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GROWTH PATTERNS OF DEER-BROWSE PLANTS IN SOUTHERN FORESTS

L. K. Halls and R. Alcaniz

Southern Forest Experiment Station
Forest Service
U. S. Department of Agriculture

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Among plants of 16 browse species growing in an open field and beneath a stand of pines in east Texas, twig elongation began earliest in years when mean March temperatures were high. Growth on plants of six species began a few days earlier in the woods than in the open.

Tree overstory significantly affected growth cessation in only three species. Rainfall variations did not affect beginning date of growth, but twigs ceased growth earlier in a very dry year than in other years.

The combination of the species studied that would furnish succulent green forage earliest in the spring and extend growth latest in the fall includes yellow jessamine, Alabama supplejack, yaupon, rusty blackhaw, and flowering dogwood.

This report describes seasonal growth patterns of 16 southern browse species as influenced by temperature, rainfall, and pine-tree overstory. The effects of environment on growth rate are important because, in general, rapidly growing and recently formed plant tissues are more palatable and nutritious for deer than slow-growing or old tissues (Blair and Epps 1969; Short and Blair 1971). Game managers can alter overstory density and the species composition of the understory to increase the quantity or improve the seasonal distribution of palatable tissue available to deer.

The species observed are common in forests throughout the South. The forage and fruit they produce are eaten by white-tailed deer (*Odocoileus virginianus* L.), for which most of the species are considered medium to choice food (Goodrum and Reid 1959; Lay 1967).

Preliminary results of the studies described here were reported by Halls and Alcaniz (1965). Similar information has been reported for the common trees of eastern forests (Bonck and Penfound 1944; Cook 1941; Farnsworth 1955; Jacobs 1965; Kozlowski and Ward 1961; Kozlowski and Clausen 1966), and for some browse plants in the West (Bedell and Heady 1959; Costello and Price 1939; Watkins and de Forest 1941).

[1] Respectively, Principal Ecologist and Biological Technician (Wildlife), Wildlife Habitat and Silviculture Laboratory, which is maintained at Nacogdoches, Texas, by the Southern Forest Experiment Station, USDA Forest Service, in cooperation with Stephen F. Austin State University.

SPECIES

Alabama supplejack (*Berchemia scandens* (Hill) K. Koch) is a high-climbing deciduous vine. It occurs on all except very sandy soils, but prefers moist to wet sites. It tolerates shade and thrives even under fully stocked timber stands. Through spring and fall the leaves and succulent stems within reach are readily eaten by deer, but the vines rapidly twine upward about the trunks and crowns of trees and shrubs and much of the foliage is unavailable. The fruit, a blue drupe, is eaten by many kinds of wildlife, including deer, wild turkey, and bobwhite quail.

American beautyberry (*Callicarpa americana* L.) is a shade-tolerant deciduous shrub. Though its leaves may wilt during droughts, it can persist on very dry sites. The twigs and leaves are eaten by deer and cattle during the growing season and occasionally in early winter. The berrylike fruit is relished by deer. It is eaten by many mammals and birds and is considered an important quail food from August to November. Plants bear fruit at a very early age.

Common trumpetcreeper (*Campsis radicans* (L.) Seem.) is a deciduous woody vine that often forms dense thickets in old fields and forest openings. It survives but does not flourish under fully stocked timber stands. It grows on almost any soil but is most common on those of heavier texture in bottom lands. It is made conspicuous by its bright orange funnel-shaped flowers in summer and the large seed

pods in the fall. The foliage is eaten by deer in spring and summer.

Flowering dogwood *(Cornus florida* L.) is a deciduous understory tree. It grows on a wide variety of soils but does best in longleaf pine stands and on the moist rich loams along stream bottoms and on northern slopes. The showy white flowers of spring and the bright red fruits and red and yellow leaves of autumn make this species an attractive ornamental in yards and a showpiece in the woods. Larger trees bring a good price because the strong, shock-resistant wood enjoys a continuing market for shuttleblocks, mallet heads, and similar woodenware. Virtually all game species and many songbirds eat dogwood fruit, which ripens in early fall and lasts through much of the winter. The fruit is a special favorite of wild turkeys, squirrels, and white-tailed deer. Leaves and twigs are also a source of food for deer. Even in winter, twigs and fallen leaves may be eaten.

Swamp cyrilla *(Cyrilla racemiflora* L.), an evergreen shrub, is a principal component of titi swamps and thickets and it also forms dense borders along streams and ponds. Whorls of racemes with white-petaled flowers form in the spring at the tip of the previous season's twig. Cyrilla is a preferred browse plant for deer. In thickets, it also provides escape cover for wildlife. Cattle graze new growth of leaves and twigs in spring and consume leaves sparingly through the fall and winter.

Brook euonymus *(Euonymus americanus* L.) is a shade-tolerant shrub that grows in rich, moist soil in the woods. Although widely distributed it usually is not abundant. Its leaves are persistent in the southern part of its range. In fall its pinkish capsules open to expose conspicuous orange-red seeds. The leaves and stems are highly preferred by deer.

Carolina jessamine *(Gelsemium sempervirens* (L.) Ait. f.) is an evergreen vine. It is well distributed throughout forested areas, forming broad interlacing carpets on moist to dry sites and on a variety of soils. It grows best in wooded stream bottoms. Jessamine is eaten yearlong by deer but is taken most readily in late fall and winter when other green feed is scarce. Because plants often climb 20 feet or higher in trees, much of the forage is unavailable to deer on forested sites. All parts of the plant contain alkaloids that are poisonous to livestock and humans, but the plant is apparently not harmful to deer when it is only part of the diet.

Yaupon *(Ilex vomitoria* Ait.) is an evergree shrub. It inhabits a variety of sites but is usually most abundant on moist sandy soils. Yaupon grows well beneath trees but best in th open. Yaupon provides fruit for deer, turkey quail, raccoon, and many songbirds. For dee yaupon leaves are a reliable source of gree forage in late winter and of special significanc because they contain sufficient protein for dee maintenance. Yaupon is also grazed by cattl in winter but it is considered a weed specie in central Texas because it competes with fo age grasses for moisture. It offers little hir drance to tree growth, and is not considere a pest in forest management. Summer burn or a series of hot winter fires will kill yaupo However, infrequent winter fires of moderat intensity may serve a useful purpose in keepin the new growth near the ground and availabl to deer. The species withstands heavy grazing

Sweetbay magnolia *(Magnolia virginiana* L. is an evergreen, swamp-loving shrub or tre It grows on acid sandy soils that are poorl drained or often flooded and in alkaline soil of ravines and hammocks. Sweetbay tolerate shade but does best in full sunlight. The leave and twigs are browsed all year. Utilization b deer is generally moderate. Cattle compet strongly for sweetbay in winter. Songbird gray squirrels, and other small mammals ea the seeds. The persistent leaves, fragrant whit flowers, and decorative fruit make sweetba attractive to gardeners.

Red mulberry *(Morus rubra* L.) is a smal to medium-sized deciduous tree commonl found on relatively moist sites. It is a mino component of both hardwood and coniferou stands but is more noticeable as a lone tre near streams and other moist sites. All manne of bird life feed profusely on mulberry frui while it is available for a 2- to 3-week perio in the spring. The fruits are also palatabl to squirrels and man. Mulberry browse is rate as moderately attractive deer food durin spring and summer. Sprouts following a fir are especially palatable but within a few year most growth is beyond reach of deer.

Blackgum *(Nyssa sylvatica* Marsh.) is adapt ed to a wide variety of sites—from the cree

bottoms of the Southern Coastal Plain to altitudes of 3,000 feet. It will tolerate brief spring flooding on alluvial sites and is common on relatively dry upper and middle slopes in the mountains. It is usually found in mixture with other species. It rarely obtains dominance in its age group but is in the intermediate crown class on most sites. The leaves and twigs of blackgum are eaten by cattle and deer through the spring and summer. After a fire the numerous young shoots emerging from the tree base are especially palatable. The fruits are a source of food for deer, small mammals, upland birds, and waterfowl.

Sassafras (*Sassafras albidum* (Nutt.) Nees) grows in open woods on moist well-drained sandy loam soils. It is a pioneer species on abandoned fields and on dry ridges and upper slopes, especially after fire. Sassafras is intolerant and reproduction is sparse and erratic except by sprouting. In forest stands it usually occurs as individual trees or in small groups and is usually in the dominant overstory. If it becomes overtopped in mixed stands it is one of the first species to die. Deer browse the leaves and succulent growth during the spring and summer and the twigs lightly during the winter. Sprouts following a burn are especially palatable to deer. The fruit is eaten by songbirds, wild turkey, bobwhite quail, and many small mammals such as raccoons and squirrels.

Saw greenbrier (*Smilax bona-nox* L.) and common greenbrier (*S. rotundifolia* L.) are thorny, woody vines that grow in thickets, woodlands, roadsides, and fields on a wide variety of soils and moisture conditions throughout the South. Common greenbrier is especially abundant in low, damp flatwoods, where it may overburden young trees. The fast-growing green canes and tender shoots are very palatable and the tardily deciduous leaves are eaten yearlong by deer. The plants can withstand heavy use. The fruits are eaten by many species of upland game birds, songbirds, and small mammals. The tangled vines provide good protective cover for rabbits and other small wildlife.

Rusty blackhaw (*Viburnum rufidulum* Raf.) is a deciduous understory shrub or small tree. It grows on a variety of sites ranging from river bottom to dry upland. Deer eat the leaves and twigs in the spring. The fruit is eaten by many kinds of birds and mammals.

Muscadine grape (*Vitis rotundifolia* Michx.) is a deciduous, strong-climbing vine that grows freely in brushy thickets, fence rows, low grounds, and borders as well as trees. Deer browse the vines in spring and summer and may consume fallen leaves in winter. Fruits mature in September and October, promptly falling but remaining edible for a short period to wild turkey, bobwhite quail, ground-feeding mammals, and many songbirds. The dense foliage provides good escape and shelter cover and nesting sites for songbirds.

PROCEDURES

Growth patterns were observed near Nacogdoches, Texas, in a stand of shortleaf and loblolly pines (*Pinus echinata* Mill., *P. taeda* L.) mixed with hardwoods, and in a nearby open field that had been abandoned for several years. In early 1963, 1-year-old locally grown seedlings of the 16 browse species were planted beneath a sawtimber-size stand of pines recently thinned to a basal area of 70 square feet per acre. Nine plants of each species were equally spaced within each of four contiguous ¼-acre blocks. Vegetation other than pines was either cut or killed with chemicals before the browse plants were set out.

The same planting schedule and arrangement were carried through in the field, where there were no trees. The vegetation between browse plants was mowed.

Soils at the two locations are Ruston and Magnolia fine sandy loams. They are deep, well-drained upland soils with a rapid infiltration and medium percolation rate. They have a medium amount of organic matter and natural plant nutrients, and are acid in reaction. The water table is deep and storage capacity high. The soils usually support a rapidly growing stand of pine and hardwood trees with a mixed and often dense understory of vines, shrubs, and small trees.

From February 1964 through December 1968, the beginning and ending dates of twig elongation were recorded on 12 open-grown and 12 forest-grown plants of each of 12 species (that is, three plants of each species in each of the four blocks at the two planting sites). Some plants of a few species died.

In late winter the plants were checked at least three times during the week for beginning date of growth. Two lateral branches were randomly selected and tagged with a small ribbon each February for growth measurements. Recordings of twig length and numbers were then made at 2-week intervals until the end of June, and at 4-week intervals thereafter through December for all twigs that formed above a marked reference point. The date at which twig elongation terminated was recorded, but since twigs were measured only at scheduled dates through the year, the actual time of growth termination occurred during the measurement interval prior to the recorded date. For four species, twig elongation was not recorded until growth began in 1965.

Temperatures were continuously recorded by hygrothermographs at both study locations, and the daily rainfall by a standard rain gage at a station less than ½ mile from the study site.

WEATHER RECORDS

Temperature

For the 5-year period the average of maximum monthly temperatures was 77.9°F. in the open and 75.8°F. in the woods. Occasionally, however, the recorded temperature in the woods was highest. The widest differences were in the falls of 1966 and 1968, when temperatures in the open were 4°F. to 8°F. above those in the woods. The highest maximum temperature, 94.3°F., was in August.

The average daily minimum temperature was 52.7°F. in the woods and 52.3°F. in the open, but the temperature relations were not always consistent between locations. The lowest mean minimum temperatures were in February, 33.2°F.

In comparison to longtime Weather Bureau temperature records at nearby Nacogdoches the following winter and early spring months were several degrees colder than normal: January in 1964 and 1966, February in all years of the study, and March in 1965. Spring and summer months hotter than average were August 1964, April 1965, and March and April 1967. Summer months cooler than normal were July and August of 1968.

The dates of the last freeze in the spring varied from March 9 in 1967 to April 5 in 1966 and the first freeze in fall from October 19 in 1967 to November 11 in 1968. The length of the frost-free season ranged from 208 days in 1964 to 235 days in 1968.

Rainfall

There was a wide variation in annual and in seasonal rainfall during the 5 years (table 1). In 1964 and 1965 winter and spring rainfall

Table 1.—*Monthly rainfall at Stephen F. Austin Experimental Forest, 1964-1968*

Month	1964	1965	1966	1967	1968	65-year average [1]
	Inches					
January	3.27	3.77	6.10	0.83	7.40	3.81
February	2.02	4.45	3.20	3.56	3.05	3.72
March	4.07	2.70	2.40	2.16	2.59	4.10
April	8.18	1.25	8.42	3.23	9.08	4.94
May	.89	7.76	5.16	5.52	7.94	5.22
June	4.16	2.88	1.48	2.41	9.63	3.42
July	.50	1.11	.48	3.23	3.45	3.98
August	3.44	2.18	7.51	2.31	1.44	2.39
September	3.21	3.88	4.65	.79	9.06	2.74
October	1.86	.55	2.58	1.78	1.64	2.90
November	3.71	3.40	.59	.95	6.98	4.13
December	3.30	7.70	3.62	5.25	3.75	4.88
Total	38.61	41.63	46.19	32.02	66.01	46.23

[1] From Weather Bureau records at Nacogdoches, approximately 12 miles from study area.

was slightly below average, and July was very dry. The 6-week summer drought in 1964 was broken by 6 inches of rain between August 17 and September 17. In 1965, the drought began in early July and continued until September 21. In 1966, the total rainfall was very close to the 65-year average but it varied considerably seasonally, being above average through May, much below in June and July, and high again in late summer and early fall. The total rainfall in 1967 was 14 inches below average and soil moisture was scarce from June through November. In contrast, rainfall in 1968 was 20 inches above average; the buildups of moisture in spring and again in September counteracted slight deficiencies in late summer and fall and there were no prolonged dry spells of any consequence.

BEGINNING AND ENDING DATES OF TWIG ELONGATION

The species beginning growth earliest in the year (March 18-19) were Alabama supplejack, Carolina jessamine, and rusty blackhaw. Thus, these species furnish green forage at a time when succulent forage is scarce and when deer must have nutritious food.

Differences in beginning dates of twig elongation between locations were inconsistent among species (table 2). For common trumpetcreeper, brook euonymus, Carolina jessamine, red mulberry, common greenbrier, and muscadine grape the beginning date of growth was significantly earlier (3 to 6 days) in the woods than in the open. The growth differences were not related to temperature differences between locations. Where these species are a major component of the habitat, deer would benefit by having access to the earlier green forage of woods-grown plants.

The open versus woods difference was not statistically significant for rusty blackhaw, sassasfras, blackgum, swamp cyrilla, or dogwood.

For Alabama supplejack, American beautyberry, yaupon, sweetbay magnolia, and saw greenbrier the difference between locations was significant during certain years, but it was not related to temperature differences.

Other studies have also shown that the effect of overstory on beginning date of growth may not always be consistent. Collins (1961) showed that red maple (*Acer rubrum* L.) started growth in both old field and forest at about the same time, whereas Kozlowski (1964) noted that red maples in the open initiated height growth later than those in the forest.

Kozlowski (1964) also showed that there was an increasing delay in growth initiation with an increase in soil moisture content. Under the conditions of the present study, where the fine sandy loam soils were well drained, there was no relation between rainfall and bginning date of growth.

The beginning date of twig elongation varied significantly among years for all species and was closely related to March temperatures. In 1965 the mean monthly temperature for March was the lowest for any year of the study (51.5°F.), and the beginning date of growth was latest. Conversely, March of 1967 was the warmest March (63.7°F.) and the beginning date of growth was earliest. There was no apparent relationship between January or February temperatures and beginning date of growth. Nearly all plants had begun growth prior to the late freeze on April 5, 1966, and were not noticeably affected by it.

The recorded dates for maximum twig elongation varied widely among species (table 2). Muscadine grape plants beneath trees ceased growth earliest. On the average, flowering dogwood, yaupon, and Carolina jessamine plants grew later in summer and fall than plants of other species. Presence of the three late-growing species tends to extend the period when succulent green forage is available for deer.

There was a very wide range in growth termination from year to year among plants of the same species, exceeding 200 days for many species. The variation could not always be attributed to climatic conditions. Even within the same year some plants within a species grew several weeks later than other plants. For example, most plants of yaupon would form new shoots following a late summer rain, but occasionally one or two did not. Likewise, Kozlowski (1964) noted that in a specific area most trees stop growing over a considerable period of time.

Twig elongation ceased significantly later in the open than in the woods for Carolina jessamine and yaupon, the two evergreen, late-

Table 2.—*Beginning and ending dates of twig elongation for browse plants growing in the open and beneath pine trees*

Species and location	Beginning date of growth		Ending date of growth	
	Mean	Range	Mean	Range
Alabama supplejack *(Berchemia scandens)*				
Open	March 19	March 10-March 21	June 16 [1]	April 4-December 17
Woods	March 19	March 13-March 31	June 26	March 16-September 30
American beautyberry *(Callicarpa americana)*				
Open	April 4	March 26-April 11	August 3	May 27-December 17
Woods	April 3	March 28-April 11	August 7	May 14-December 22
Common trumpetcreeper *(Campsis radicans)*				
Open	April 6 [1]	March 21-April 14	August 19	May 28-November 11
Woods	April 2	March 16-April 14	August 18	May 14-October 22
Flowering dogwood *(Cornus florida)*				
Open	March 27	March 21-April 13	September 6	May 8-December 17
Woods	March 25	March 16-April 9	September 14	April 20-December 22
Swamp cyrilla *(Cyrilla racemiflora)*				
Open	March 31	March 21-April 21	August 10	May 14-November 22
Woods	April 1	March 21-April 28	July 29	April 20-December 22
Brook euonymus *(Euonymus americanus)*				
Open	March 27 [1]	March 21-April 7	July 10	April 15-December 17
Woods	March 23	March 16-April 2	July 17	April 12-December 22
Carolina jessamine *(Gelsemium sempervirens)*				
Open	March 22 [1]	March 13-March 31	August 28 [1]	March 27-December 17
Woods	March 19	March 8-March 29	August 19	April 3-December 22
Yaupon *(Ilex vomitoria)*				
Open	March 31	March 21-April 9	September 24 [1]	May 14-November 22
Woods	April 1	March 16-April 15	September 4	June 4-December 21
Sweetbay magnolia *(Magnolia virginiana)*				
Open	April 9	April 4-April 15	July 21	April 30-October 27
Woods	April 10	April 4-April 27	July 22	May 14-October 28
Red mulberry *(Morus rubra)*				
Open	April 4 [1]	March 16-April 19	July 9	April 10-October 27
Woods	March 30	March 16-April 15	July 11	April 20-September 30
Blackgum *(Nyssa sylvatica)*				
Open	April 4	March 23-April 23	August 20	April 30-December 17
Woods	April 2	March 21-May 6	August 7	April 12-December 22
Sassafras *(Sassafras albidum)*				
Open	March 31	March 21-April 13	July 23	May 8-October 27
Woods	March 30	March 21-April 13	July 18	April 12-October 28
Saw greenbrier *(Smilax bona-nox)*				
Open	March 31	March 16-April 9	July 20	April 10-November 9
Woods	March 29	March 16-April 9	June 24	April 12-December 22
Common greenbrier *(Smilax rotundifolia)*				
Open	April 6 [1]	March 21-April 15	July 11	April 10-November 11
Woods	April 1	March 16-April 21	July 6	March 27-December 22
Rusty blackhaw *(Viburnum rufidulum)*				
Open	March 19	March 13-April 5	July 18	April 3-October 27
Woods	March 18	March 16-April 5	July 21	April 5-December 22
Muscadine grape *(Vitis rotundifolia)*				
Open	March 31 [1]	March 21-April 11	June 20	April 30-September 11
Woods	March 25	March 13-April 9	June 8	April 12-September 30

[1] Indicates significant difference between open and woods at probability level of 0.05.

season growers. This result may be partly attributable to the higher maximum temperature in the open during the late summer and early fall. Alabama supplejack was the only species in which growth terminated significantly later in the woods. For other species the differences between open- and woods-grown plants were not statistically significant.

Cessation of twig growth was not closely related to temperature and rainfall except in 1967. During this year when rainfall was extremely light, twig elongation for most species ceased earlier than in other years. These findings agree with Kramer's (1943) observation that severe droughts or excessively high temperatures may check growth but that the usual variations in moisture and temperature have little effect.

TWIG LENGTH

The mean length of measured twigs was greatest for common trumpetcreeper and least for yaupon (table 3). The average twig length was longer in the open than in the woods for eleven species but because of wide variation in length among twigs on the same plant the difference was significant only for American beautyberry. The twig length on brook euonymus and Carolina jessamine, two of the more shade tolerant species, was significantly longer in the woods than in the open.

Table 3.—*Mean length of browse twigs*

Species	Open	Woods
	Inches per season	
Alabama supplejack	10.9	9.5
American beautyberry	31.1	[1] 18.9
Common trumpetcreeper	91.3	121.4
Flowering dogwood	13.3	10.7
Swamp cyrilla	16.3	12.6
Brook euonymus	10.5	[1] 16.5
Carolina jessamine	10.2	[1] 20.2
Yaupon	5.9	7.7
Sweetbay magnolia	14.3	11.7
Red mulberry	30.9	28.7
Blackgum	19.4	13.9
Sassafras	11.8	10.2
Saw greenbrier	14.5	18.3
Common greenbrier	14.1	10.0
Rusty blackhaw	11.2	9.4
Muscadine grape	25.5	20.5

[1] Indicates significant difference between open and woods at probability level of 0.05.

GROWTH RATE

Twig elongation was rapid for all species during the spring. For a few species there was an occasional spurt of growth in late summer.

Similarities in growth patterns suggested arbitrary groupings of species that (1) respond to late summer rains, (2) grow most rapidly in spring, (3) make moderate growth in spring, (4) show consistent rate of growth to early summer, (5) die back at an early age, and (6) show extreme dieback annually. The groupings are slightly different from those previously used by Halls and Alcaniz (1965) because of additional species and some variation in growth patterns between years.

Regrowth Following Summer Rain

Growth patterns of yaupon and Carolina jessamine were associated with summer rainfall (fig. 1). Yaupon growth was slow in early spring but accelerated during the usually moist period in late May and June. Thereafter, plants both in the open and in the woods grew mainly after summer rains. During the protracted droughts in the summers of 1964 and 1966 growth practically ceased. But following the soaking rains of late summer there was a new spurt of growth. Most of the late growth was by new twigs formed from lateral buds rather than a lengthening of previously formed twigs. In 1965 growth was practically nil during the summer, and the September rains came too late to cause formation of any new twigs. In 1967, a very dry year, over 80 percent of the growth had accumulated by mid-July. In the wet year of 1968 growth continued at a fairly constant rate to late August. It then slowed and did not resume a rapid rate after the heavy rains that began in September. Thus, there was a rapid spurt of late summer growth during the 2 years that soaking rains came in August, but the late spurt of growth failed to occur in the 2 years that summer rains did not come until September.

Carolina jessamine also formed new twigs after the August rains of 1964 and 1966, but, like yaupon, it did not respond to September rains in 1965 and 1968. Carolina jessamine always formed some new growth during the summer, even when rainfall was light. Some twigs usually died back during late fall, but

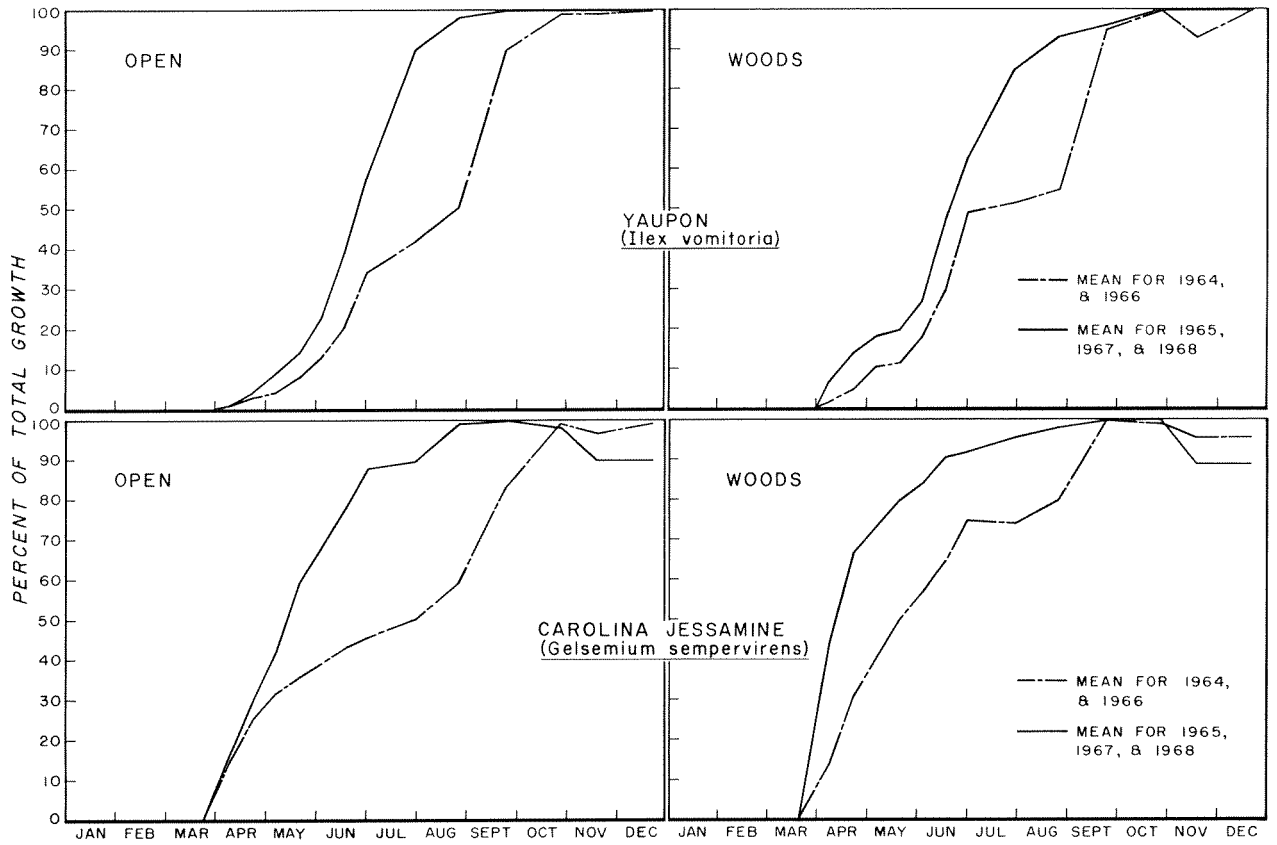

Figure 1.—*Browse plants that grew rapidly after summer rains.*

dieback was severe only in the extremely dry fall of 1967.

The secondary growth spurt of yaupon and Carolina jessamine increases their forage production potential during years when summer rainfall is above average. The intermittent and late-season growth shown by these species has also been noted for certain species of forest trees (Kozlowski 1963, 1964).

Rapid Spring Growers

The species making most rapid growth in early spring were brook euonymus, the greenbriers, rusty blackhaw, and red mulberry (fig. 2). They had one major spurt of growth that was usually 80 to 90 percent complete by April or early May. This relatively high proportion of the total annual growth was formed slightly earlier in the spring on plants in the woods than on those in the open.

The spring growth pattern of common greenbrier was consistent among years. Over 90 percent of growth occurred by May 1 for plants in the woods and by May 20 for plants in the open. Small variations in summer growth were unrelated to rainfall. During 1964 and 1967 the years of lowest rainfall, twig dieback occurred for plants in the open.

Saw greenbrier growth in the woods was usually 95 percent complete by May 5, but frequently some of the plants in the open would continue to form a few new twigs until October, regardless of the rainfall.

Brook euonymus completed over 95 percent of its growth by May 5, except in 1965 when the open-grown plants formed a few new twigs in late September. During the first few years of the study the euonymus plants in the open appeared to be vigorous and healthy, but by 1967 they had begun to deteriorate and several plants were dead by 1969. The species grows naturally in the shade along moist stream bottoms. Euonymus plants in the woods had a longer average twig length than those in the open and they appeared healthy throughout the study.

Rusty blackhaw growth was consistent between years for plants in the woods but in

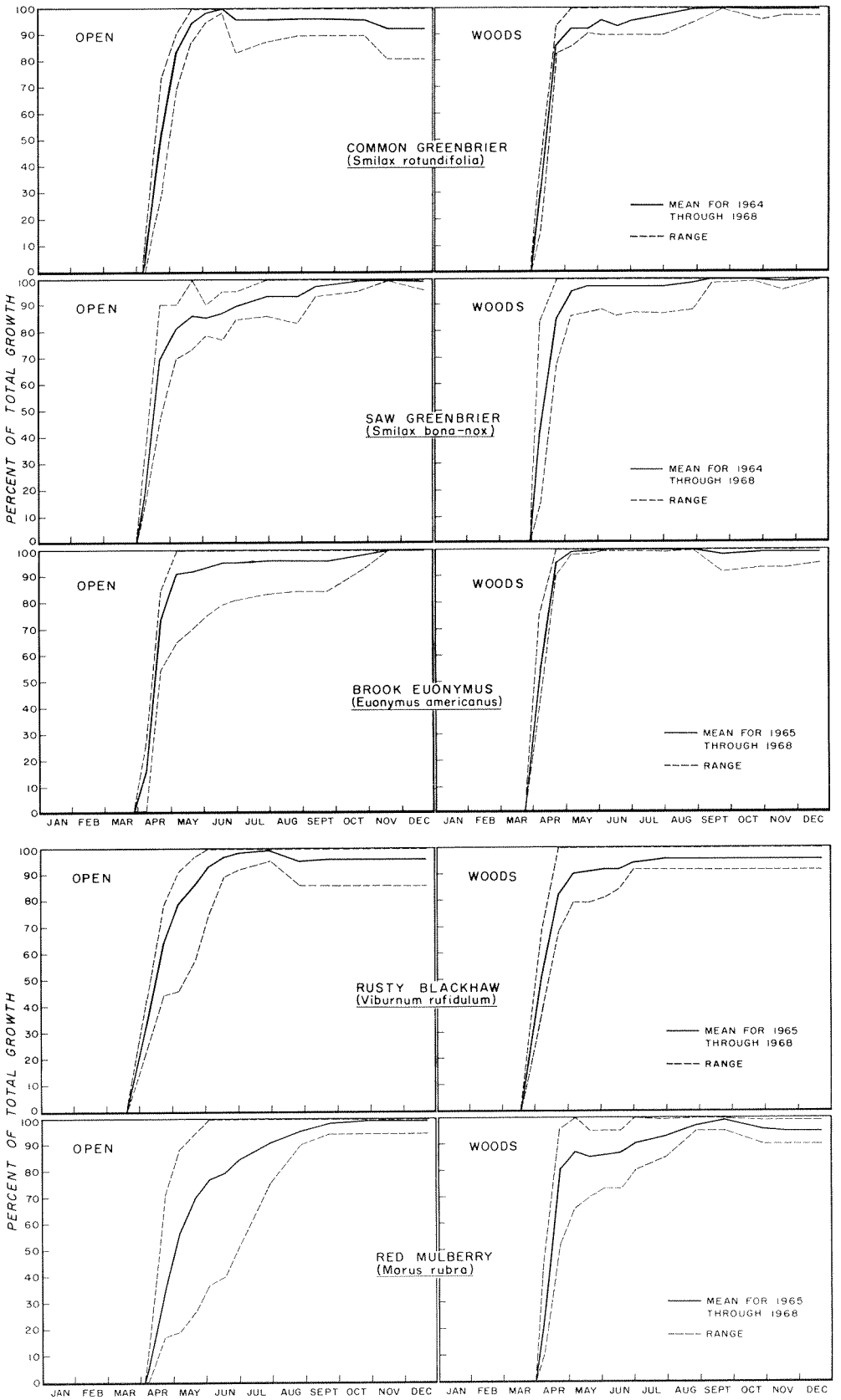

Figure 2.—*Browse plants that completed almost all growth in spring.*

1965 and 1967 the plants in the open accumulated about 25 percent of their total growth during June. This relatively rapid rate of growth was not associated with rainfall.

Red mulberry showed the most inconsistent spring growth pattern of any species in this group. Usually, however, 85 percent or more of the growth had accumulated by May 20. Main exceptions were for open-grown plants in 1965 when about 45 percent of total annual growth occurred in July and August, and for woods-grown plants in 1967 when about 25 percent of growth occurred in June and July even though rainfall was below average. Twig dieback, though of minor extent, was more frequent on plants in the woods than in the open.

In this group of species the shape of the growth curve appeared to be influenced more by internal genetic factors than by the environment, a phenomenon also noted by Kramer (1943) and Gilbert (1961). Because of the minimal amount of summer growth, the total forage production of these species is influenced little by summer rains. Too, since forage value is closely associated with growth (Short and Blair 1971), these species probably have high nutritive value for only a brief period each year.

Moderate Spring Growth Rate

Although similar in growth pattern to the previous group, sweetbay magnolia, Alabama supplejack, and muscadine grape tended to grow a little less rapidly in early spring, but continued to grow slightly later into the season (fig. 3).

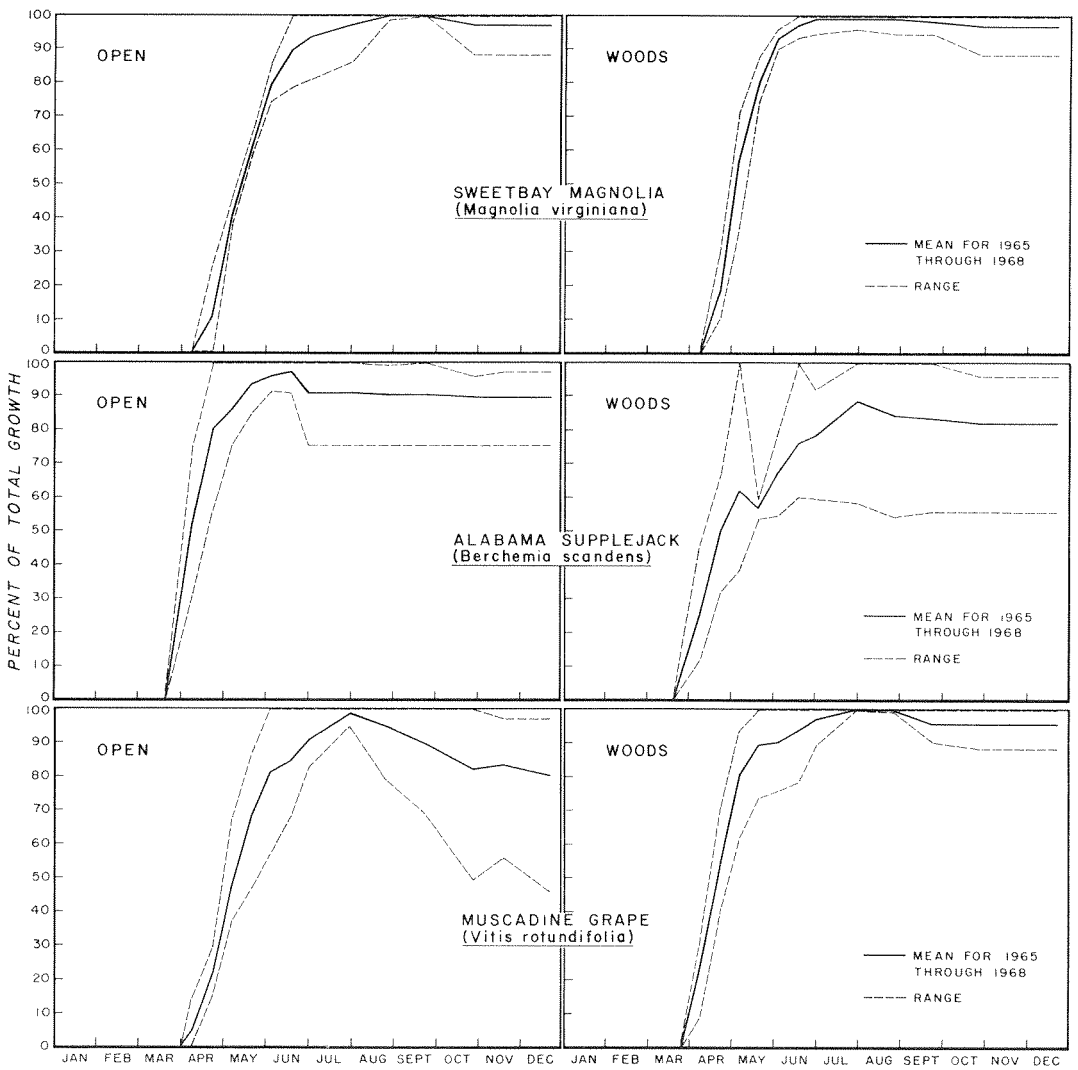

Figure 3.—*Browse plants that grew at moderate rate in spring.*

Sweetbay magnolia had the most consistent pattern among these three species. With the exception of open-grown plants in 1965, annual twig growth was more than 90 percent complete by June 30 on both sites.

Alabama supplejack growth varied considerably between years and sites. For example, in 1965 twig elongation in the woods was complete by May 6 but not in the open until fall. In 1967 maximum twig elongation occurred by May 8 for plants in the open but not until July 20 for plants in the woods. On the average, the major portion of annual growth occurred by June for plants in the open but not until July for plants in the woods. This is the only species where the relative growth rate of open-grown plants exceeded that for woods-grown plants in the spring.

The spring growth pattern of muscadine grape was fairly consistent among years. About 90 percent of the length had accumulated in the woods by May but not until July 1 in the open.

Occasionally, Alabama supplejack and muscadine grape twigs died back considerably, as previously noted by Halls and Alcaniz (1965). In some years this dieback constitutes a considerable loss of green forage.

Growth Rate Consistent To Early Summer

A group of species that showed a fairly constant rate of growth from early spring through June or July included flowering dogwood, swamp cyrilla, blackgum, and sassafras (fig. 4).

Growth patterns of dogwood were consistent between years and sites. Twig growth was only about 80 percent complete by July 1. Usually, plants continued to grow relatively slowly through July and August and occasionally to late September.

Swamp cyrilla had completed over 90 percent of its growth by July 1, except in 1964 and 1965 for plants growing in the open. Twig dieback was of consequence only in 1967 and was most severe for plants in the woods.

Sassafras grew at a constant rate to mid-June in the woods and to mid-August in the open. Twig dieback was rare, occurring in 1965 on one plant in the woods.

Blackgum growth usually continued through July but in some years the major portion had accumulated by June.

Growth patterns of these four species were noticeably influenced by rainfall only in 1967. During this very dry year summer growth of most plants was less than in other years. Thus, the total forage yields of these species are not likely to be greatly affected by summer rains except during extended droughts.

Dieback At An Early Age

American beautyberry growth patterns were similar to the above group of species, but in 1967 and 1968 severe dieback occurred on plants in the open (fig. 5). During the first few years in the field American beautyberry plants were very robust and produced an abundance of vegetative growth and fruit. In 1967 the dieback appeared to result from the severe drought, but dieback occurred again in 1968 even with an abundance of rainfall. Nearly all of the older stems were dead on most plants at the end of 1968, but on some plants new stems had sprouted from the base. There was no evidence of disease or insect damage.

American beautyberry plants in the woods were smaller than plants in the open, but those in the woods appeared healthy and did not suffer any twig dieback through 1968. The robust nature of open-grown American beautyberry plants up to 6 years of age confirms other observations that they grow best in the open (Halls and Oefinger 1969). However, the apparent longer life span of plants beneath the pines explains why beautyberry is less prevalent in the open.

Extreme Annual Dieback

The growth pattern for trumpetcreeper was erratic and distinct from other species because of the extreme dieback in late fall and winter (fig. 6). These plants usually continued to grow through the summer but the time of maximum elongation ranged from June to late October. Dieback of twigs began on many plants almost immediately after the twigs reached their maximum length. By winter most of the current season's growth was usually dead.

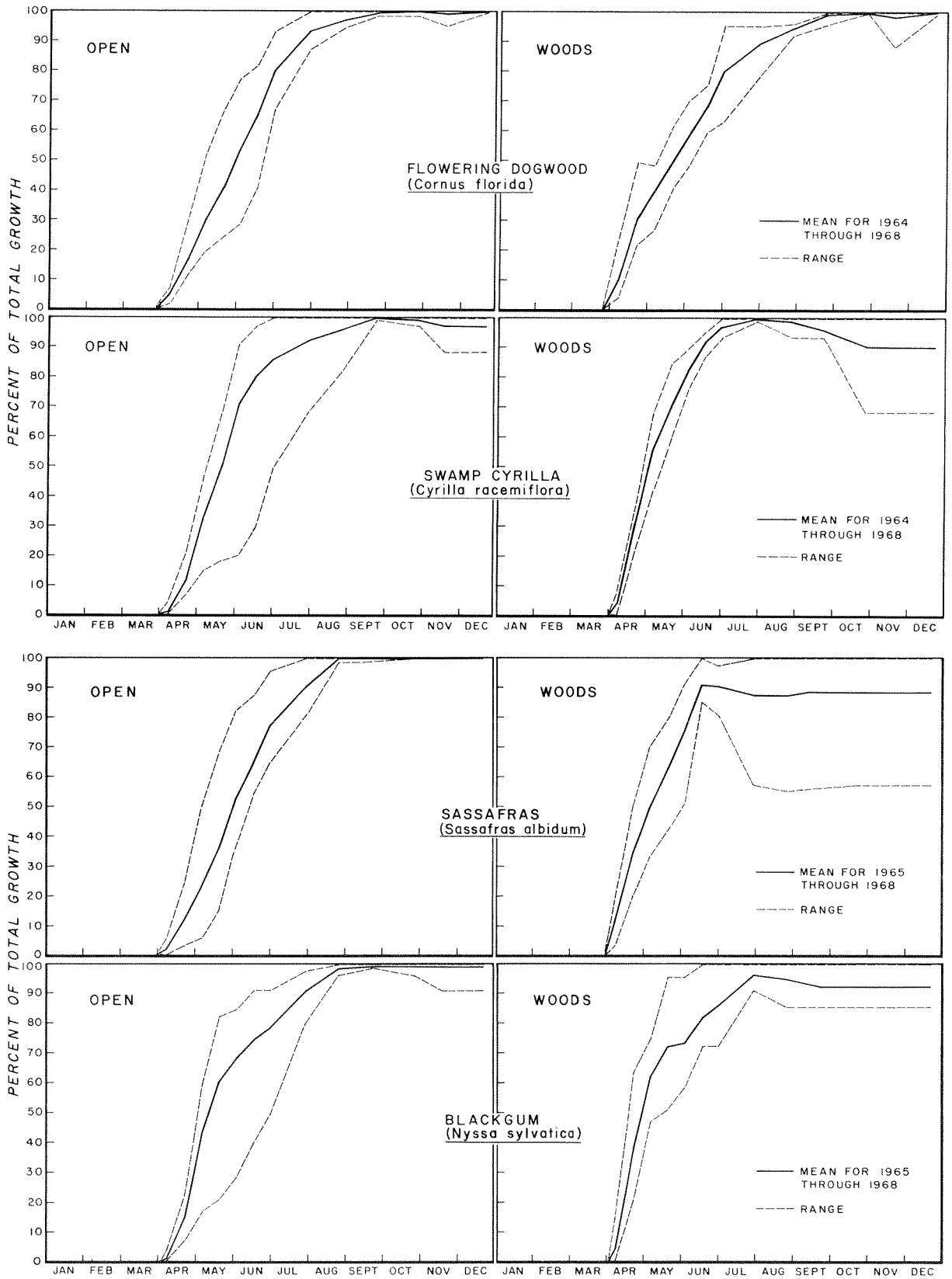

Figure 4.—*Browse plants that continued to grow until early summer.*

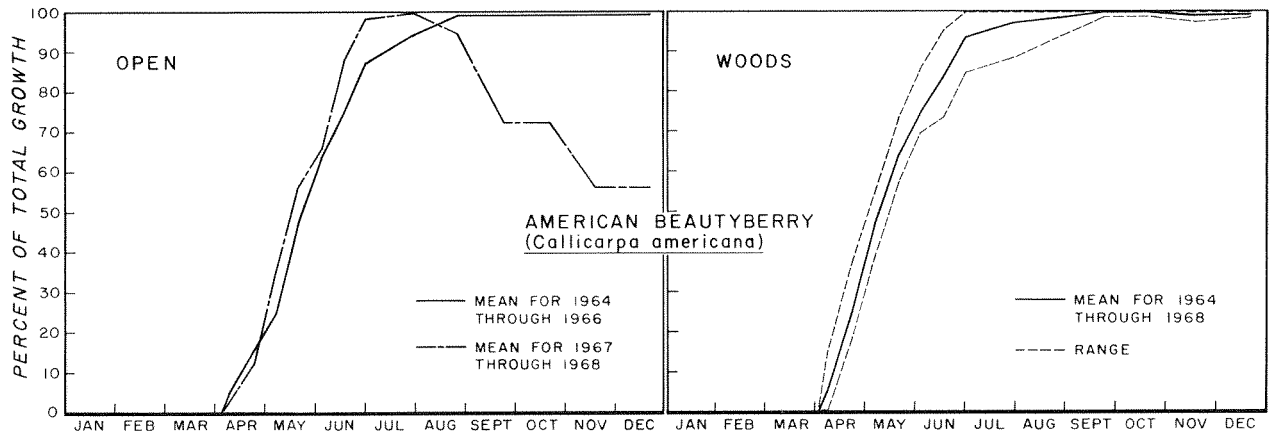

Figure 5.—*American beautyberry plants had severe dieback at early ages.*

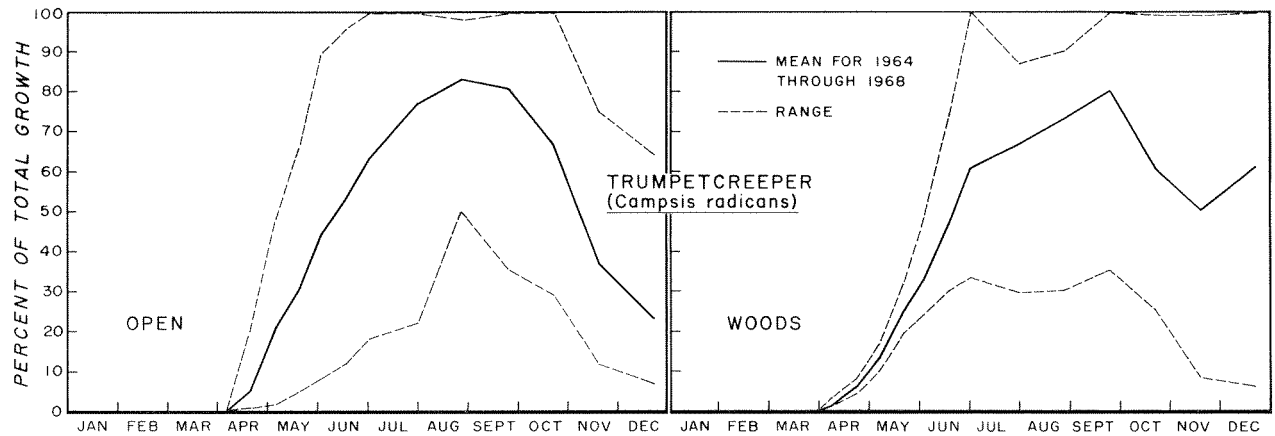

Figure 6.—*Trumpetcreeper stems died back in fall and winter.*

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Among plants of 16 browse species common in east Texas, the combination that would furnish succulent green forage earliest in spring and latest in fall includes yellow jessamine, Alabama supplejack, yaupon, rusty blackhaw, and flowering dogwood.