States Naval Observatory, the 1972 average monthly daylengths for Stillwater, Oklahoma are shown in Table II.

3). Temperature. To determine variances in temperatures between plots, thermometer stands were placed in the center of each plot. Each stand contained two thermometers that recorded the maximum and minimum temperatures at the one-half and four foot levels (Figure 18).

During the course of the study several random readings were compared to the official daily maximum and minimum temperatures as obtained from an Official U. S. Weather Station located within a mile of the study area. As a result of this comparison, average monthly

TABLE I  
AVERAGE DAILY INTENSITY/MONTH OF SOLAR RADIATION  
FOR STILLWATER, OKLAHOMA (1972)

Month	Average Daily Solar Radiation* (Langleys**)
January	234
February	290
March	390
April	446
May	515
June	551
July	547
August	439
September	366
October	299
November	145
December	125

\*Variations rounded to nearest whole number.

\*\* A unit of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface.

TABLE II  
AVERAGE DAYLENGTH/MONTH FOR STILLWATER,  
OKLAHOMA (1972)

Month	Average Daylength (Hours <sup>*</sup> )
January	10.25
February	11.00
March	12.00
April	13.00
May	14.00
June	14.50
July	14.25
August	13.50
September	12.25
October	11.25
November	10.50
December	10.00

\* Rounded to nearest one-quarter hour.

maximum and minimum temperatures were equated for each plot at both levels of measurement (Table III).

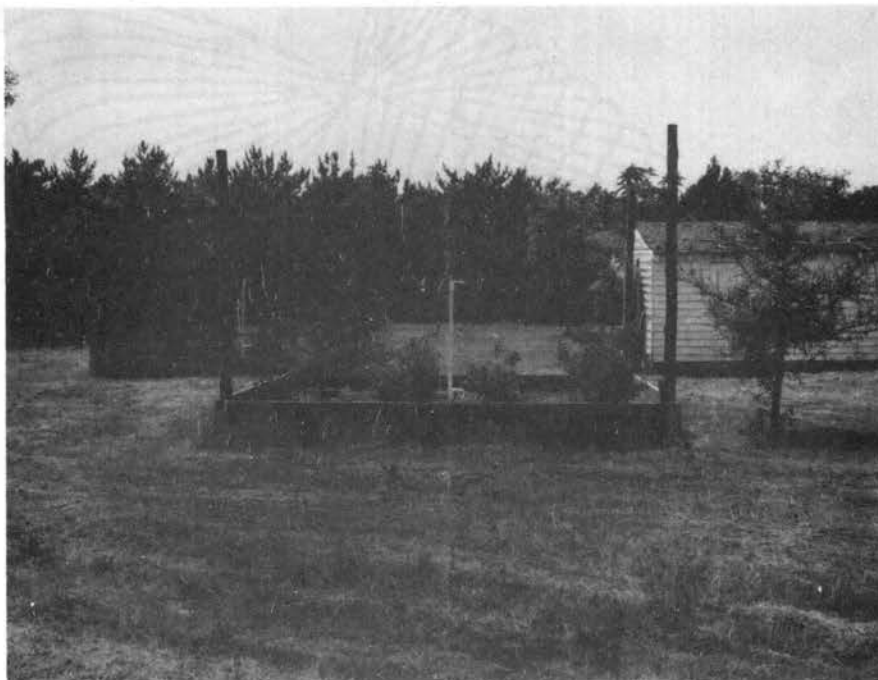


Figure 18. Looking West at Plots 1 and 2  
With Maximum-Minimum Thermometer  
Stands Located in the Center of  
the Plots.

TABLE III  
AVERAGE MONTHLY MAXIMUM AND MINIMUM TEMPERATURES PER PLOT  
AT THE .5 AND 4 FOOT LEVELS (1972)

Month	Control*		Average Monthly Maximum and Minimum Temperatures at the .5 Foot Level								Average Monthly Maximum and Minimum Temperatures at the Four Foot Level							
			Plot 1		Plot 2		Plot 3		Plot 4		Plot 1		Plot 2		Plot 3		Plot 4	
	MX	MN	MX	MN	MX	MN	MX	MN	MX	MN	MX	MN	MX	MN	MX	MN	MX	MN
January	45	22	48	22	44	20	47	21	43	21	47	22	46	21	47	23	47	22
February	53	27	57	27	53	25	56	26	51	26	56	27	55	26	56	29	56	27
March	66	38	71	39	65	36	69	37	63	38	70	38	68	38	70	41	69	38
April	75	49	80	49	74	46	78	48	71	48	79	49	76	49	79	53	78	49
May	80	55	85	56	79	52	83	54	76	55	84	55	82	55	84	60	83	55
June	91	65	97	66	90	62	94	64	87	65	96	66	93	65	96	71	94	65
July	91	69	97	70	90	66	94	68	87	69	96	70	93	69	96	75	94	70
August	92	67	99	68	91	64	96	66	81	66	97	67	94	67	97	22	96	67
September	84	65	90	66	83	62	87	63	80	64	89	65	86	64	89	70	88	65
October	71	48	76	49	70	46	74	47	68	48	75	48	73	48	75	52	74	48
November	51	35	54	35	50	33	53	34	48	34	53	35	52	34	53	37	53	35
December	42	24	45	24	42	22	44	23	40	23	45	24	43	23	45	25	44	24

\* Official U. S. Department of Commerce, National Oceanic and Atmospheric Administration 1972  
Temperatures for Stillwater, Oklahoma.

### CHAPTER III

#### RESULTS

The data reported here is based on observations and measurements taken during the 1972 growing season.

##### A. Growth Patterns

Measurements for the two plants of the same species within each plot were averaged together to give a single growth pattern per plot. Average quantities were plotted on two graphs, one to represent average twig elongation and the other to show average cubic volume increases.

Starting points for each curve depict an average beginning date for spring growth activities as was evidenced by the opening of the leaf buds. Terminal ends of the curves represent either the time of leaf turning and falling or the official U. S. Weather Service recorded first fall hard freeze for Stillwater, Oklahoma which occurred on November 22, 1972. This time of first hard freeze was used because the late growing plants differ considerably within species and plots in time of leaf turning and falling. The reason for this physiological variance appears to be genetic.

In the text that follows, each individual plant species will be treated in alphabetical order according to scientific names.

1. American Beautyberry - *Callicarpa americana*

Growth activities began with a rapid flush in the first week of April. Vegetative growth, as measured by both techniques, was greatest for those plants in Plot 3 and decreased, in descending order, in Plots 4, 2 and 1.

Twig elongation (Figure 19) in Plots 1 and 2 continued, although only slightly towards the end of the growing season, until termination of growth occurred during the first week of October and the first week of November respectively. Further elongation of the twigs measured in Plots 3 and 4 had ceased by the first week in September although these plants retained their leaves in an apparent vigorous state through the first hard freeze of fall. Quantitative growth differences were not as separable between the plants in Plots 2, 3 and 4 as between the plants in this group and those in Plot 1, whose total growth was approximately one-half that of plants in Plot 3.

Cubic volume increases per plot (Figure 20) followed the same general trend discussed above with the exception that two distinct growth groups were apparent. Total growth for plants in Plots 1 and 2 was nearly equal but only about one-third as great as the growth attained in Plots 3 and 4. The reversing growth pattern depicted by the curves was largely the result of the weeping habit of the branches as they mature and become laden with vegetation. Maximum volumetric growth was obtained by the plants within Plot 1 in mid-August and about a week later for plants in Plots 2 and 4. Volume was highest for plants contained in Plot 3 around the third week of July.

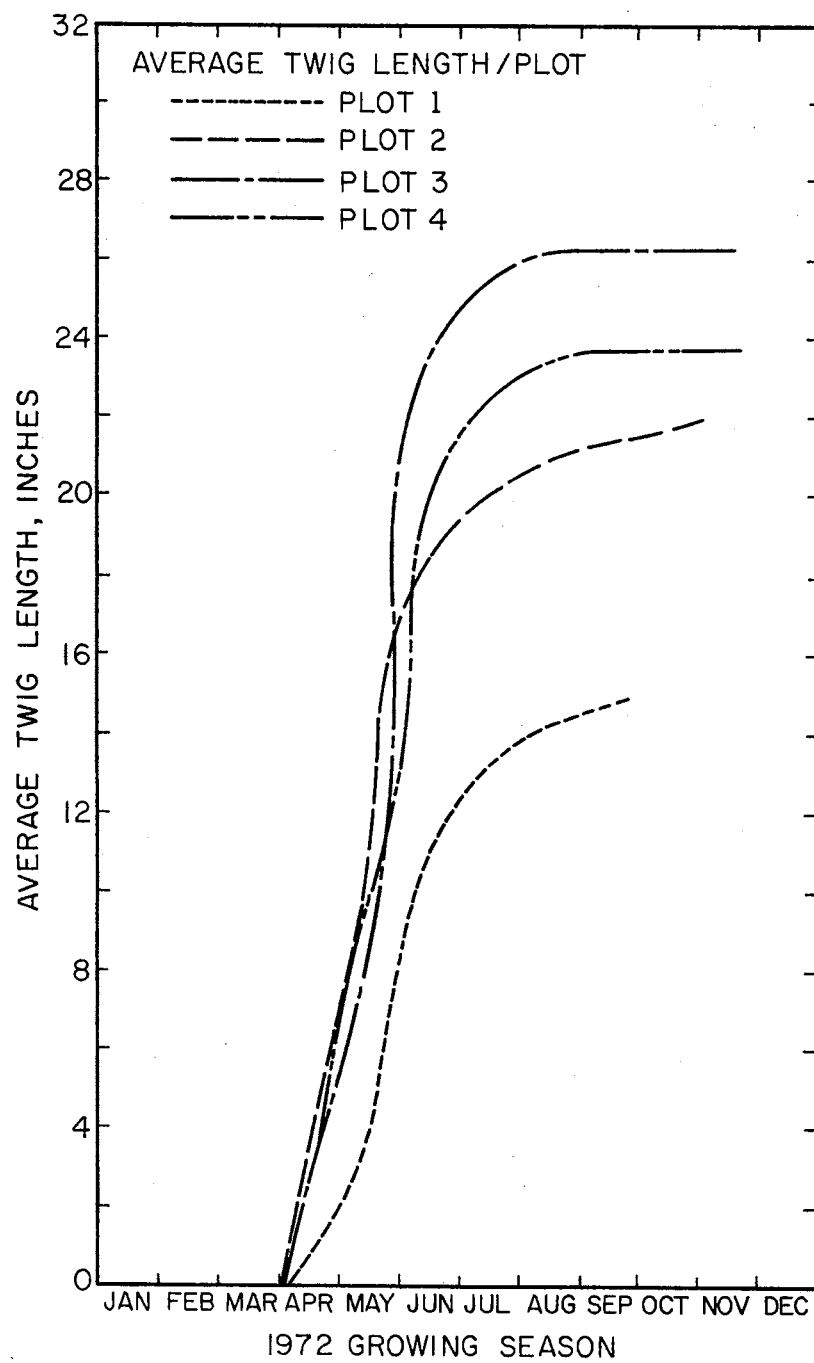


Figure 19. Graph of Average Twig Length - American Beautyberry.

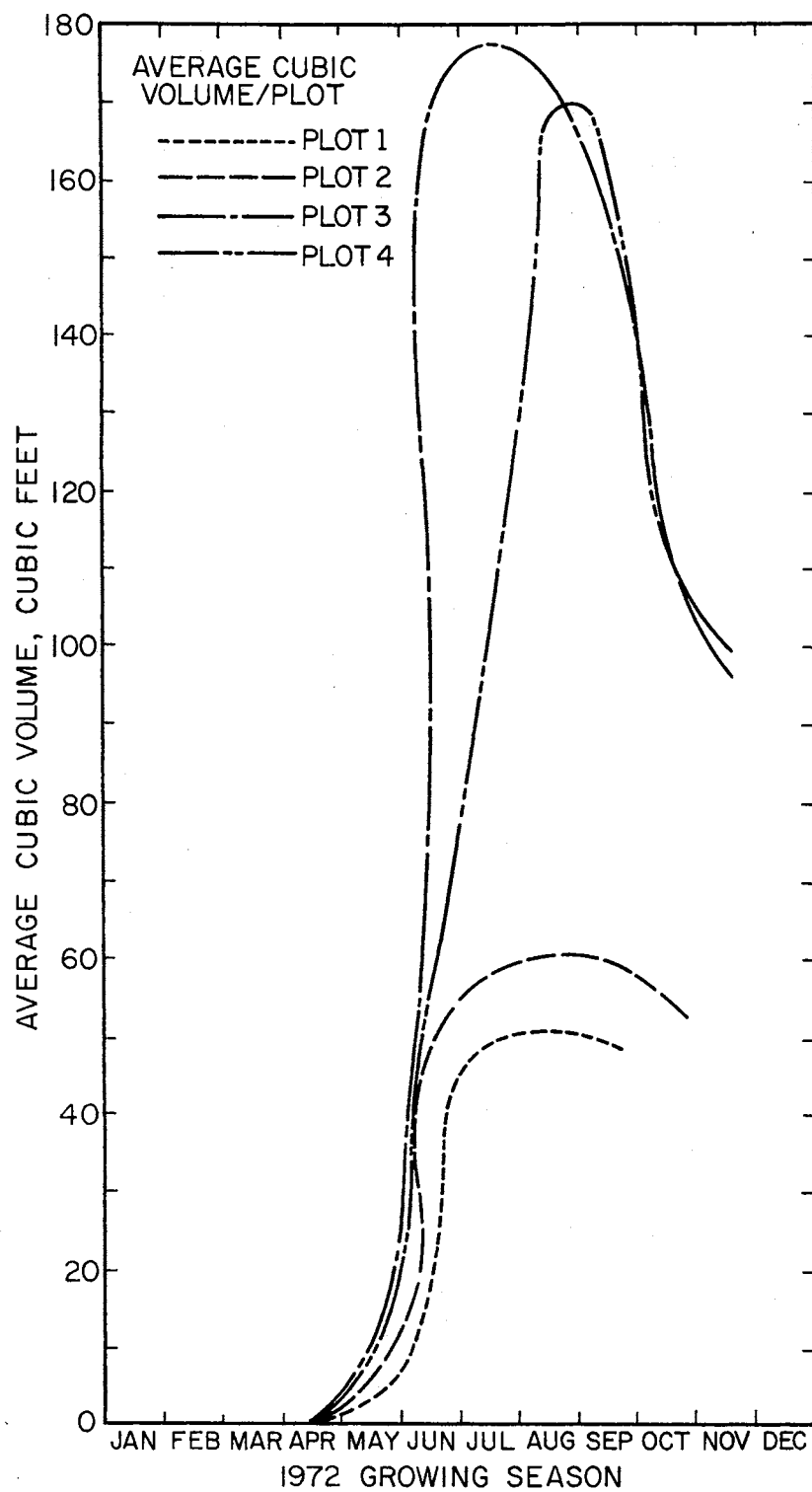


Figure 20. Graph of Average Cubic Volume - American Beautyberry.

While the results from measurements employing both techniques represented general observed growth differences, cubic volume increases best present observed growth differences. There was a comparatively larger total growth occurrence in plants contained in Plots 3 and 4 in relation to those in Plots 1 and 2 which were nearly equal.

The results above are generally the same reported by Halls and Alcaniz (13, 16) with the exception that they found woods-grown or shaded plants to be less productive and smaller than those open-grown which is contrary to the results of this study.

The only apparent rationale for this difference is that those plants used in this study were supplied ample nutrients and moisture which are not always attainable in field conditions. Also, plants in the open plot were subjected to high temperature and drying conditions, unlike those conditions in humid east Texas where Halls and Alcaniz conducted their study. These conditions place the plant under stress and hinder growth.

## 2. Fringetree - *Chionanthus virginicus*

Spring growth began during the second week in April. Differing results were obtained from the two measuring techniques.

Twig elongation (Figure 21) was greatest for plants contained in Plot 4 and followed in order for plants in Plots 2, 3 and 1. Additional twig elongation had ceased for plants in Plots 1 and 3 by mid-May, Plot 2 during the first week of June and by the third week in June for those contained in Plot 4.

Plants within Plot 3 had the largest volume increase (Figure 22) followed with those in Plots 2 and 4 where growth rates were nearly

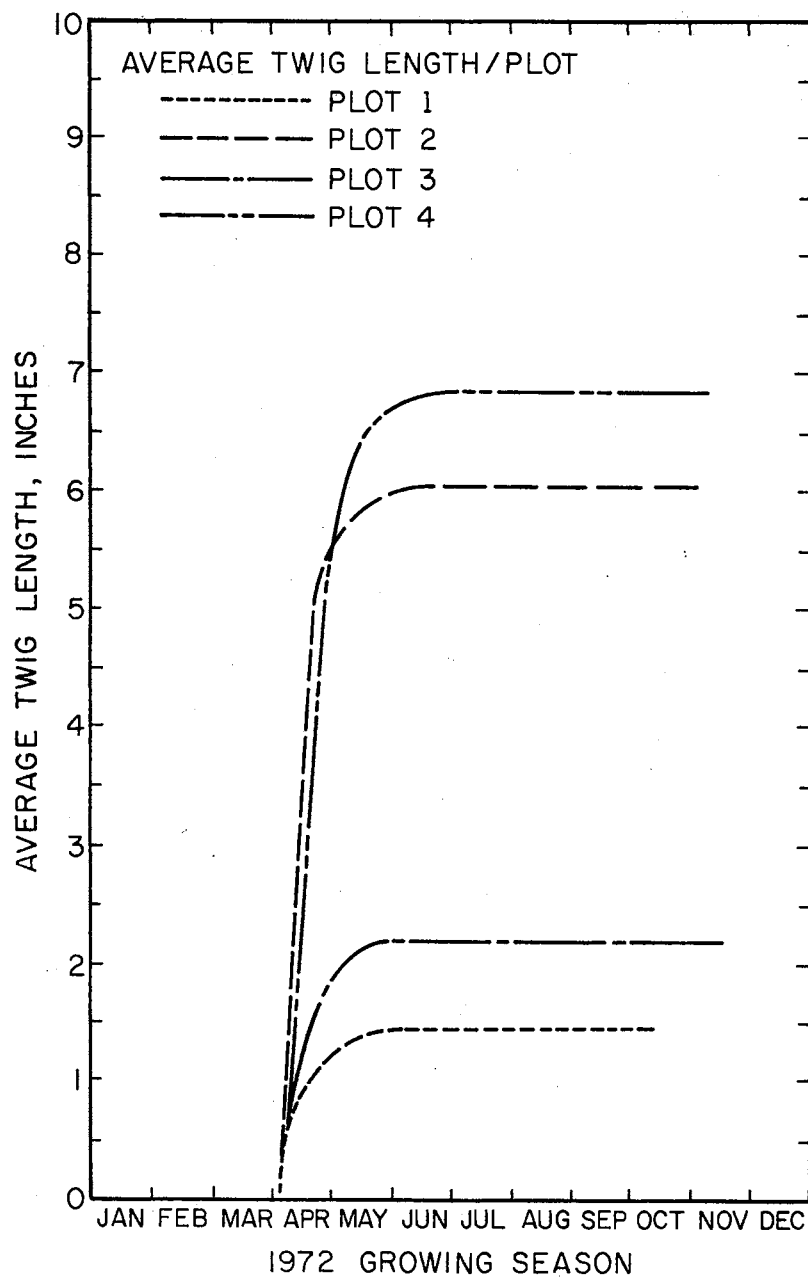


Figure 21. Graph of Average Twig Length - Fringetree.

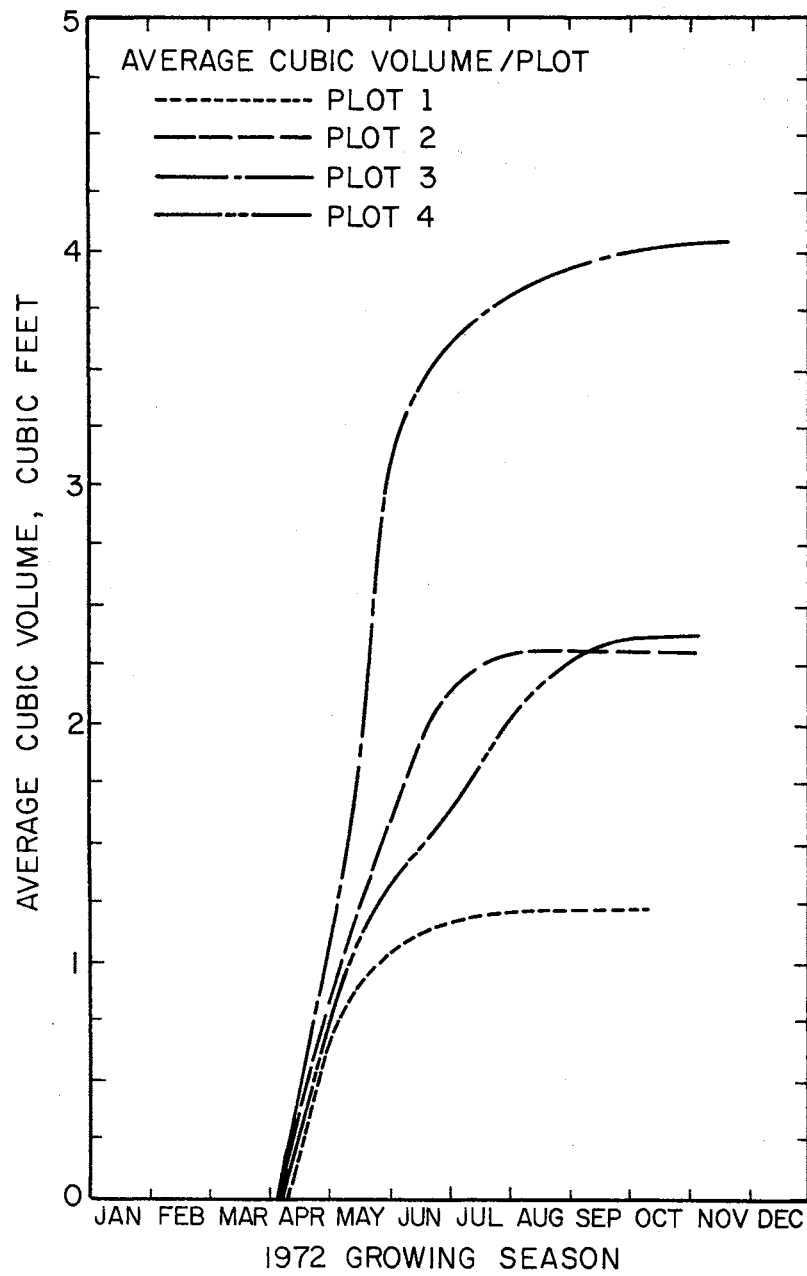


Figure 22. Graph of Average Cubic Volume - Fringetree.

equal. Plants in Plot 1 had the least volume increase. Further elongation had stopped within Plot 1 by mid-July and Plot 2 by the first of August. Those plants within Plots 3 and 4 continued to increase, although only slightly later in the season, until termination of growth occurred in mid-June and the first of September respectively.

Leaf margins began browning in Plot 1 in mid-October and at the first of November for Plot 2. Plants within Plots 3 and 4 retained their leaf color through the first hard fall freeze of late November.

From observing growth activities, the growth pattern which Figure 21 represents in terms of twig elongation is most near accurate. After a spring flush, further growth activities stopped and terminal buds formed. These findings are consistent to those of Halls and Alcaniz (12).

### 3. Strawberry Bush - *Euonymus americanus*

Leaf buds began opening during the second week of March. The two measuring methods yielded differing results concerning the plot in which maximum total growth was obtained.

Continued elongation (Figure 23) had halted for plants contained in Plots 1, 2 and 3 by the first week in June and by the first week in August for Plot 3, which also had considerably more elongation. The plot whose plants had the second highest growth was Plot 2 and then in order, Plots 4 and 1. Total growth in these last three plots was nearly equal.

Considering observed overall plant size, increases during the season are best depicted by the graphs showing volume increases (Figure 24). These graphs indicate that the most volumetric growth was

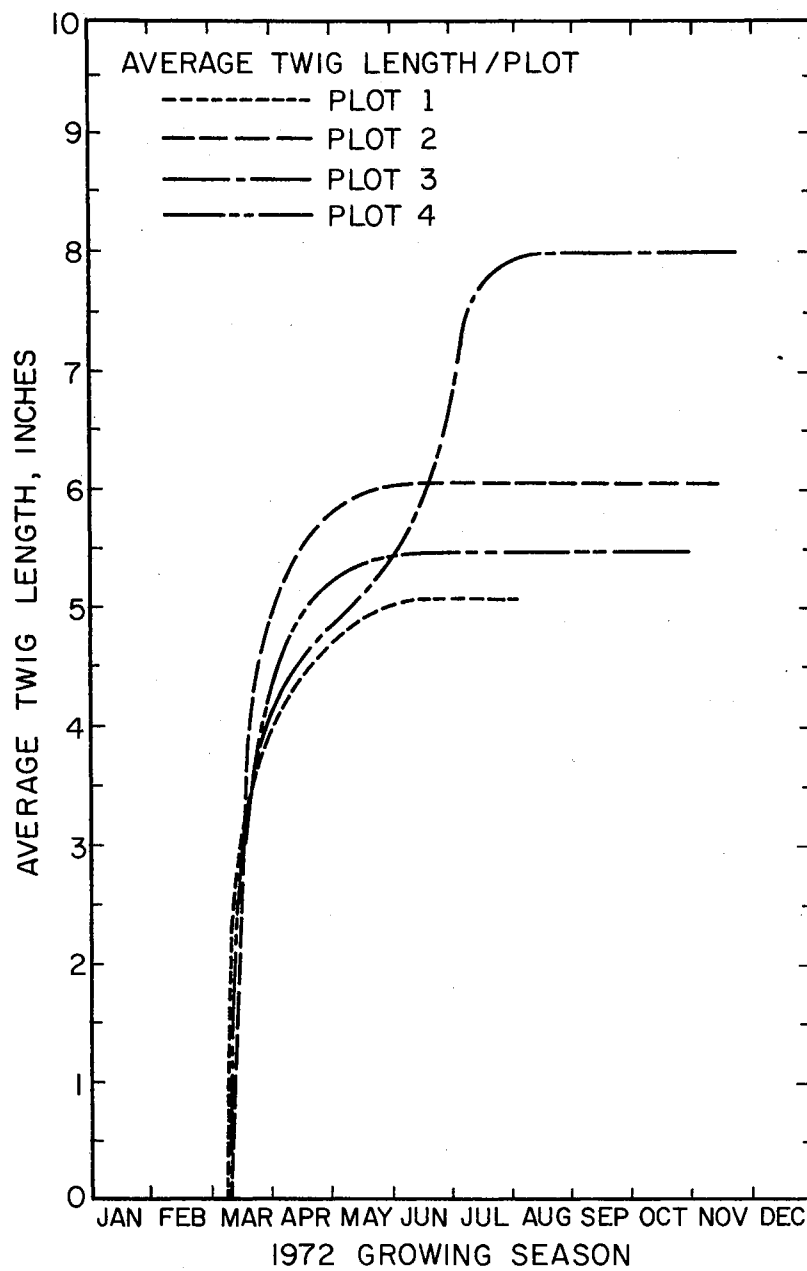


Figure 23. Graph of Average Twig Length - Strawberry Bush.

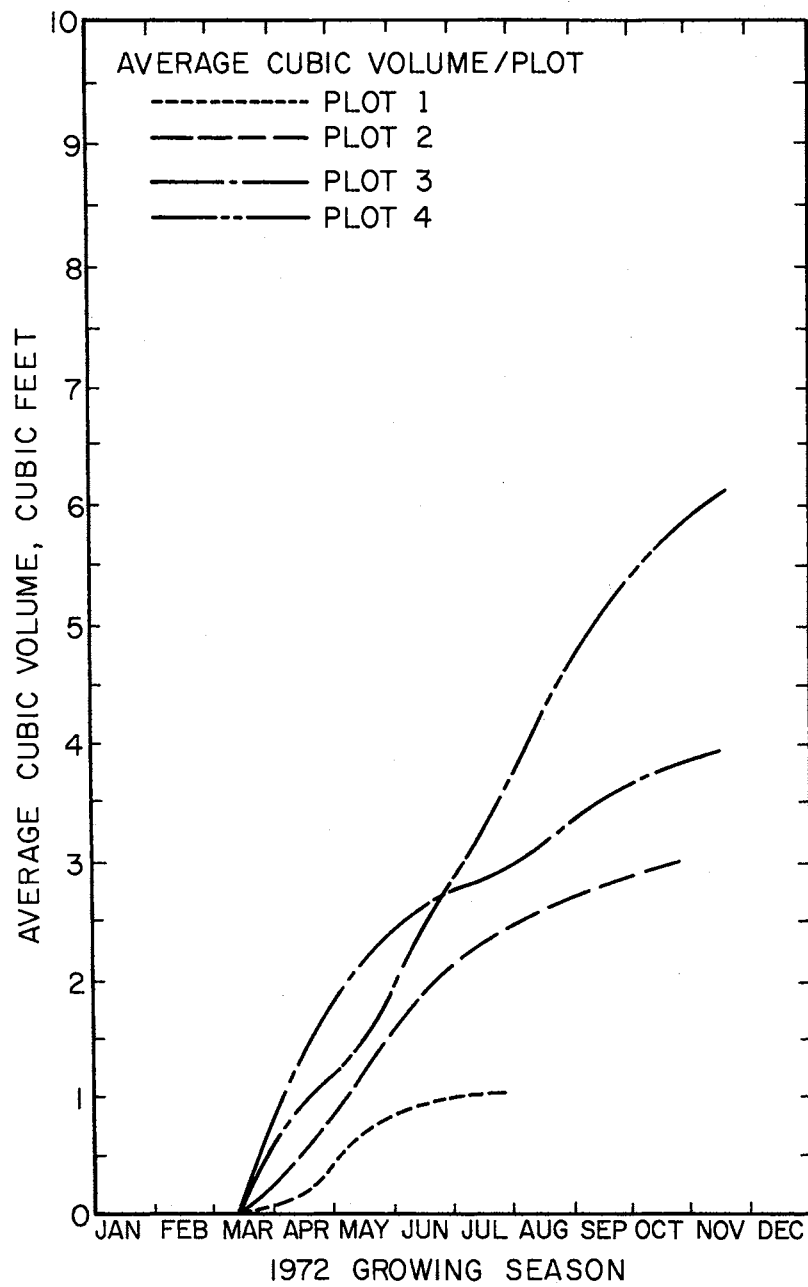


Figure 24. Graph of Average Cubic Volume - Strawberry Bush.

obtained by the plants in Plot 4, 3, 2 and 1 in that order.

Growth was measured until the end of the growing season for all plants. Toward the end of the season growth tapered sharply. Most of the later growth was in the form of height extension which was not detected by measuring selected twig elongations.

Leaves began to turn reddish and fall by the first of August in Plot 1 but were retained in Plot 2 until the last week of October. Plants in Plots 3 and 4 remained green and healthy until the time of the first hard freeze in November.

Those findings reported in the above discussion of growth as measured by cubic volume increase agree with findings reported by Halls and Alcaniz (15) in that this species continued growth through the summer and woods-grown, or shaded, plants attained greatest growth and were more healthy.

#### 4. Smooth Hydrangea - *Hydrangea arborescens*

Initial spring growth started rapidly in the first week of April. Plants within Plot 3 attained the high total growth as measured by both techniques. Correlative differences between the other three were conflicting.

As measured by twig elongation (Figure 25) those plants in Plot 3 began with a rapid elongation which continued until fall termination. The next longest total elongation was achieved in Plot 1 and then in Plots 4 and 2. Steady increased growth had ceased in mid-May for plants in Plot 2, mid-July in Plot 4 and the first of September for Plot 1.

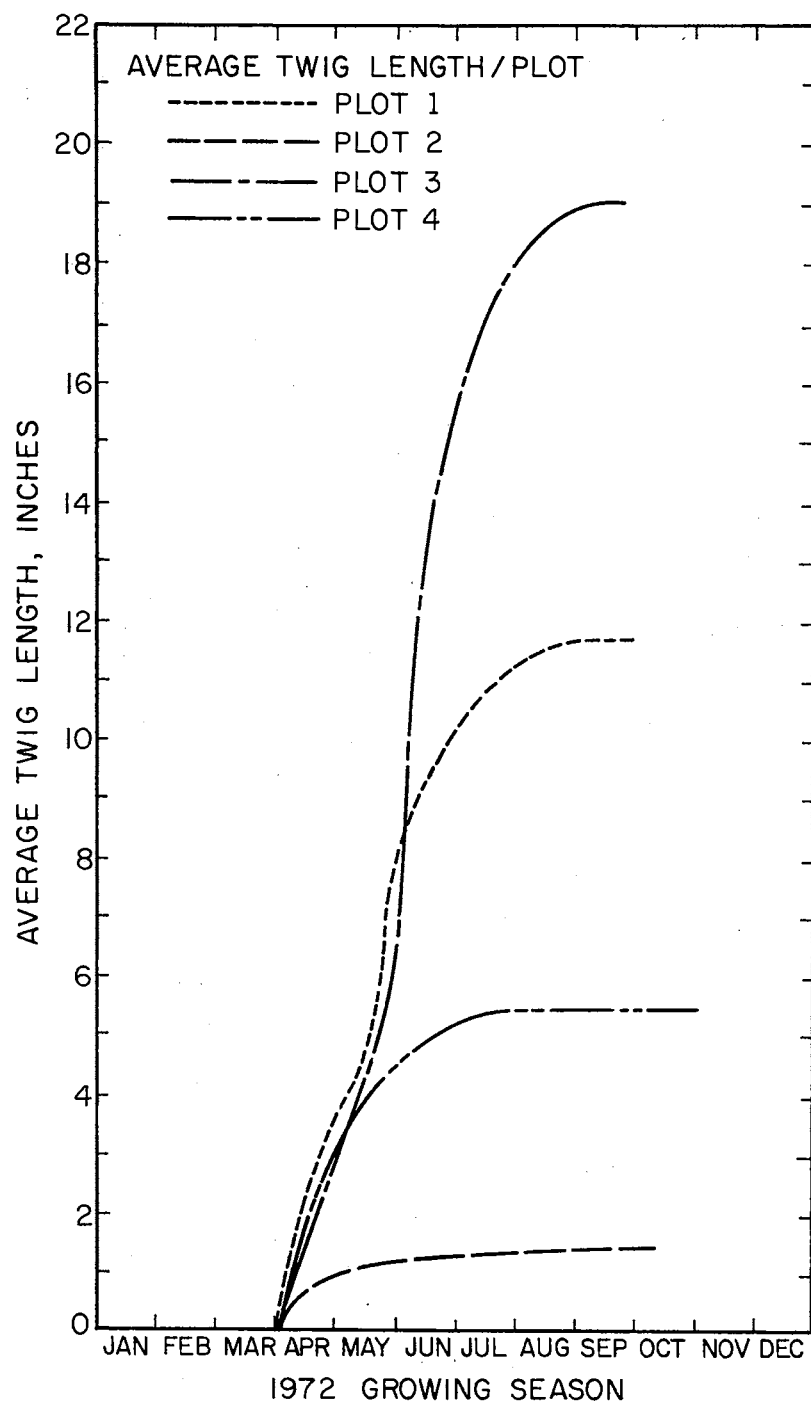


Figure 25. Graph of Average Twig Length - Smooth Hydrangea.

Comparing plant volumetric increases (Figure 26) in all plots, those plants contained in Plot 3 produced the greatest increase. Plants in Plot 4 attained the second largest increase followed in descending order by plants in Plot 1 and Plot 2. In Plot 4 basal sprouting accounted for a large part of the volume increase which was not detected by measuring twig elongation. The recurve depicted for Plot 4 was a result of die-back of the stems.

Late season terminal growth occurred during the last week in September for plants in Plot 3, the first week of October for Plot 1, the end of the second week of October for Plot 2 and the first week in November for Plot 4.

#### 5. Deciduous Holly - *Ilex decidua*

Growth became evident around mid-March with opening of new leaf buds. The results from the two measuring techniques were almost opposite.

Twig elongation (Figure 27) was greatest for plants in Plots 1, 3, 2 and then 4 in declining order. Elongation of plants in Plots 1 and 3 were almost equal while those in Plot 4 exhibited very little elongation. Growth had stopped by the last week in August for plants in Plot 1, the last week of September for Plots 2 and 3 and in mid-June for Plot 4.

Plants contained within Plots 3 and 4 attained the largest volume increase (Figure 28) with Plot 2 next and then Plot 1. Those plants within Plot 1 ceased to increase in volume growth during the last week of August. However, plants in the other three plots continued to increase through the hard freeze of latter November. Most of the late

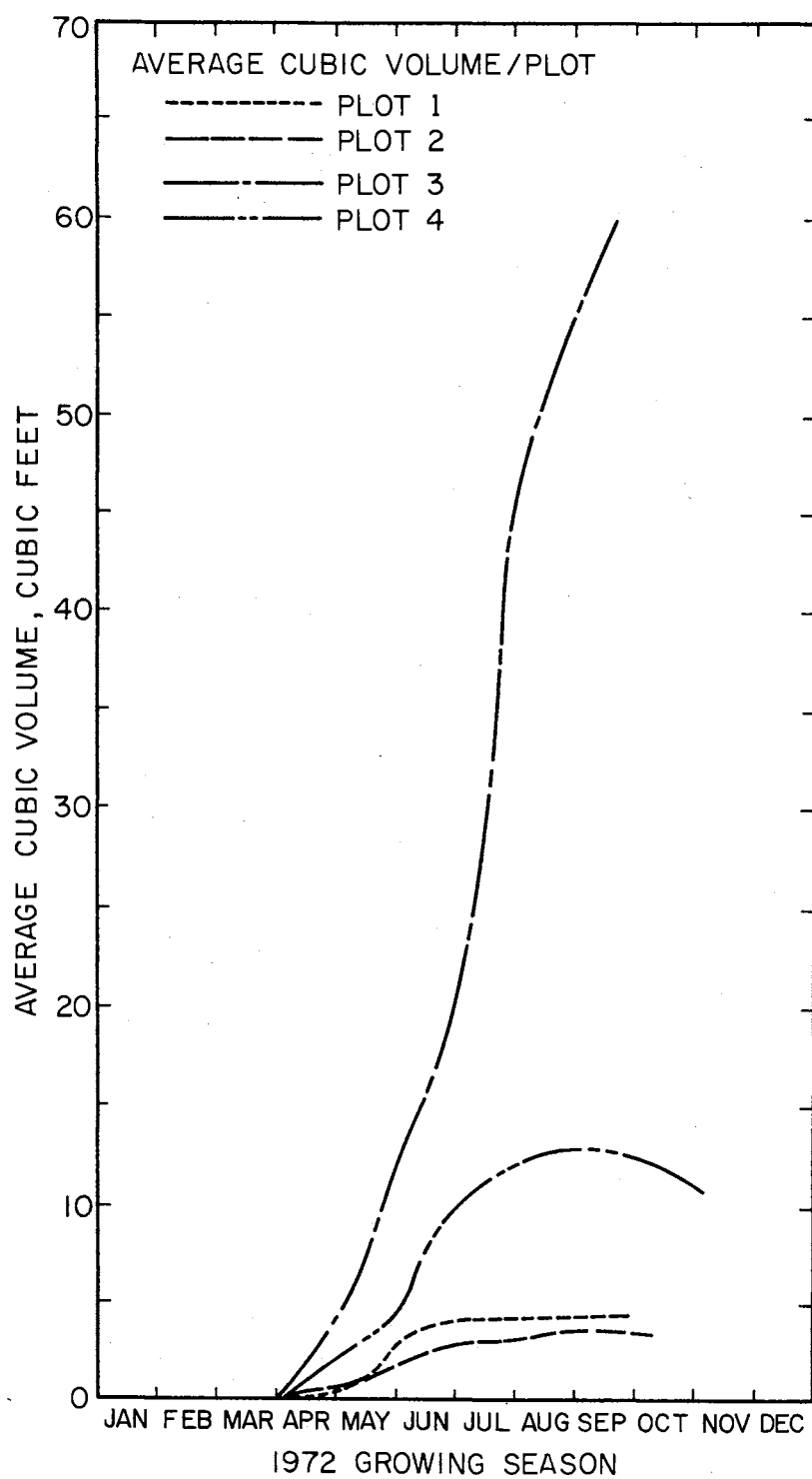


Figure 26. Graph of Average Cubic Volume - Smooth Hydrangea.

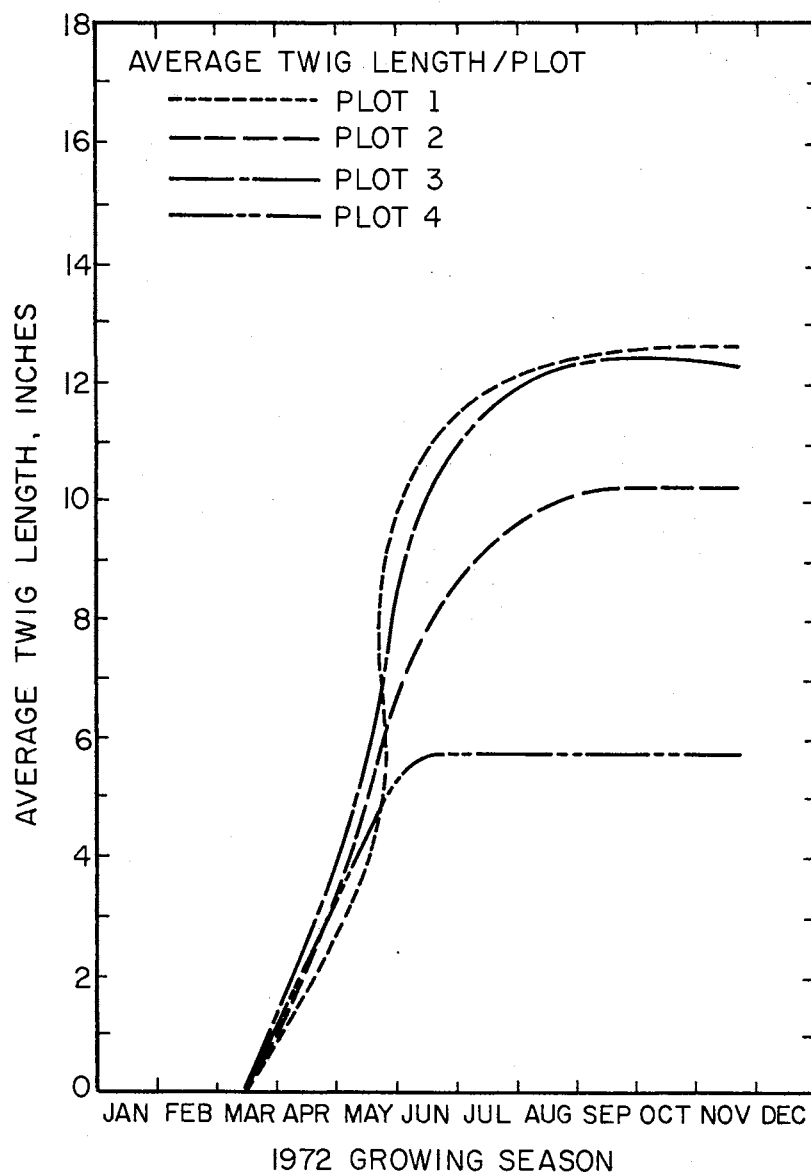


Figure 27. Graph of Average Twig Length -  
Deciduous Holly.

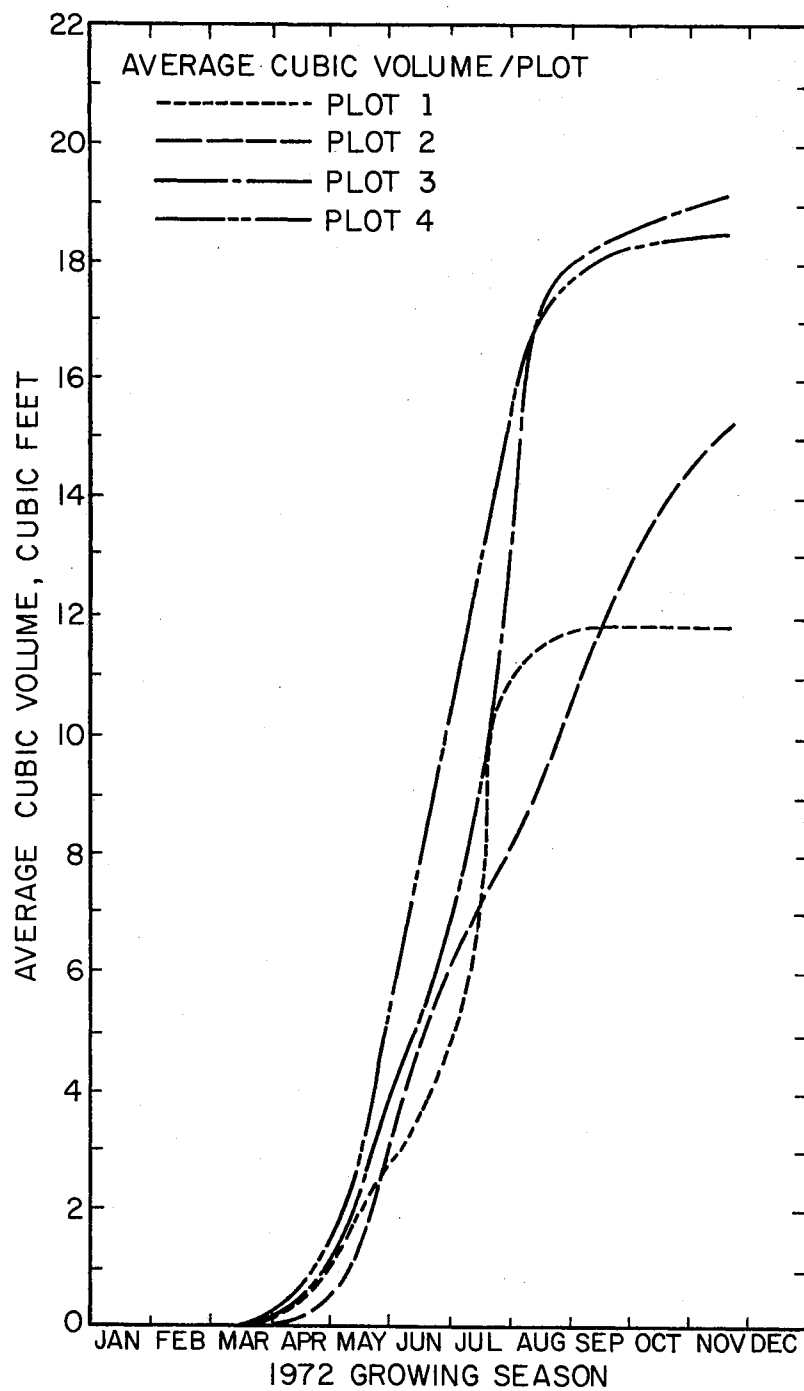


Figure 28. Graph of Average Cubic Volume -  
Deciduous Holly.

season growth increases were in the form of lateral branch shoots which grew mostly in an upward fashion. This growth was not detected by the twig elongation measuring technique.

All plants retained their leaves in almost the same condition of vigor through the first hard freeze of fall.

#### 6. Youpon - *Ilex vomitoria*

The first sign of the beginning of spring growth occurred in the first days of April. The largest amount of vegetative growth occurred within Plot 4 but the two measuring techniques produced conflicting results for the remaining plants.

Twig elongation measurements (Figure 29) reflected a definite growth advantage for plants in Plot 4. Comparative totals for the remaining plants were more closely grouped with plants within Plot 1 having the second largest amount and then Plot 2 and lastly Plot 3. Except for plants within Plot 3 which ceased to further elongate around the middle of August, all plants continued to grow through November.

As above, plants within Plot 4, measured by volume increase (Figure 30), showed a definite growth advantage. Total growth for plants within Plot 3 were grouped more closely to Plot 4 with Plots 2 and 1 in another close group. Plot 2 plants had the least increase. The growth patterns and amounts within all plots were nearly equal until the latter part of May at which time growth soared in Plots 3 and 4. Most of the volume growth was in the form of lateral shoots which was not measurable except by this technique. This same growth pattern was reported by Halls and Alcaniz (12, 15).

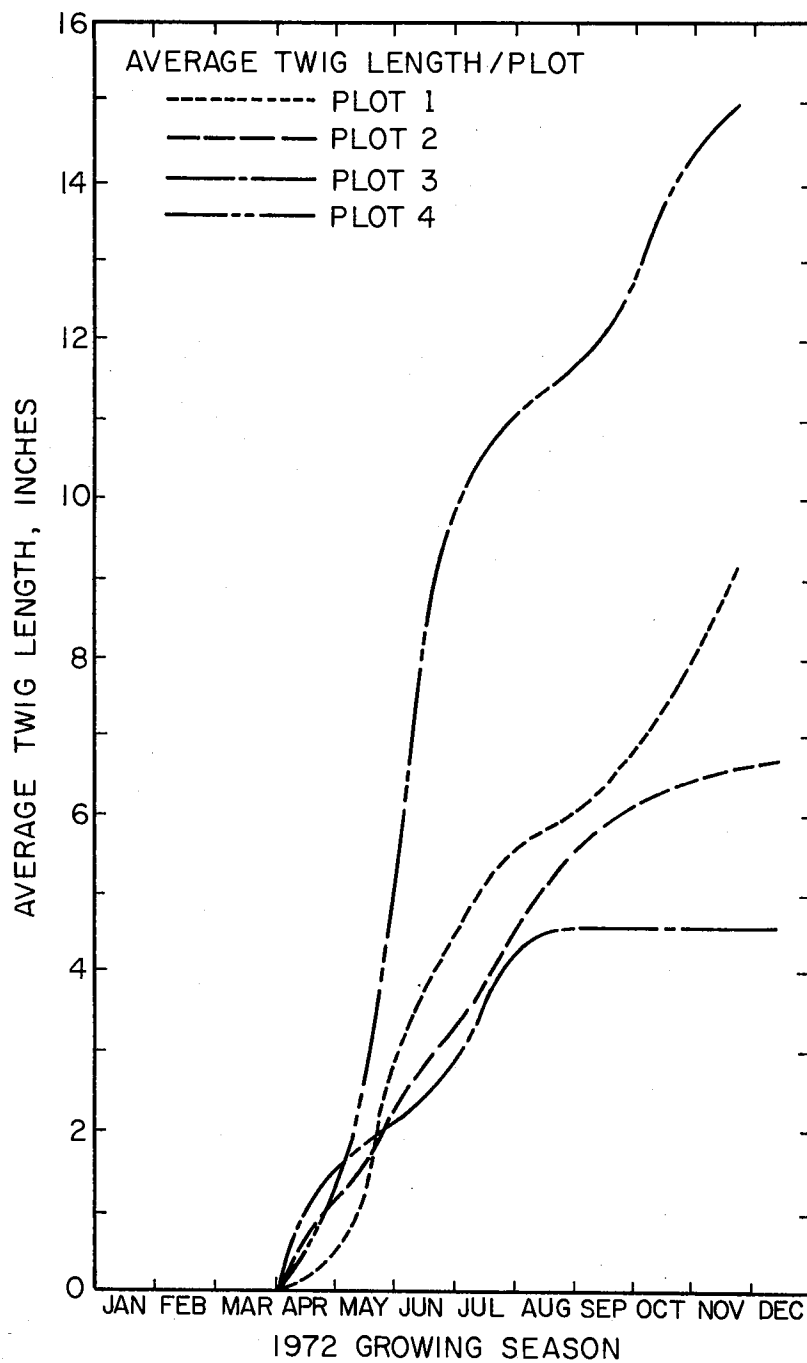


Figure 29. Graph of Average Twig Length -  
Youpon.

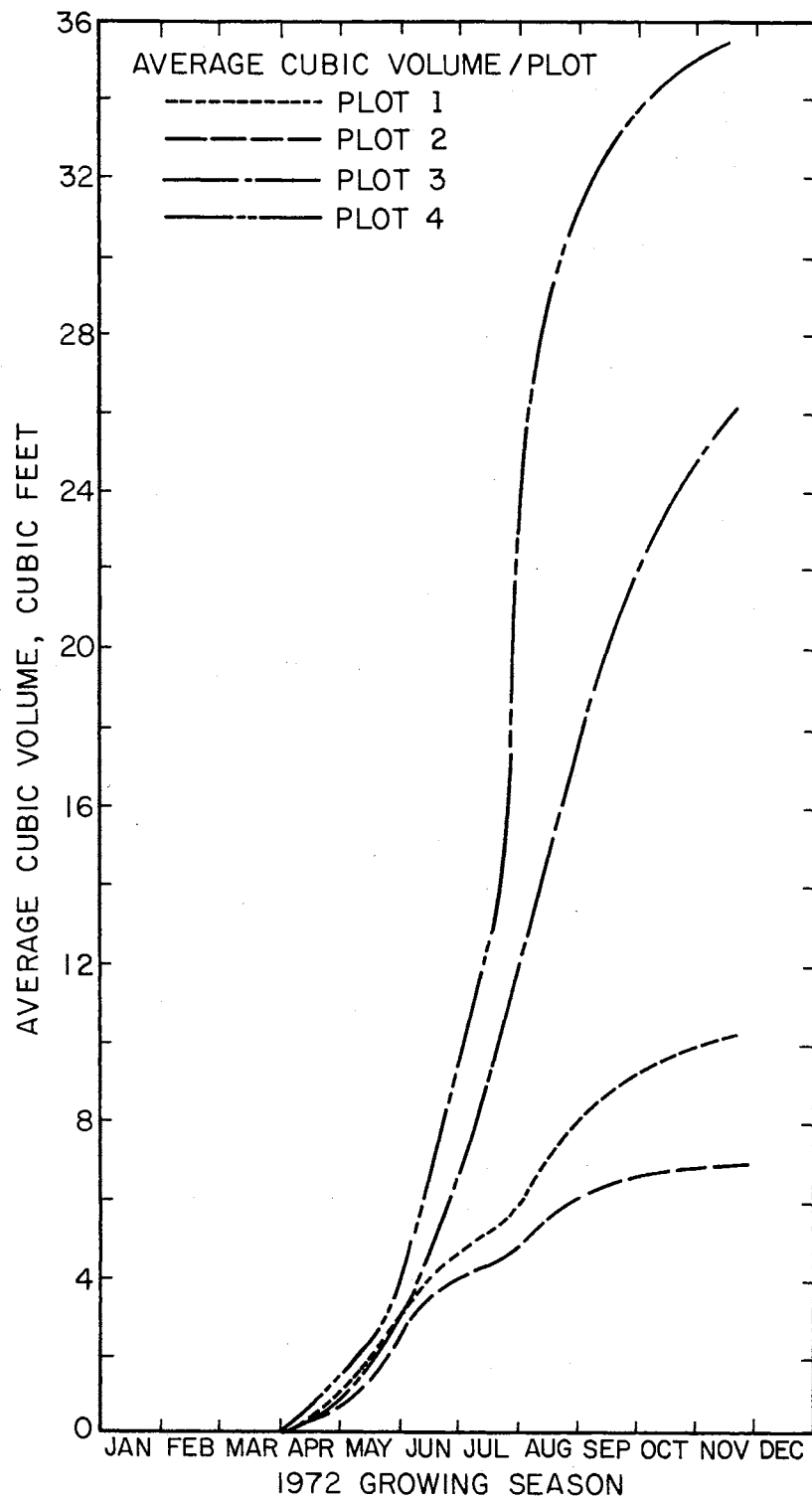


Figure 30. Graph of Average Cubic Volume - Youpon.

Youpon, being an evergreen, did not signal fall cessation of growth except in the form of no further increase of measurable growth. Using this criteria, growth had almost ceased in Plot 2 by the first part of November but continued through late November for the remaining plots.

7. Zabels' Bush Honeysuckle - *Lonicera*  
*korolkowii* var *zabelii*

This species began spring growth earliest of all plants used in this study; leaves opened during the last week in February. Consistent results were obtained from the two measurement methods.

Plants within Plot 4 attained the greatest total elongation (Figure 31) with plants in Plots 1, 2 and 3 trailing in that order. Elongation of those plants within Plot 3 was approximately one-half of that obtained in the other plots. Increasing growth had stopped in the last week of June for Plot 4, mid-August for Plot 3, mid-July for Plot 2 and the first week in September for Plot 1.

This growth pattern and relative quantities as shown by graphs of the cubic volume increase (Figure 32) was most near that observed. Maximum volume was obtained by plants within Plot 3 which was far ahead of the remaining Plots 4, 2 and 1 in that order. The recurved pattern represented on the graph was a result of the weeping growth habit of this species. All plants continued to grow somewhat until the end of the growing season itself.

Leaves began to turn and fall from plants in Plot 1 during the first week of October, Plots 2 and 3 at mid-October and those within Plot 4 continued through the fall first hard freeze of November.

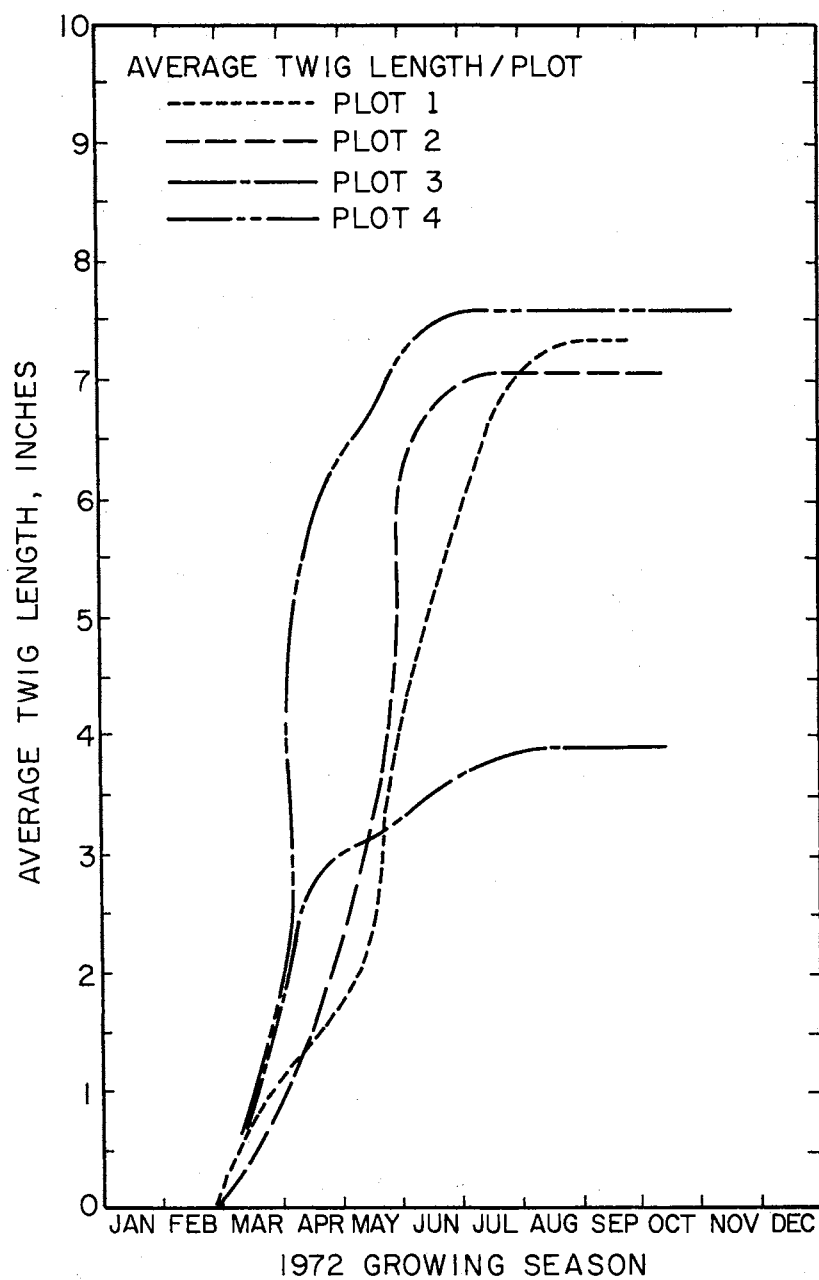


Figure 31. Graph of Average Twig Length -  
Zabels' Bush Honeysuckle

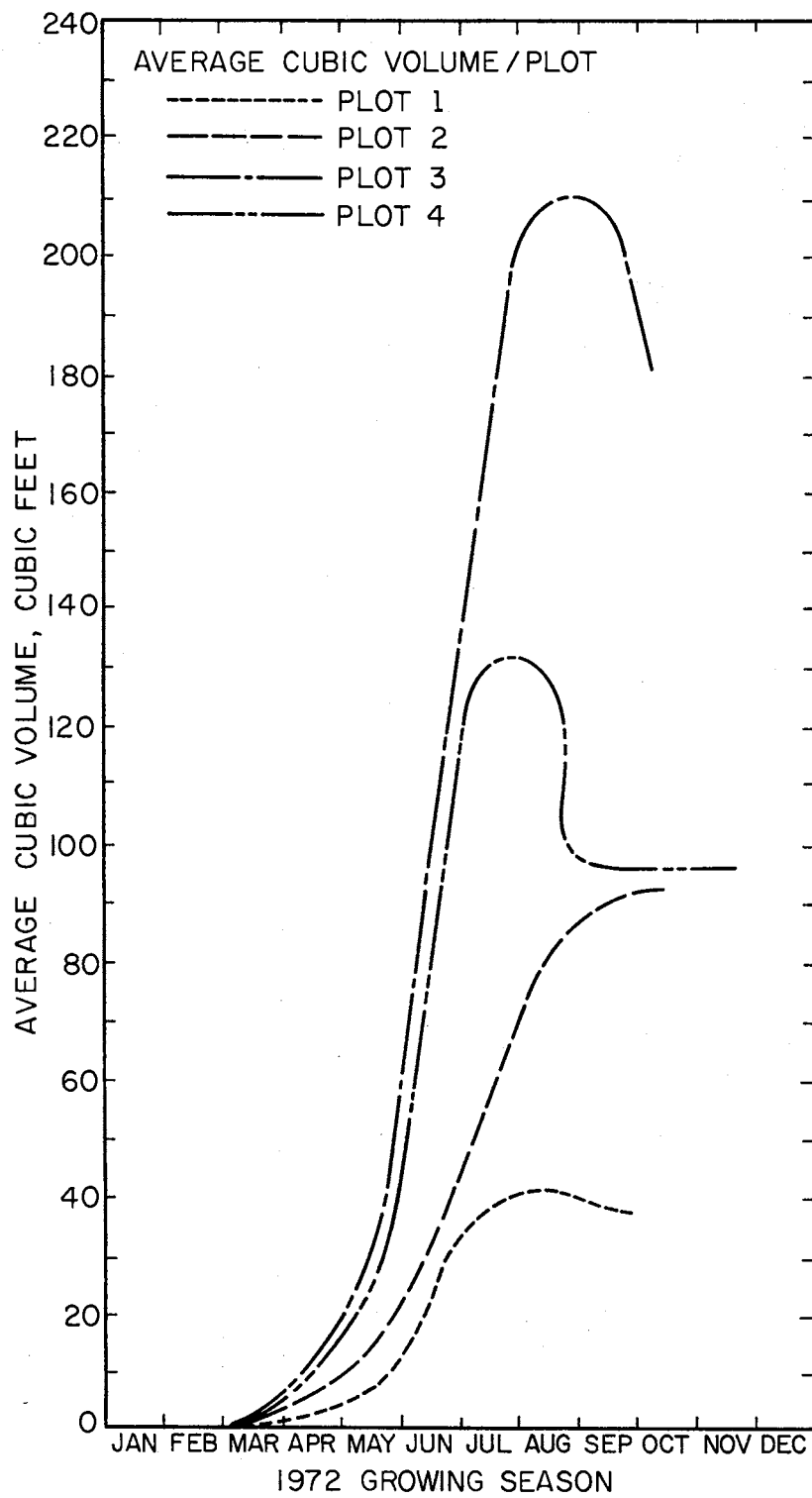


Figure 32. Graph of Average Cubic Volume -  
Zabels' Bush Honeysuckle.

#### 8. Dryland Blueberry - *Vaccinium vacillans*

During the second week of March, leaves began to evolve. Total growth differences, as measured by both methods, were not in agreement because a minimal number of twigs was available for elongation measurement and most of these had flower bracts develop, thereby terminating further lengthening. The majority of the vegetative growth was in the form of lateral shoots which was detected by measuring volume increase.

Total twig elongation (Figure 33) measured on plants in Plot 2 was largest followed by Plot 4, 3 and then Plot 1. Growth had ceased in mid-June for plants in Plots 1 and 2, mid-July for Plot 3 and continued until the first fall freeze in Plot 4.

Plants contained in Plot 4 experienced by far the most volume increase (Figure 34) followed by Plots 3, 2 and 1. The reverting curve pattern shown for all plots except 4, was a result of the flower bracts maturing and falling. This measurement technique best represents observed growth. That is, very little increase was present in Plots 1 and 2 but good, healthy, continued growth was apparent in Plots 3 and 4.

Leaves began to turn red within Plot 1 the third week of September and in Plot 2 the third week of October. Leaves remained healthy and vigorous in Plot 3 until the first of November. Plants within Plot 4 remained vigorous until the fall hard freeze in latter November.

#### 9. Mapleleaf Viburnum - *Viburnum acerifolium*

Growth activities began near the first of April. As revealed through both measurement methods, plants within Plot 4 had a definite growth advantage. The next high production occurred in Plot 3 with very little activity evident in Plots 1 and 2.

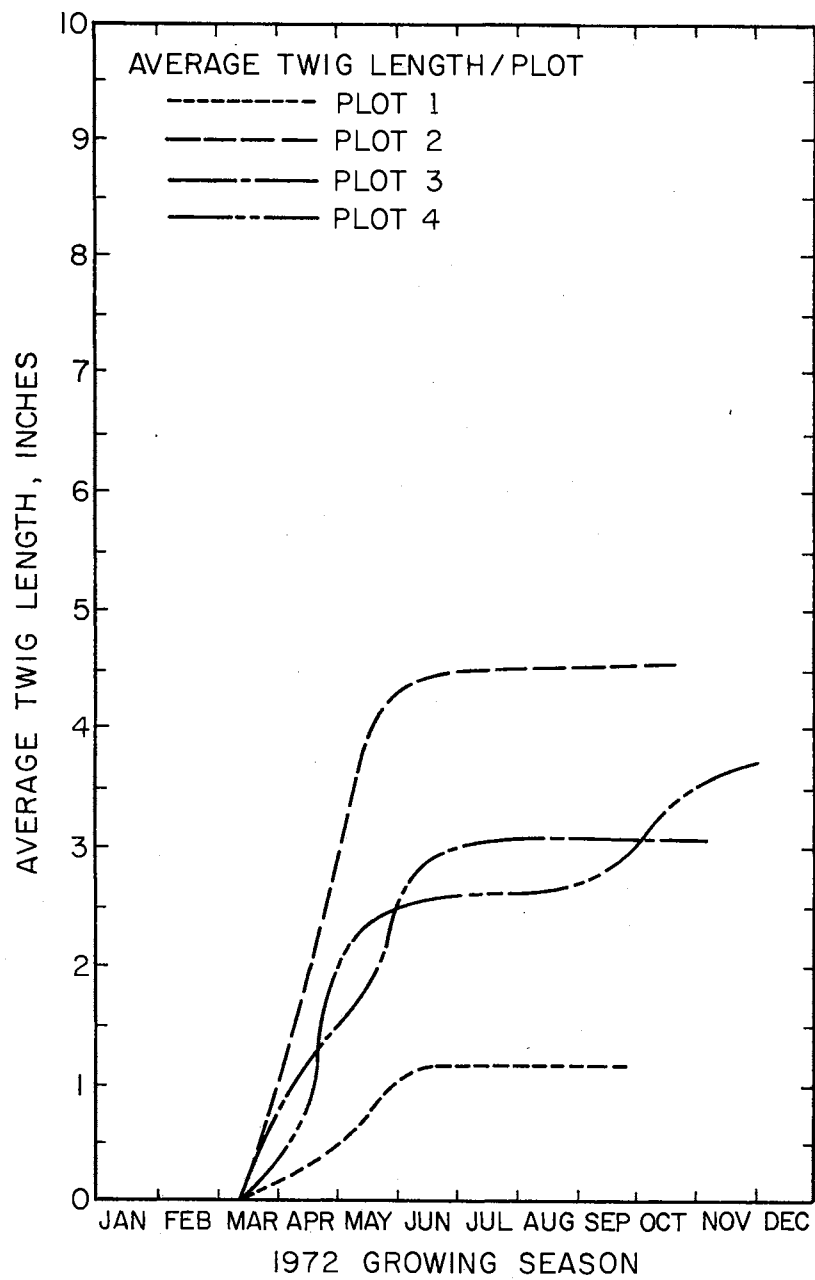


Figure 33. Graph of Average Twig Length -  
Dryland Blueberry.

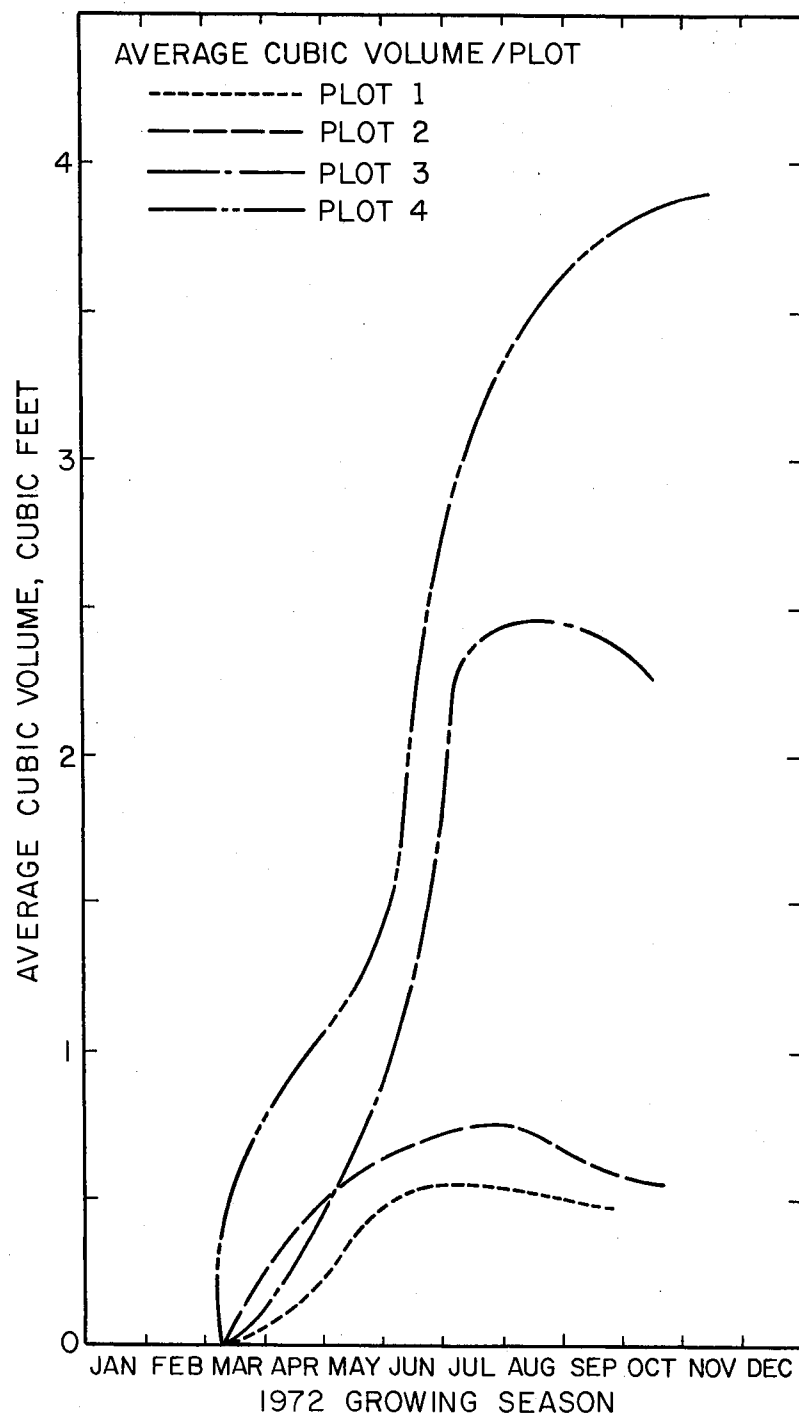


Figure 34. Graph of Average Cubic Volume -  
Dryland Blueberry.

Continued twig elongation (Figure 35) in Plots 1 and 2 nearly ceased by the end of April. Growth continued in Plot 3 and 4 until the last of May. Two definite growth groups were formed with Plots 1 and 2 being in one group together and Plots 3 and 4 being in another. Growth in Plots 3 and 4 was superior compared to that in Plots 1 and 2.

Measured cubic volume increase was greatest for plants within Plot 4 (Figure 36). Plant growth in Plot 3 was more closely equated with Plots 1 and 2. Except for plants in Plot 4, all further growth had virtually ceased prior to the first killing frost.

Leaves began to turn around mid-August in Plot 1 followed about a week later in Plot 2. Leaves remained intact and healthy in Plot 3 until the first of October and in Plot 4 until the middle of October.

#### 10. Southern Arrowwood - *Viburnum dentatum*

During the last week of March, leaves began to appear. Total growth results from both measurement techniques produced equal results with plants in Plot 4 showing the greatest growth followed closely by Plot 3. Plants in the group formed by Plots 2 and 1 succeed the above.

Further twig elongation (Figure 37) had ceased by the middle of June for plants in Plot 1, by the middle of July for Plot 2 and the first week of August for Plot 3. Plants within Plot 4 continued growth through the first fall freeze.

Cubic volume increase (Figure 38) was almost nil for plants in Plots 1 and 2. The comparative large amount represented for Plot 3 and 4 was a result of lateral shoots patterning mostly in the form of height growth.

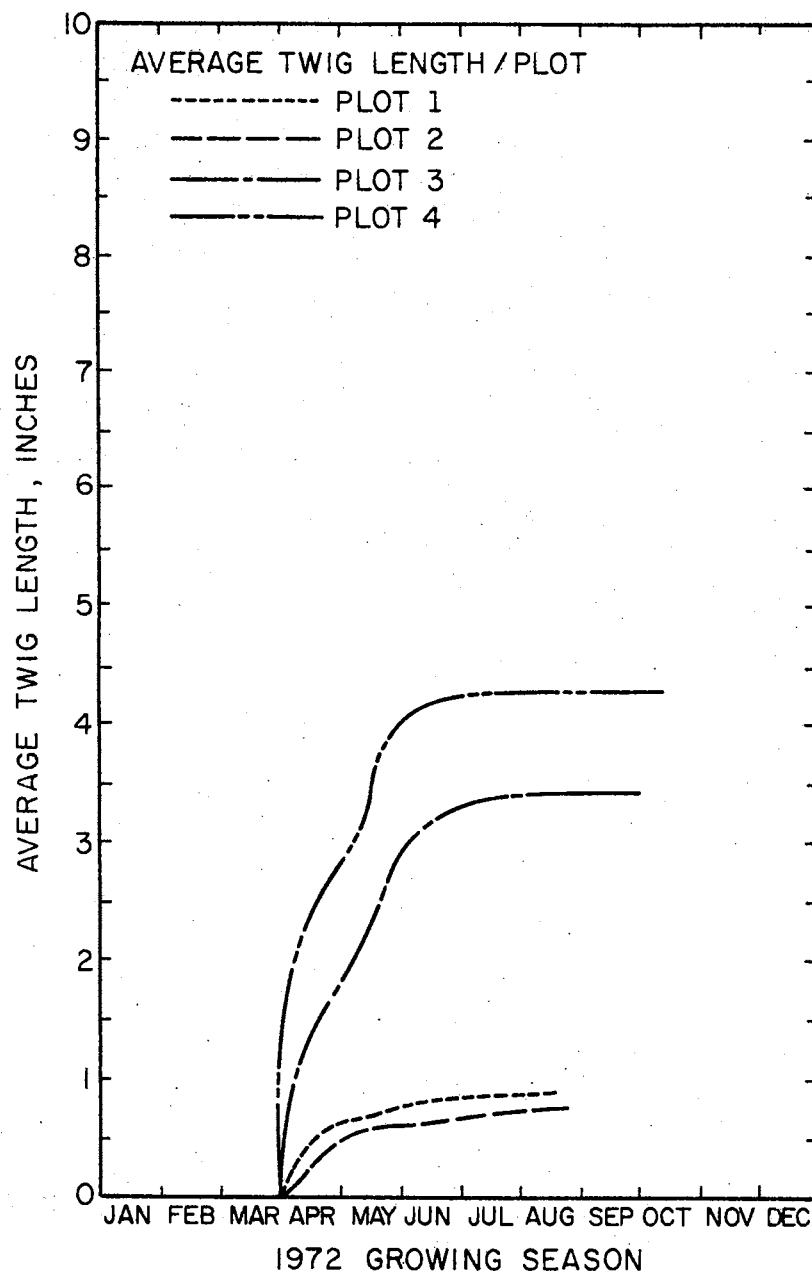


Figure 35. Graph of Average Twig Length -  
Mapleleaf Viburnum.

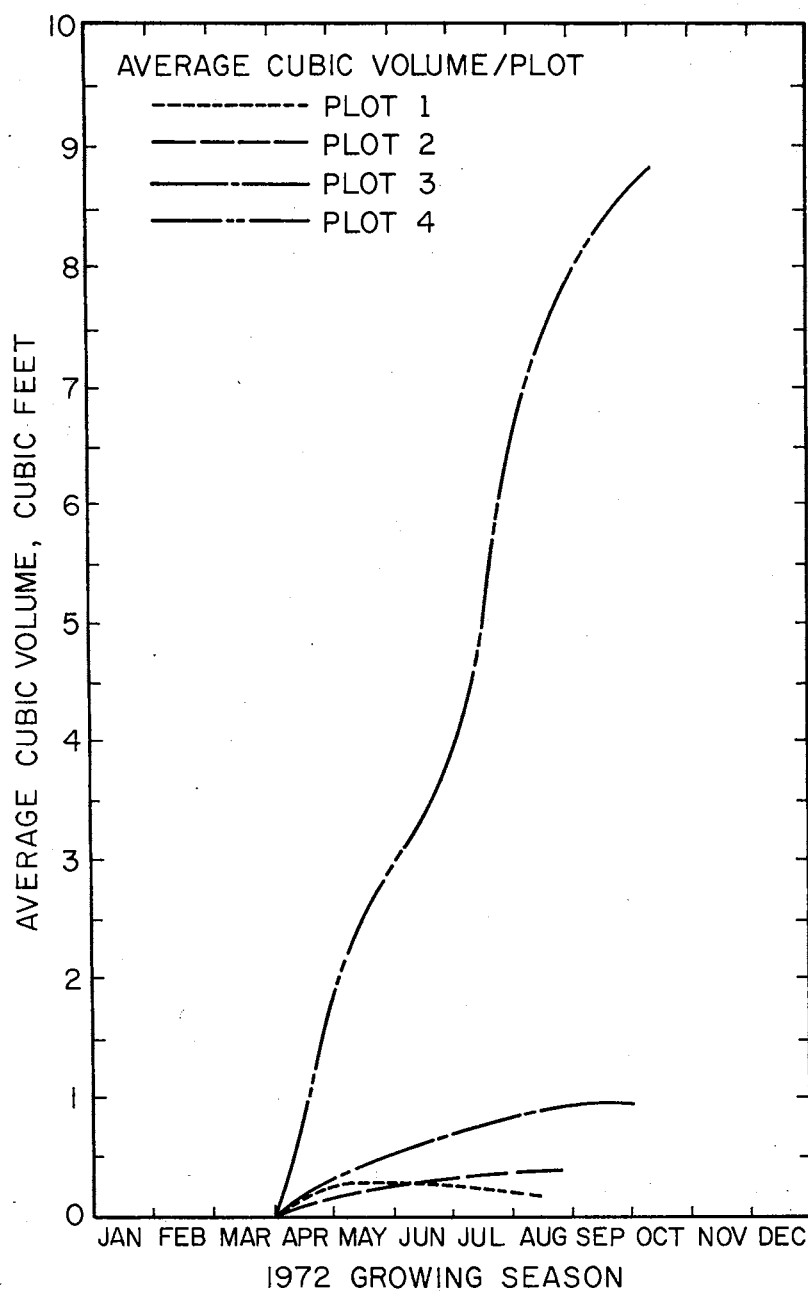


Figure 36. Graph of Average Cubic Volume -  
Mapleleaf Viburnum.

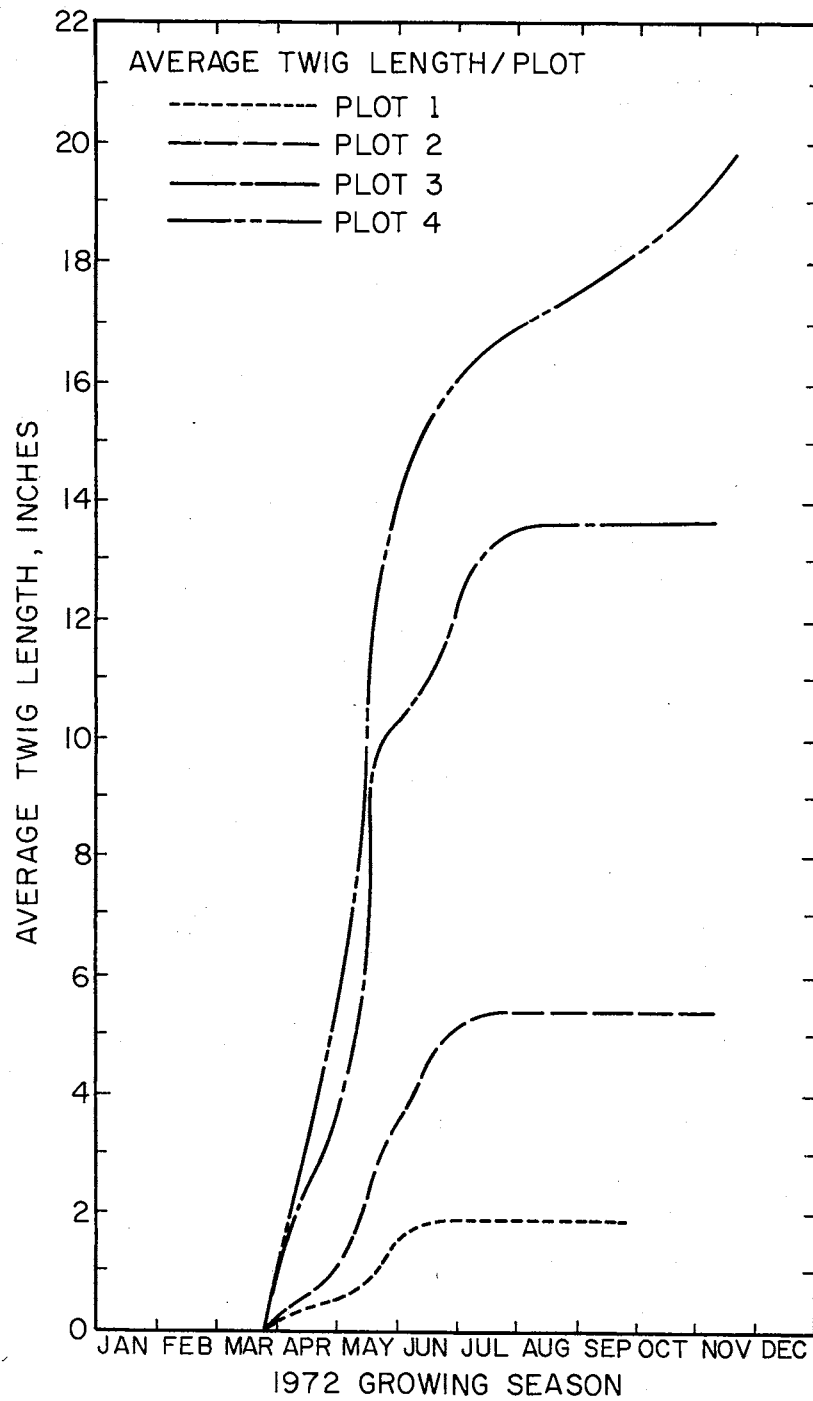


Figure 37. Graph of Average Twig Length - Southern Arrowwood.

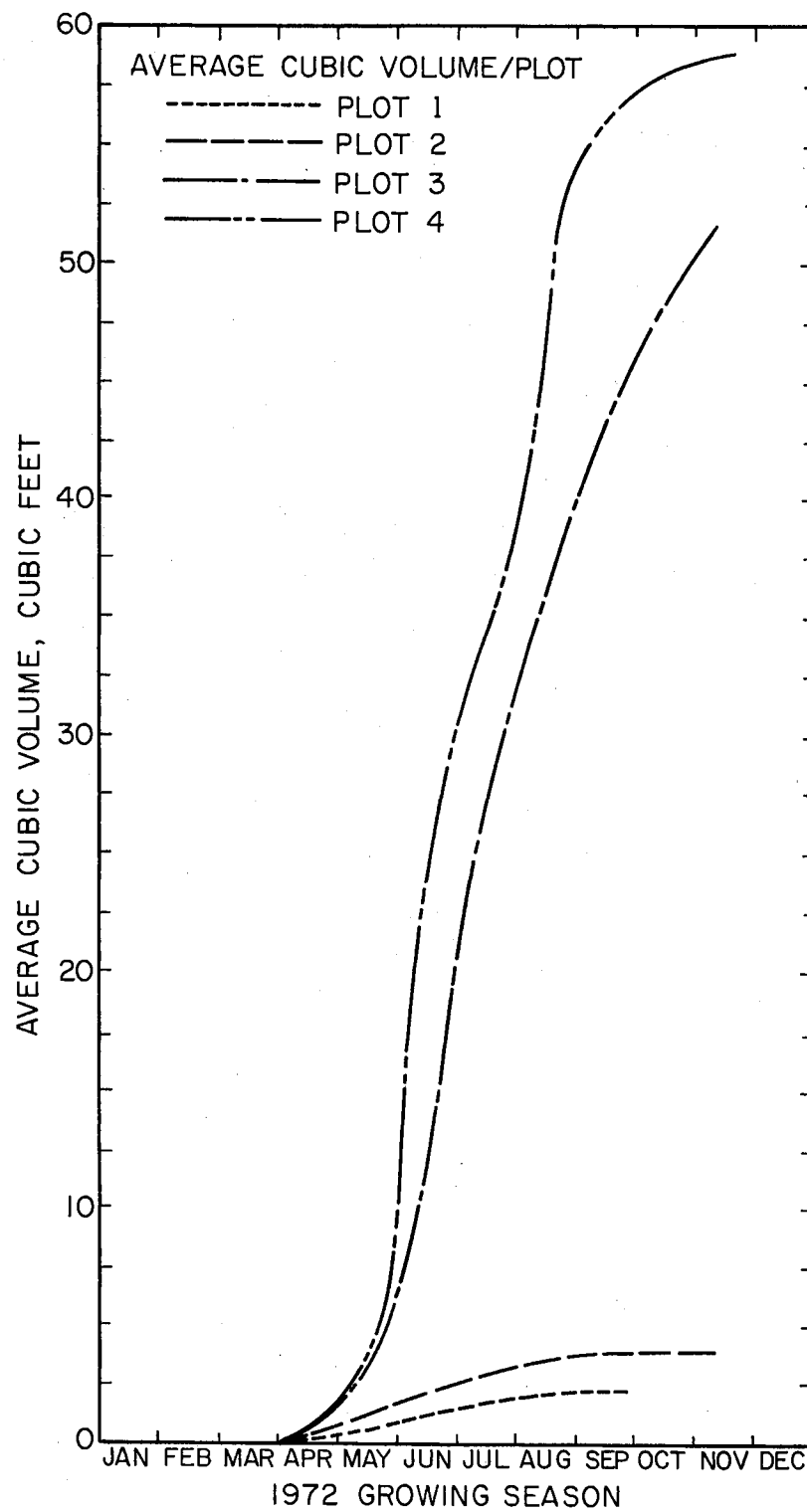


Figure 38. Graph of Average Cubic Volume - Southern Arrowwood.

Continuous growth increase had ceased in Plot 1 by the first of August followed by Plot 2 by the first of September. Plants within Plots 3 and 4 continued to increase growth throughout the growing season.

Fall termination of growth occurred first in Plot 1 in the last week of September and then in Plot 2 near the middle of November. Plants within Plots 3 and 4 remained green and vigorous until the November hard freeze.

#### B. Statistical Significance Test

Two analyses of variance were made with the data represented by Figures 19 through 38. Actual vegetative growth increments, as determined from both measurement techniques, for individual plant species in each of the four light conditions were compared by application of the "F" test. Results from this analysis are shown in Table IV. These results show a significant difference for the growth of strawberry bush and smooth hydrangea as measured by cubic volumes. Significant differences in growth were not proven for the remaining species as measured by either method.

Included in the second analysis was a "t" test comparison of species mean growth which occurred in each plot to that growth in the plot in which maximum growth was attained. Results at the .05 significance level are shown in Table V. With the exception of growth measured by cubic volume for strawberry bush, smooth hydrangea and youpon, there was no statistically significant difference in individual species growth among the various plots.

TABLE IV  
ANALYSIS OF VARIANCE FOR THE VEGETATIVE GROWTHS PER SPECIES

Species	Source	Twig Elongation				Cubic Volume			
		d.f.	S.S.	M.S.	Signif- icance Level	d.f.	S.S.	M.S.	Signif- icance Level
American Beautyberry	Shade	3	31.3600	10.4533	N.S.	3	41.9871	13.9957	N.S.
	Plant (Shade)	4	13.2863	3.3216		4	15.1002	3.7750	
Fringetree	Shade	3	7.1927	2.3976	N.S.	3	38.3980	12.7993	N.S.
	Plant (Shade)	4	14.8707	3.7177		4	38.6047	9.6512	
Strawberry Bush	Shade	3	4.9093	1.6364	N.S.	3	65.9293	21.9764	.01
	Plant (Shade)	4	1.7193	.4298		4	.1104	.0276	
Smooth Hydrangea	Shade	3	53.9261	17.9754	N.S.	3	641.7149	213.9050	.05
	Plant (Shade)	4	12.4464	3.1116		4	90.5238	22.6209	
Deciduous Holly	Shade	3	8.0954	2.6985	N.S.	3	10.7796	3.5932	N.S.
	Plant (Shade)	4	19.2667	4.8167		4	50.4072	12.6018	
Youpon	Shade	3	14.8793	4.9598	N.S.	3	143.9687	47.9896	N.S.
	Plant (Shade)	4	6.1879	1.5470		4	46.6683	11.6671	
Zabels' Bush Honeysuckle	Shade	3	6.8301	2.2767	N.S.	3	61.5219	20.5073	N.S.
	Plant (Shade)	4	13.5267	3.3817		4	44.5297	11.1324	
Dryland Blueberry	Shade	3	2.2666	.7555	N.S.	3	2.2394	.7465	N.S.
	Plant (Shade)	4	2.8155	.7039		4	3.5912	.8978	
Mapleleaf Viburnum	Shade	3	1.8588	.6196	N.S.	3	14.7277	4.9092	N.S.
	Plant (Shade)	4	1.5454	.3863		4	17.1537	4.2884	
Southern Arrowwood	Shade	3	33.2261	11.0754	N.S.	3	776.7125	255.5708	N.S.
	Plant (Shade)	4	41.2338	10.3085		4	178.1206	44.5302	

TABLE V

ANALYSIS OF SIGNIFICANCE BETWEEN THAT PLOT IN WHICH MAXIMUM  
MEAN GROWTH OCCURRED AND THE REMAINING PLOTS  
PER SPECIES AT THE .05 SIGNIFICANT LEVEL\*

Species	Significance**							
	Twig Elongation				Cubic Volume			
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 1	Plot 2	Plot 3	Plot 4
American Beautyberry	N.S.	N.S.	N.S.	***	N.S.	N.S.	***	N.S.
Fringetree	N.S.	***	N.S.	N.S.	N.S.	N.S.	N.S.	***
Strawberry Bush	N.S.	N.S.	***	S.	S.	S.	S.	***
Smooth Hydrangea	N.S.	S.	***	N.S.	S.	S.	***	S.
Deciduous Holly	N.S.	N.S.	***	N.S.	N.S.	N.S.	***	N.S.
Youpon	N.S.	N.S.	N.S.	***	S.	S.	S.	***
Zabels' Bush Honeysuckle	N.S.	***	S.	S.	N.S.	N.S.	***	N.S.
Dryland Blueberry	N.S.	***	N.S.	N.S.	N.S.	N.S.	N.S.	***
Mapleleaf Viburnum	N.S.	N.S.	N.S.	***	N.S.	N.S.	N.S.	***
Southern Arrowwood	N.S.	N.S.	N.S.	***	N.S.	N.S.	N.S.	***

\*"t" test .05 significant level value with 4 d.o f. is 3.18. Number of observation is 14. M.S. for each species as shown in Table IV in the respective plant (shade) rows.

\*\*Significance of .05 or less is depicted by S. Those comparisons with no significant differences are depicted by N.S.

\*\*\*Comparison plot (species obtained maximum growth within).

The statistical data contrasts with actual measured physical growth differences as obtained in the field and shown in Figures 19 through 38. This difference is probably due to the small sample size resulting from only one year's growth measurements.

## CHAPTER IV

### SUMMARY AND CONCLUSIONS

This study was designed to compare and evaluate vegetative growth of ten southern forest deer browse species as influenced by four differing light conditions. The critical environmental factors of moisture and soil conditions were eliminated by application of adequate moisture throughout the study and by potting each plant in an identical soil mixture. Temperatures were naturally slightly higher in the more open plots which presumably submitted these plants to higher degrees of stress. While this condition was not desirable, it was not damaging to the intent of this study since the same circumstances may occur in the natural environment under forest conditions.

#### A. Measuring Technique

Methods of measurement which employed the determination of twig elongation and cubic volume increases were used in evaluating vegetative growth patterns and quantities. The twig elongation measurement method was found to be advantageous only for fringetree. Rationale for this occurrence lies in the small size and nominal number of stems present on these study plants, thus allowing almost total sampling of twig growths. Otherwise, this technique, which consisted of measuring two twigs per plant, was too confining and therefore inadequate since other growth activities such as new shoot growths were not accountable.

For these reasons the discussion that follows will evaluate growth in terms expressed by measured volumetric increases, excepting the species above.

#### B. Beginning Dates of Spring Growth (Figure 39)

Spring growth of all plants was characterized by an early flush. Beginning dates of each species were identical irrespective of the degree of shade they were subjected to. Therefore, the warm spring temperatures and adequate moisture applied was the major triggering mechanism for the commencement of growth activities.

Plants which began growth earliest were Zabels' bush honeysuckle, which started growth during the last week of February, and southern arrowwood, whose growth began during the first week of March. About a week later strawberry bush and dryland blueberry showed their first signs of growth activity and these were followed the next week by deciduous holly. As a result of their early growth, these species are of special value in deer habitat management. They provide succulent green browse to the deer at a time when other foods are scarce and thereby fill a critical nutritional void.

With the exception of fringetree, which began growth during the second week of April, the remaining four study species initiated their spring growth activities during the first week of April.

#### C. Growth Performance Analysis (Figure 39)

Individual species were evaluated in terms of their growth performance under the four conditions of shading used in this study. None of the plant species used attained maximum total growth increases in

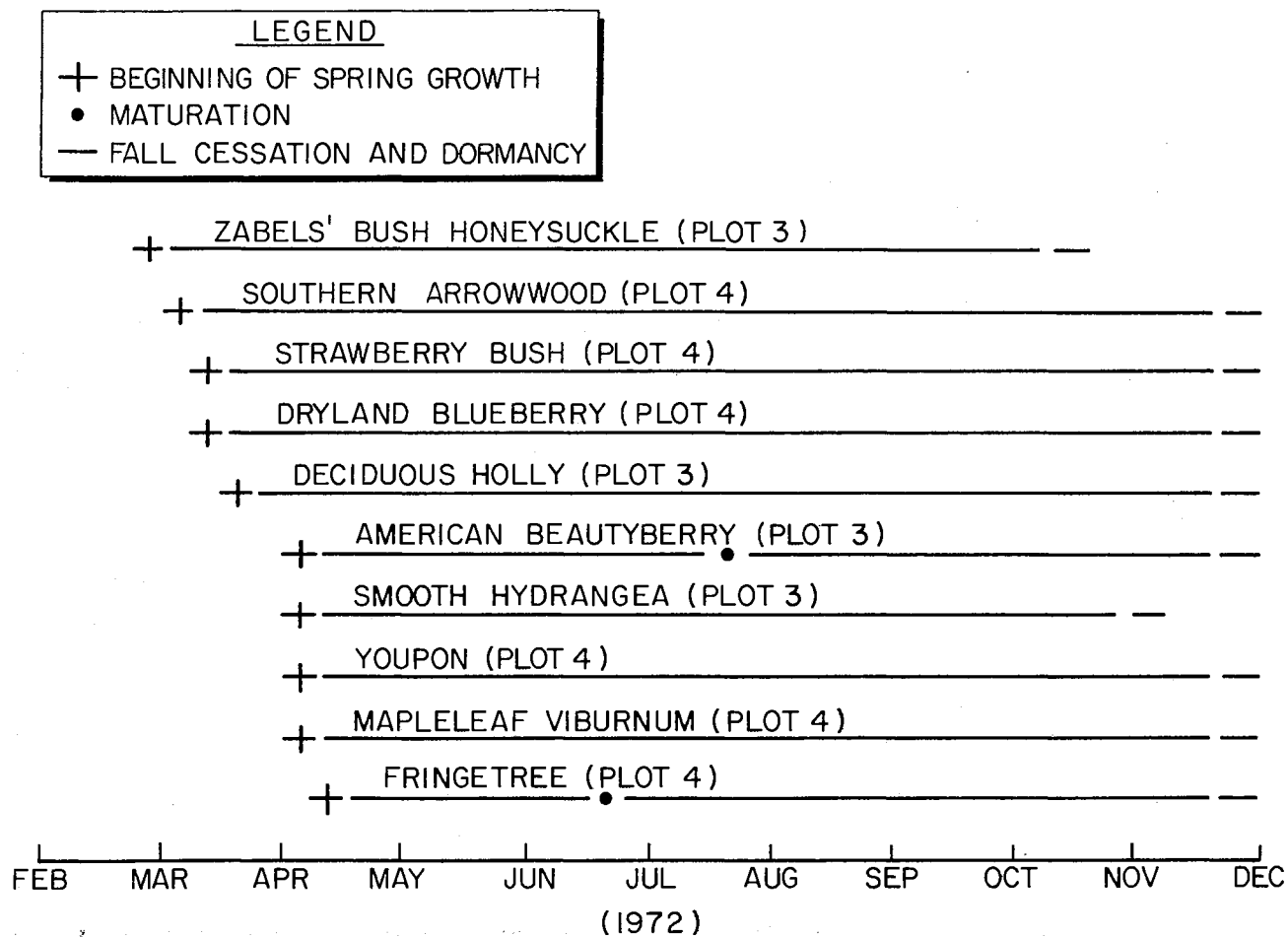


Figure 39. Graph of Relative Growth Patterns.

Plot 1, the non-shaded condition, nor in Plot 2, the 37 percent shade condition. Within Plot 3, which had 56 percent shade, American beautyberry, smooth hydrangea, deciduous holly and Zabels' bush honeysuckle attained their maximum growths. The remaining species consisting of fringetree, strawberry bush, youpon, dryland blueberry, mapleleaf viburnum and southern arrowwood all reached their maximum growth under the 77 percent shade condition of Plot 4.

Five species, consisting of American beautyberry, fringetree, deciduous holly, youpon and southern arrowwood, produced very similar, in fact almost equal, results in Plots 3 and 4 which shows these plants have a wide range of shade tolerance.

#### D. Growth Patterns (Figure 39)

This section discusses only those growth patterns of the plants of each species that attained the maximum total growth in their respective plots or shaded conditions. Growth seasons are important since during the time of continuous growth, or before maturation, the newly forming plant tissues are at a stage of highest palatability and digestibility which directly influence feed intake and value to the white-tailed deer.

Generally, the shaded conditions of Plots 3 and 4 retarded plant development and maturation and therefore retained these plants in a succulent and more available condition for longer periods of time than those plants contained in Plots 1 and 2.

American beautyberry and fringetree reached maturity during the third week of July and the third week of June respectively. The remaining plants continued growth throughout the season.

Zabels' bush honeysuckle was the species which initiated growth earliest in the spring and was the first of the species to have its leaves turn and fall during mid-October. Smooth hydrangea was the next species to terminate growth. This occurred during the first week of November. The remaining plants retained their leaves in a vigorous stage through the latter part of November.

The findings of this study give the forest manager insight into the light requirements these plant species can best tolerate. Using these relative shade percentages and a simple light measuring device, the light conditions of a forest stand can be determined and correlated to the results of this study.

In order to maintain an economic and ecological balance while growing a dual crop of wildlife and useful timber, the forest manager must have facts on which to base his management decisions. To obtain these facts as they pertain specifically to the habitat of the white-tailed deer, much more research and study is necessary. Additional browse species should be subjected to the same conditioned light environment as those plants used in this study. Cumulative long-termed effects of varying light intensities on growth quantities is also needed.

Plant nutrition is a very important component of deer management. It determines feed intake, growth, health and reproduction of deer. Therefore, nutrition should be quantified under varying light environments.

Fruiting habits were observed during the course of this study. The time, amount and environmental influences on fruiting were inconclusive. It appears that fruiting capabilities are most strongly tied

to the plant's genetic make-up as it relates to environmental factors and plant maturity. Genetic refinement is needed to produce plants with superior fruiting characteristics as well as maximum vegetative productivity. In conjunction with this research, improved seed germination and methods to produce planting stock in large volumes could be determined.

No one environmental factor such as light, soil nutrient, moisture or physiological tolerance to browsing can be studied separately. The interrelationships of all factors must be found to have final conclusive results. Disclosure of the different growth patterns and tolerances offer possibilities for combining species within a deer's home range that provide year around food. Armed with these findings the forest manager can select and favor species combinations suited to particular locations or adjust the kind, number, spacing and size of the tree overstory to meet a particular need.

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