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Seasonal Distribution of Nutrients in Plants of Seven Browse Species in Louisiana

R. M. Blair
and
E. A. Epps, Jr.

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CONTENTS

Seasonal Distribution of Nutrients in Plants of Seven Browse Species in Louisiana

R. M. Blair [1] and E. A. Epps, Jr. [2]

Loblolly-shortleaf pine-hardwood forests provide much of the upland range for white-tailed deer in the South. The understory of this plant community consists primarily of browse growing in association with varying amounts of grasses and forbs. Deer depend upon these ranges for year-round sustenance. To remain healthy and productive, they must obtain an adequate supply of essential nutrients from the native forage or from seasonal supplements provided by man.

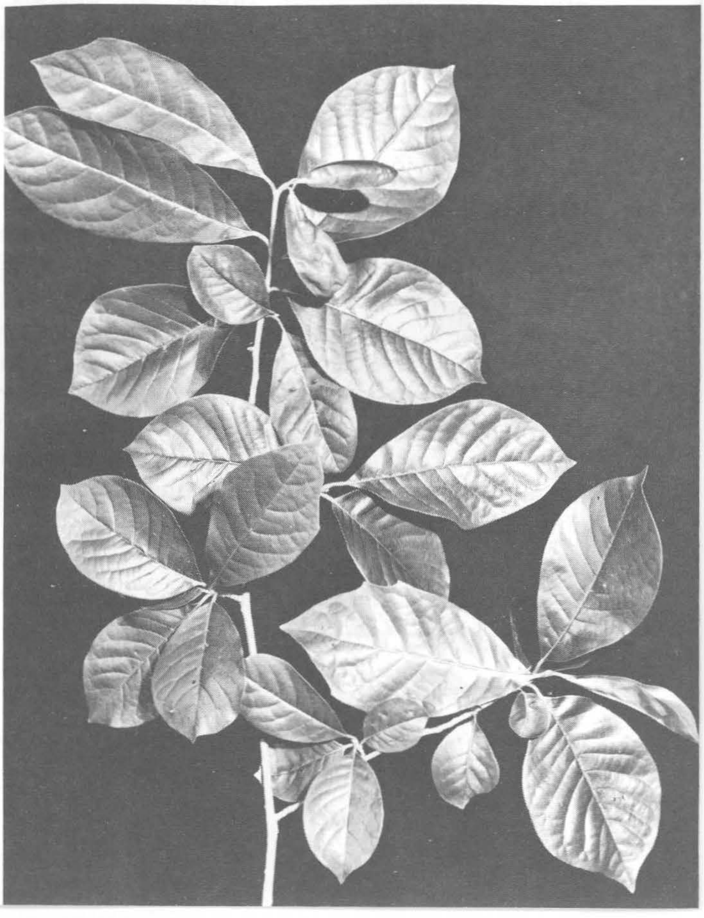
Since browse plants are abundant and a significant source of food throughout the year, information on their nutritive content can be very helpful to a deer-management program. This paper reports the results of chemical analyses of two different fractions of current stem tissues and the excised leaves at four seasons for seven common browse species—American beautyberry (*Callicarpa americana* L.), blackgum (*Nyssa sylvatica* Marsh.), sweetgum (*Liquidambar styraciflua* L.), common greenbrier (*Smilax rotundifolia* L.), common sweetleaf (*Symplocos tinctoria* (L.) L'Hér.), loblolly pine (*Pinus taeda* L.), and yellow jessamine (*Gelsemium sempervirens* (L.) Ait. f.). The data presented are not intended as a direct determinant of food value but as indicators of the relative forage quality of the species. Firm conclusions about nutritive value must await digestion trials with animals.

Nutrient composition of plants is influenced by many environmental and physiological factors, such as soil, site, climate,

[1] Blair is Associate Ecologist at the 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.

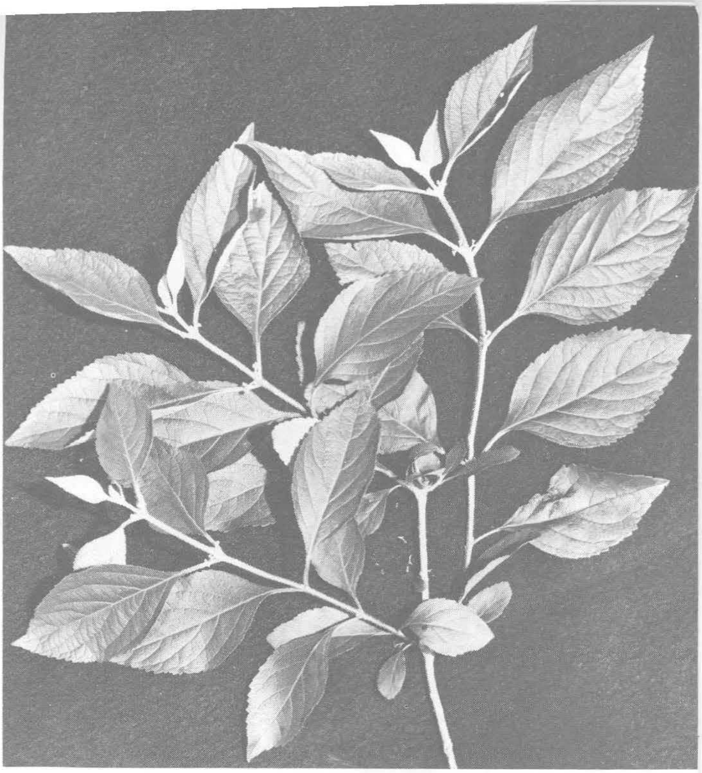
[2] Epps is Chief Chemist for the Feed and Fertilizer Laboratory, Louisiana Agricultural Experiment Station, located at Louisiana State University, Baton Rouge.

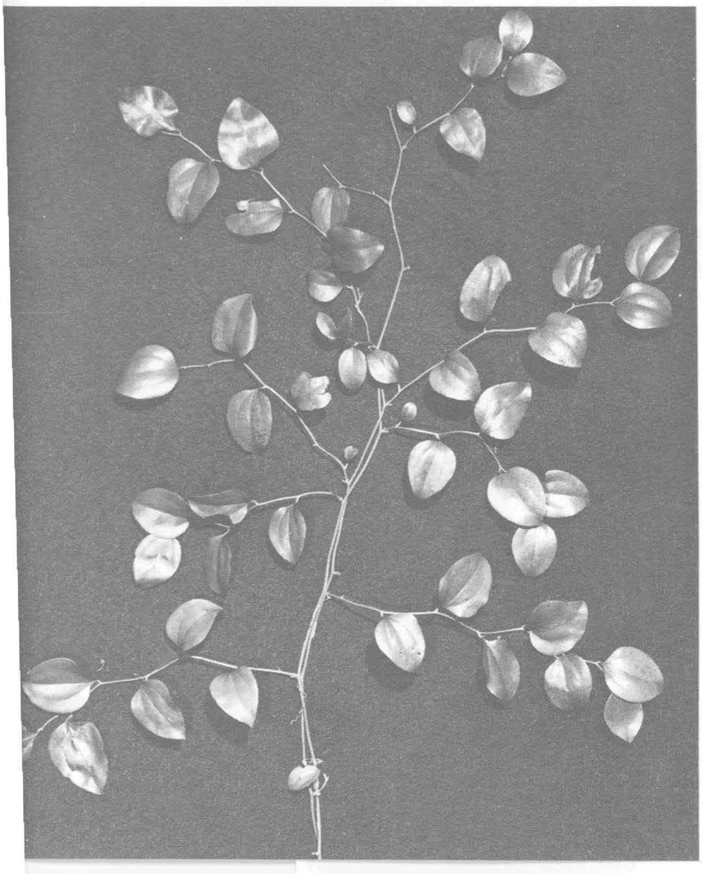
Sweetgum is a deciduous and shade-tolerant tree of high commercial value. Though seedlings and saplings produce an abundance of browse, they are seldom eaten by deer.



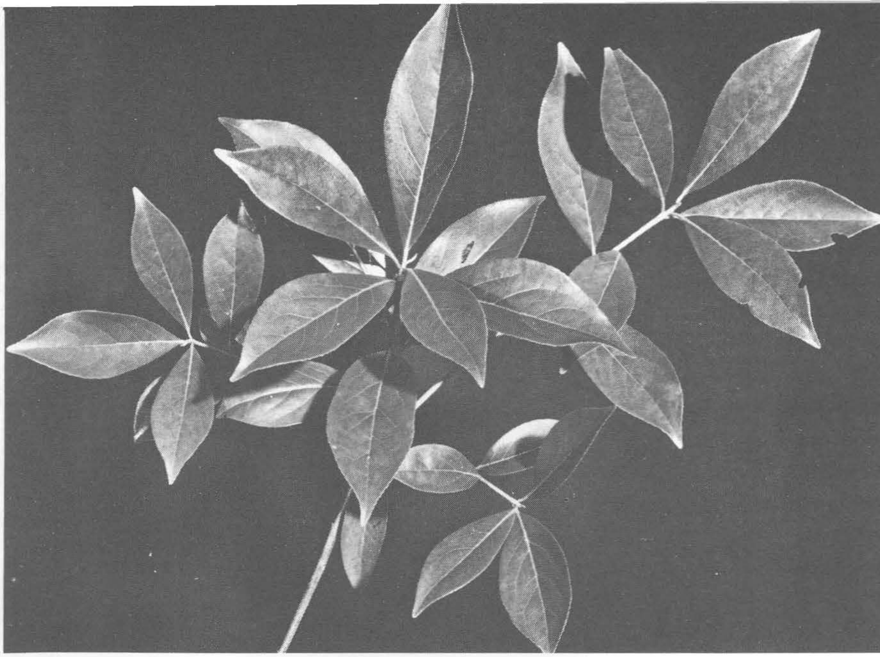
Blackgum, a deciduous and commercially valuable tree, is relatively common in pine-hardwood forests. Leaves and current twigs of seedlings and saplings provide good deer forage.

American beautyberry, a low-growing, deciduous shrub, is abundant in pine-hardwood stands which have a relatively high canopy. It often dominates the low cover in a forest opening. It is thought to be given medium to low preference by deer.



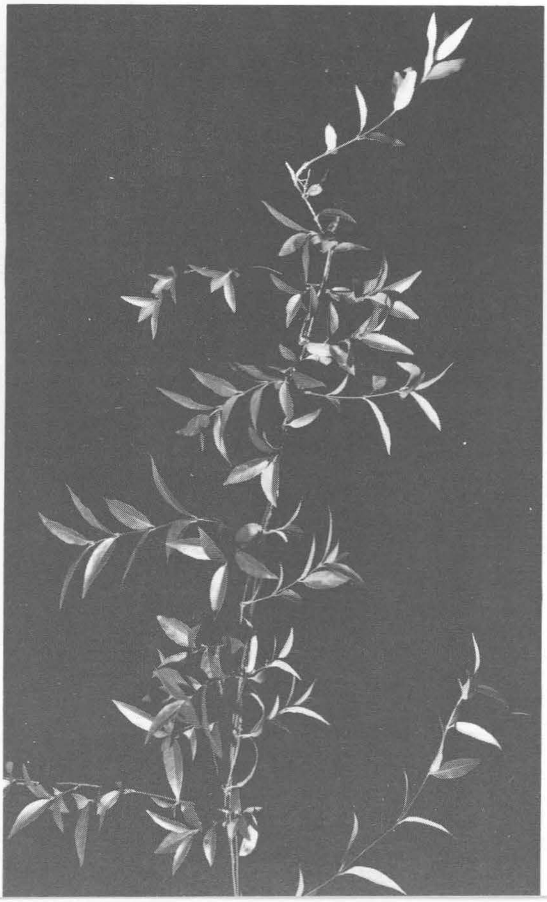


Common greenbrier, a deciduous and shade-tolerant woody vine, abounds in the understory, generally growing into the crowns of low shrubs. The leaves and tender leaders are highly preferred by deer.



Common sweetleaf or horsesugar is an evergreen shrub or small tree common on moist sites with north and east exposures. Leaves and current twigs are highly preferred by deer.

Yellow jessamine, an evergreen woody vine, often blankets the low ground cover, especially in forest openings. Growth occurs even during warm periods in winter. Leaves and current leaders provide highly preferred deer forage year long.



and stage of tissue maturation. Perhaps the most significant variations are associated with tissue maturation and the distribution of nutrients among plant parts. In the present study, such variations were determined during 2 consecutive years, 1960 and 1961. General trends and striking differences between seasons and plant parts are presented in the text. Specific chemical contents of plant fractions, averaged by season for the 2 years, are presented in seven detailed tables at the end of the paper.

Study Area

A 130-acre timbered tract supporting loblolly and shortleaf pines (*P. echinata* Mill.) mixed with hardwoods was selected for study. The area is on an upland site in central Louisiana, 6 miles south of Winnfield on the Kisatchie National Forest.

The terrain is extensively dissected and well drained. It is typical of the Upper Coastal Plain. Elevation ranges from about 140 feet to 225 feet above sea level. Roughly two-thirds of the area consists of gentle undulating terrain; steep slopes and narrow bottoms comprise the remainder.

Soils are heterogeneous.[3] Two closely associated types, Susquehanna and Sawyer very fine sandy loams, are predominant on the ridges and long gentle slopes. Both are acid in reaction and generally low in organic matter and plant nutrients. They are characterized by thinly developed surface soils with slowly permeable subsoils of mottled red, gray, and yellow plastic clay.

Erosion has exposed the heavy clay subsoil on steep slopes. Surface soil from the uplands erodes during periods of heavy rainfall and accumulates in narrow bands along drainage courses.

Prevailing southerly winds during spring and summer provide warm, moist weather, which is interspersed with drier and hotter periods (*10*). Winters are generally mild. The average monthly temperature is 50° F. in January and 83° in July.

The number of days between the last frost in spring and the first in autumn averages 235. The last spring frost was on March 18 in 1960 and on April 16 in 1961.

Growth of most native woody plants is fastest between mid-March and the end of May. Twig growth slows or ceases in early summer, although minor additional growth may occur on some species, especially after summer and early fall rains that break droughts. Long droughts are infrequent. Some broad-leaved evergreens

[3]The soils on the area were surveyed and mapped by Alexander Kerr, Jr., Soil Scientist, USDA Soil Conservation Service, in cooperation with the Dugdemona Soil Conservation District of Louisiana.

grow sporadically during intermittent warm periods throughout the winter.

Forty-seven inches of rain fell in 1960, and 75 inches in 1961; 57 inches is normal. In both years, rainfall was considerably below normal during April and May, the period of maximum growth. A drought extended from early May to late June in 1960. In 1961 heavy rains occurred in February and March and again during the summer.

Timber stands on the study area are uneven-aged. Sawtimber-sized loblolly and shortleaf pines dominate the overstory, and pines and hardwoods make up a multilayered and relatively dense midstory. The common hardwoods are white oak (*Quercus alba* L.), southern red oak (*Q. falcata* Michx.), sweetgum, blackgum, American beech (*Fagus grandifolia* Ehrh.), hickories (*Carya* spp.), red maple (*Acer rubrum* L.), and American holly (*Ilex opaca* Ait.).

Predominant shrubs and woody vines in the understory are American beautyberry, yellow jessamine, common greenbrier, saw greenbrier (*Smilax bona-nox* L.), common sweetleaf, possumhaw (*Ilex decidua* Walt.), common witch-hazel (*Hamamelis virginiana* L.), haws (*Crataegus* spp.), flowering dogwood (*Cornus florida* L.), huckleberries (*Vaccinium* spp.), and arrow-wood viburnum (*Viburnum dentatum* L.).

Fire was excluded from the area for a minimum of 10 years prior to the study. Cattle grazing was negligible and deer browsing was light and sporadic.

PROCEDURE

Collection of Samples

Four deciduous browse species—American beautyberry, blackgum, sweetgum, and common greenbrier—and three evergreen species—common sweetleaf, loblolly pine, and yellow jessamine—were selected for study. Current leaf and twig tissues of American beautyberry, blackgum, common greenbrier, common sweetleaf, and yellow jessamine are considered palatable to deer. Those of sweetgum and loblolly pine are regarded as unpalatable, though they are often ingested on over-used ranges.

The study area was divided into five 26-acre compartments. Samples of current growth were collected from plants selected at random within individual compartments. Only material up to 5 feet above ground (the deer feeding zone) was sampled. It was usually necessary to composite tissue from several proximate plants of an individual species to obtain a sufficiently large sample for chemical analyses.

Material was collected only once from any plant; new plants were selected at each sampling date. Current growth was taken from throughout the crown of each plant. Pine samples were taken only from plants less than 2 feet in height. From January 1960 to October 1961, plant tissues were collected near the middles of January, April, July, and October, the approximate midpoints of the four seasons. The exact sampling time was determined by the stage of plant growth. In spring, parts were taken when new twigs were long enough to yield the desired tissue. Autumn collections were made immediately prior to leaf abscission on deciduous species.

Three portions of the current year's growth–twig tips, twig bases, and the leaves from these twig fractions–were collected for chemical analyses. On shrubs and trees, twig tips were defined as the terminal 2 inches of stems, and twig bases as the next proximal 4 inches of growth. For vines, the distal 12-inch portion was segmented into 4- and 8-inch fractions.

Only stems ½ inch or more in length were sampled. When current shoots were shorter than 6 inches on shrubs and young trees, or 12 inches on vines, the tip fraction was selected first. The remainder, if any, constituted the basal fraction.

Each sample was placed in an airtight plastic container immediately after collection and weighed at the end of the day to determine fresh or green weight. Containers were then opened and the material dried to a constant weight in a forced-draft oven at 65° F. and reweighed. Dried samples were stored in sealed containers for chemical determinations at the end of each collecting season.

Analyses

Chemical.–All plant fractions were analyzed for percents of crude protein, ether extract, crude fiber, nitrogen-free extract (by difference), ash, phosphorus, and calcium by the Feed and Fertilizer Laboratory, Louisiana Agricultural Experiment Station, Baton Rouge. Chemical contents were determined by standard Association of Official Agricultural Chemists procedures (*1*).

Dry matter is expressed as a percent of green weight, and all other constituents as percentages of ovendry weight. Concentrations of chemical constituents, when expressed on a dry-weight basis, represent relative amounts present in the dry-matter fraction, rather than actual quantities in living tissue. A change in the concentration of a constituent does not necessarily indicate that the living tissue gained or lost a specific amount. Rather, it indicates that the nutrient did not change in proportion to changes in the dry-matter content or to changes in other chemical constituents. Such interactions are meaningful, as they show that chemical assays, expressed on a dry-weight basis, do not accurately depict physiological activities within live plants (*6*). However, the value of dry-weight analysis as an indicator of forage quality is not lessened.

Statistical.—Analyses of variance were performed for differences in protein, ether extract, calcium, and phosphorus between plant fractions, seasons, and years for individual species. Other chemical constituents were not tested statistically. A factorial design with a mixed model was used to develop expected mean squares for testing the main effects and their interactions. Year and compartment were considered random, while season and plant part were fixed. Precise delineation of interspecific differences was not an objective of the study, and such differences were not tested.

All differences were statistically analyzed at the 5-percent level of probability. The effects of season x plant-part interactions were analyzed by Duncan's Multiple F test (*9*), incorporating Harter's table of critical values (*14*). Only the concentrations of protein and crude fat in sweetgum and calcium in greenbrier differed significantly between years. These differences were attributed primarily to variations in the stage of plant growth at the time of sampling. Hence, the levels of specific nutrients for individual plant fractions and seasons were averaged for the 2 years.

RESULTS AND DISCUSSION

As in previous studies (*3, 13*), notable changes in dry matter, protein, crude fiber, and phosphorus contents were associated with stages of plant growth, as indicated by season. Results of analyses and possible nutritional implications for deer are presented separately for each chemical constituent.

Dry Matter

The dry-matter content of plant tissue is closely associated with palatability and digestibility (*29*). While it may not be possible to say with certainty how digestibility varies seasonally, it is safe to say that older and coarser growth is less readily digested than newer, more succulent and tender spring growth (*2*). Some species, of course, are nonpalatable to deer regardless of their succulence.

In all species, leaves and stems were most succulent in spring, when plant growth was most rapid (fig. 1). Thereafter, the moisture content of all plant parts declined and tissues became more fibrous. Succulence remained low from summer until growth resumed the following spring. The greatest seasonal variation in dry-matter content occurred in the stem fractions.

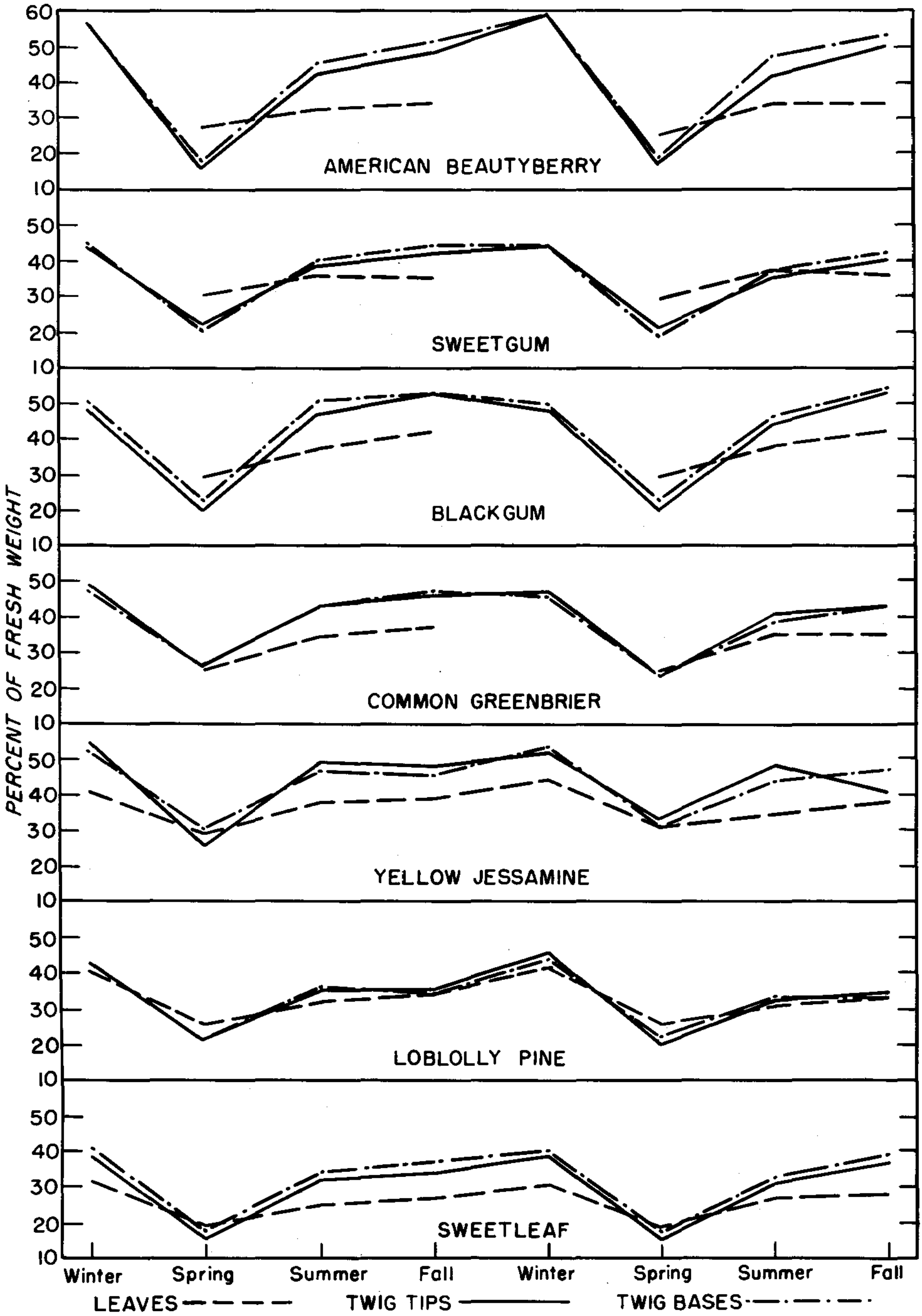


Figure 1.—*Seasonal dry-matter contents of plant parts, 1960-1961.*

Except in spring, leaves were more succulent than twigs; their dry-matter content never exceeded 44 percent. In deciduous species, leaves were generally least succulent just prior to abscission in autumn. Moisture content was lowest in evergreen leaves during the winter.

American beautyberry had the greatest seasonal range in dry-matter content of twigs—from 18 percent in spring to 58 percent in winter. In other species, dry-matter content of stems did not exceed 55 percent. As expected, twig moisture generally was lowest in winter, and most twig tips were slightly more succulent than basal tissues at all seasons.

Assuming a positive relationship between forage succulence and its palatability and digestibility, leaves and twigs of preferred species were most palatable and digestible in the spring. After tissue maturation, leaves were a better source of succulent forage than twigs. When the dry-matter content of twigs peaked in winter, the leaves of evergreen species were a prime source of relatively succulent tissue.

Protein

The protein content of leaves and twigs of all species, except pine, was highest in spring (fig. 2). At that time, plants were growing most rapidly, and nitrogen was concentrated in the physiologically active cells in leaves and in the meristematic tissues of stems. By midsummer, growth slowed or ceased, and protein content declined appreciably in all plant parts. Levels varied little after the summer, except in leaves of sweetleaf where protein declined to its lowest concentration from autumn to winter.

An abrupt decline in protein concurrent with plant maturation was also described by Taber (*30*) for the chaparral type of California. Others (*6, 7*) report a more gradual seasonal diminution of protein. Since plant phenology influences nutrient trends, differences in the rate of protein decline among species growing in various locales are probably attributable to variations in growth behavior. On southern ranges the growth of many woody species (*3, 13*) slows and ceases during a relatively short period in early summer, and dry-matter and fiber contents increase rapidly. Since protein content is inversely related to fiber content, it declines abruptly as tissues mature.

Seasonal trends in the protein level in young loblolly pine were not the same as those in other species. The protein content of needles was highest in spring, but it was higher in winter than in summer. Twig tips of pine contained the highest percentage of protein in winter, next highest in spring, and lowest in summer and

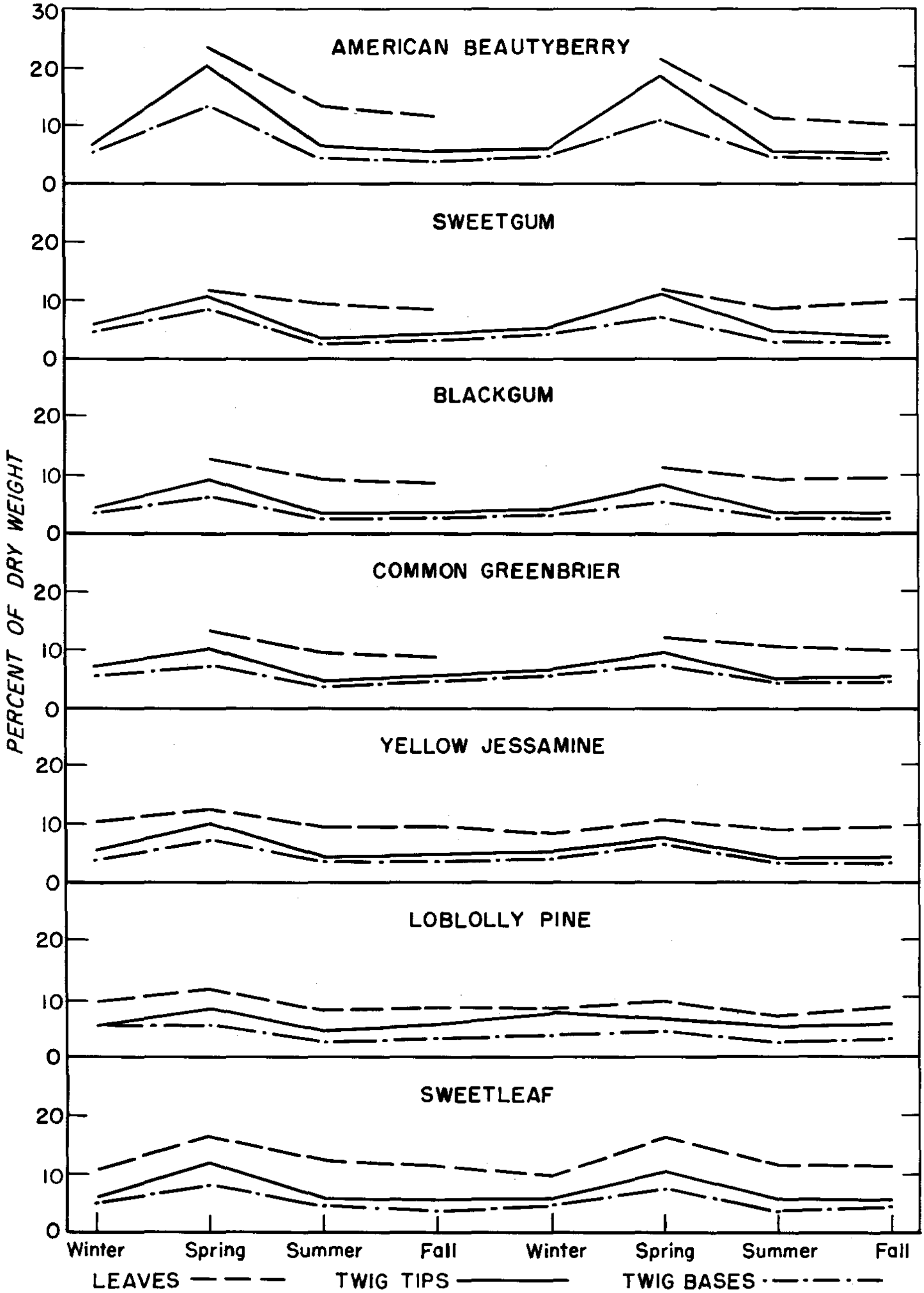


Figure 2.—*Seasonal protein contents of plant parts, 1960-1961.*

fall. There was little seasonal variation in the protein content of twig bases.

Leaves of all species usually contained more protein than twigs at all seasons in which leaves were present. Exceptions were leaves and twig tips of sweetgum, which contained similar protein levels in spring, and needles and twig tips of pine, which contained similar levels in winter. High protein content of leaves has been reported in previous studies (*3, 6, 16, 24*). Kramer and Kozlowski (*16*) attribute it to the high physiological activity of leaves. As leaves develop, nitrogen moves outward from the stems. In deciduous species this transmovement is partially reversed prior to leaf abscission, when a portion of the nitrogen moves back into stem tissues.

Since nitrogen is concentrated in active meristematic tissues, one would expect twig tips to contain more protein than the slightly older basal fractions during periods of rapid growth. Twig tips of all species contained significantly more protein than twig bases in spring. At other seasons there was usually little difference in the content between twig fractions. Exceptions were loblolly pine and sweetleaf, whose twig tips contained more protein than basal fractions at all seasons.

A browsing or grazing animal requires specific quantities of nutrients to maintain body processes and normal muscular activity without weight loss (*11, 28*). The body must be supplied with protein for building and repairing tissue, fats and carbohydrates for producing heat and energy, and minerals, especially calcium and phosphorus, for building bone and carrying on numerous body functions. Only after this maintenance requirement is met can growth and fattening take place. Since the nutrient requirements of deer on southern ranges have not been determined, they must be extrapolated from research findings elsewhere. Nutrient needs obviously vary according to the physiological demands of individual animals and their digestive efficiency at different seasons.

The protein requirement for optimal growth of young deer appears to be about 13 to 16 percent of the daily dry-matter intake (*11, 20*). About 7 percent is needed for maintenance. Feeding trials (*19*) have indicated that mature bucks require less protein, calcium, and phosphorus for body growth and antler development than young, vigorously growing deer.

Among the three plant parts and seven species studied, only leaves and twig tips of American beautyberry and leaves of greenbrier and sweetleaf contained the 13 percent protein required for growth, and then only in spring. Leaf tissue contained maintenance levels of protein in all seasons in which leaves were present. Twig tips of most species contained sufficient protein for maintenance only in spring.

Twig bases were a poor source of protein. Those of American beautyberry, sweetgum, greenbrier, sweetleaf, and yellow jessamine exceeded the maintenance level in spring; those of blackgum and pine were always below it.

Low protein contents of twigs, even during spring, have previously been reported both in the South (*3, 5, 17, 18*) and elsewhere (*6, 7, 15, 26, 27*). Since leaves are the best source of protein, the broad-leaved evergreens are particularly important during winter, when quality of other forage is low. Deer undoubtedly feed on other plants higher in protein than the ones studied, such as herbaceous legumes, and thereby compensate for the low levels in many browse species.

Ether Extract

Seasonal trends in ether extract or crude fat were erratic (fig. 3). Except in pine, plant tissues, especially twigs, were relatively low in fat content. A sizable proportion of the ether extractable material in pine tissues undoubtedly consisted of resins and oils.

Ether extract in leaf tissues of most species tended to increase slowly with seasonal progression. Consequently, leaves of deciduous species, except sweetgum, contained significantly more fat in autumn, and leaves of evergreen species contained more in autumn and winter, than in the spring. The percentage of fat in sweetgum leaves varied little over the year.

Seasonal changes in crude-fat contents of twigs of deciduous species were small. Twig tips of the evergreen yellow jessamine had the highest fat levels in spring, while twigs of young pine contained the most fat in winter. Other seasonal variations in evergreens were minor.

Leaves of all species except sweetgum, blackgum, and loblolly pine usually contained considerably more crude fat than did twigs. Twigs and leaves of sweetgum had similar fat contents in all seasons, and blackgum leaves contained more than twigs only in the fall. Twig tips of pine frequently contained as much or more ether extract than needles or twig bases.

The terminal and basal segments of twigs from other species generally contained similar percentages of crude fat throughout the year.

Crude fat is an important energy source for deer. While a precise dietary requirement has not been determined, the animals seldom appear to lack this constituent in their diet. Leaves tended to be a

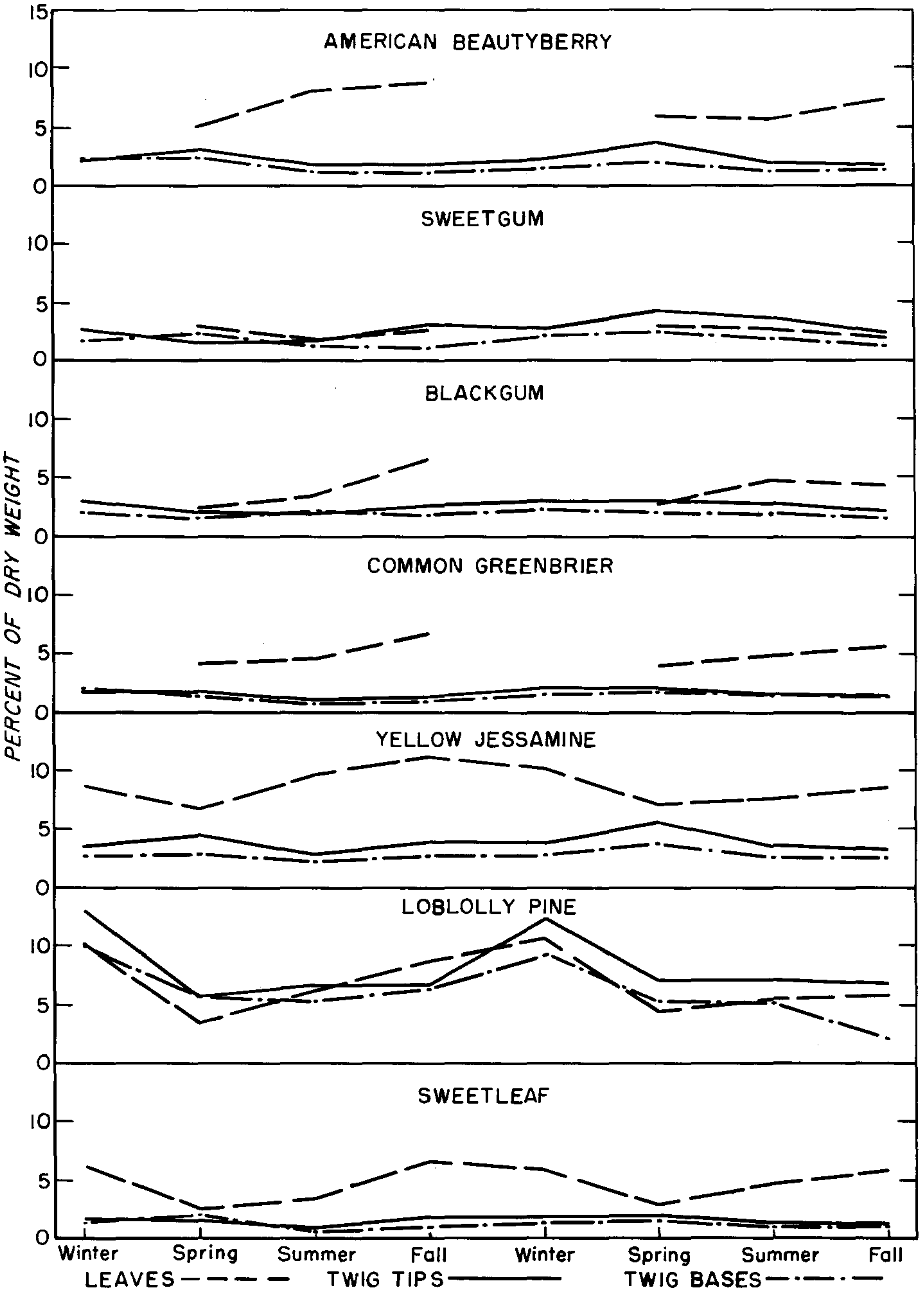


Figure 3.–*Seasonal ether-extract contents of plant parts, 1960-1961.*

better source of crude fat than twigs, especially in summer and autumn, when deer are storing body fat. Similar findings were reported by Cook and Harris (*6*) for browse species in Utah.

Crude Fiber

Crude fiber was lowest in twigs during spring, when plants were succulent and growing vigorously (fig. 4). It increased substantially by midsummer after growth had virtually ceased and remained high the rest of the year.

Moderate declines in the percentage of crude fiber in twigs, after a summer or fall peak, can be attributed to variations in other chemical constituents of dry matter. In living twig tissues, crude fiber actually increased gradually from summer to winter. With crude fiber expressed as a percent of the dry matter, however, seasonal declines in mature tissues are common (*8, 15, 17, 27*).

The crude-fiber content of leaves changed little during the year.

Except in pine in the spring, leaves of all species were less fibrous than twigs. Twig tips were less fibrous than twig bases.

Since forages high in fiber are less digestible and, therefore, less nutritious than those lower in fiber (*23, 25, 32*), leaves were more nutritious than twigs, and twig tips were superior to twig bases. On southern ranges, the leaves of many broad-leaved evergreens are probably particularly valuable deer food in late fall and winter, since they appear to be relatively low in fiber and to provide a fair source of protein in comparison with twigs of either deciduous or evergreen species.

Nitrogen-Free Extract

Nitrogen-free extract (NFE) includes the readily digestible carbohydrates in plant tissue, as well as some indigestible lignin (*31*). Soluble carbohydrates are a readily available source of energy.

Seasonal trends in the NFE content of plant tissues were somewhat erratic (fig. 5). As growth matured, the percentage of NFE increased appreciably in leaves of American beautyberry and sweetleaf but only slightly, or not at all, in other species.

The NFE content of both twig fractions of sweetgum, blackgum, greenbrier, and pine was slightly higher in spring than at other seasons. In contrast, mature twigs of American beautyberry, yellow jessamine, and sweetleaf generally contained considerably more NFE than spring tissues.

Except for pine needles in spring, leaves usually contained a higher percentage of NFE than twigs. Twig tips generally had higher levels than twig bases.

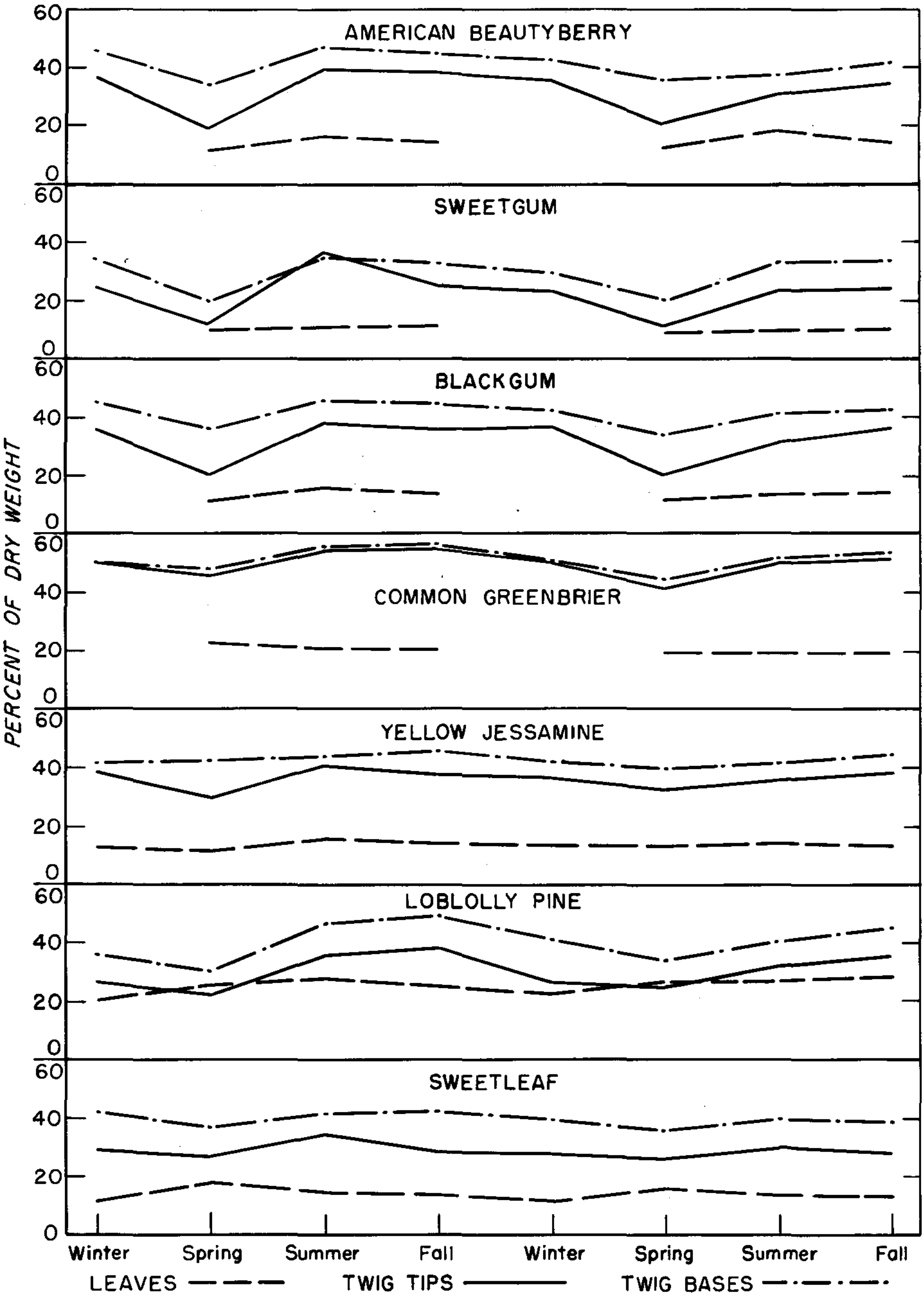


Figure 4.–*Seasonal crude-fiber contents of plant parts, 1960-1961.*

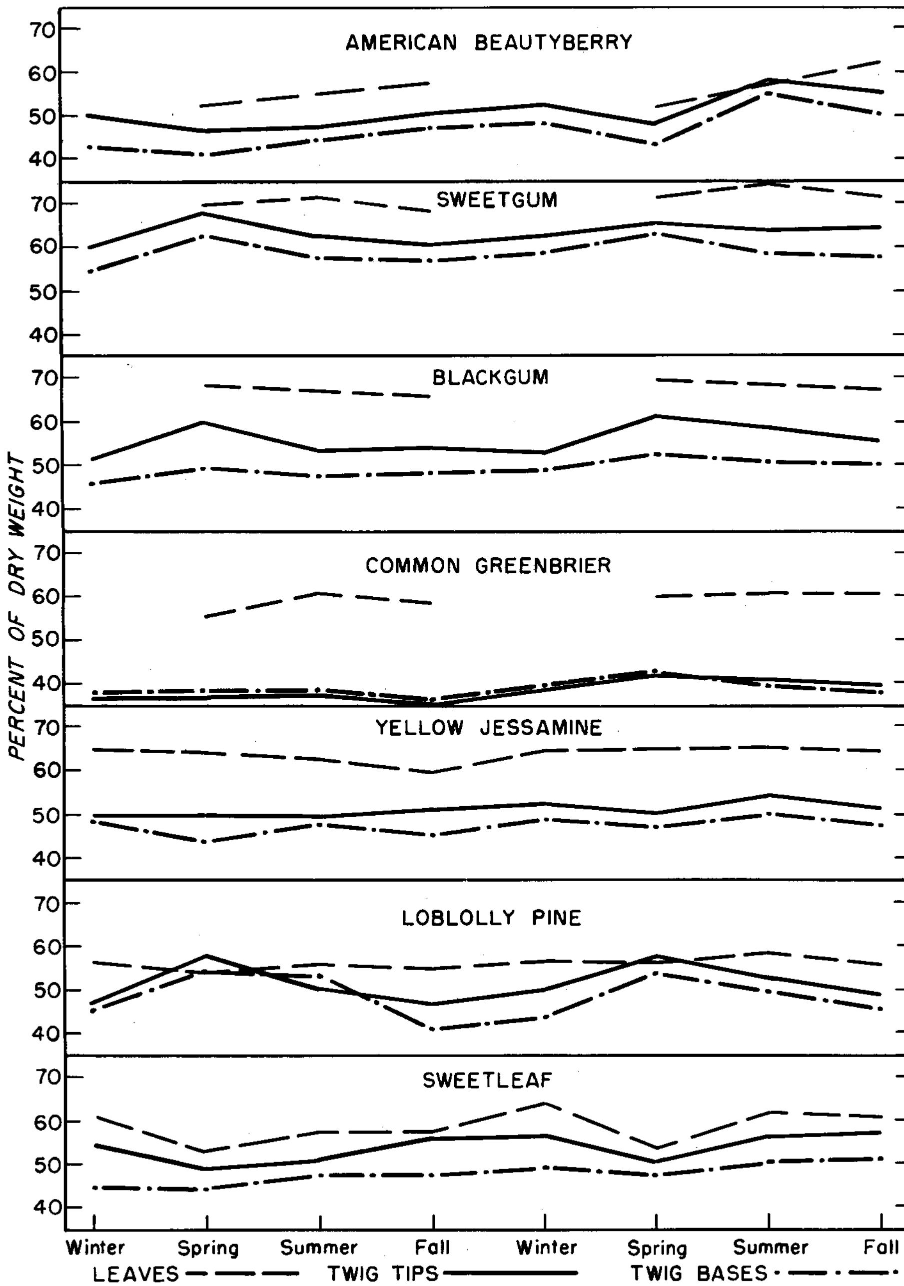


Figure 5.—*Seasonal nitrogen-free-extract contents of plant parts, 1960-1961.*

Twigs of deciduous and evergreen species provided comparable amounts of NFE during autumn and winter. Because of the presence of leaves, however, the broad-leaved evergreens were a better source of soluble carbohydrates in late fall and winter.

Ash

In leaves, mineral content varied erratically by species, season, and year (fig. 6). For example, in 1960 the ash content of American beautyberry leaves was lowest in the spring and highest in the fall, while in 1961 the opposite was true.

Trends in twig tissues were considerably more orderly. The percentage of ash in twigs of all species was highest in spring, and declined sharply as stems matured. Ash levels fluctuated little from summer to winter, except in sweetgum twigs, which contained the least in summer.

Leaves of American beautyberry, sweetgum, and blackgum contained less ash than twigs in the spring, but leaves contained more at other seasons. In the remaining species, leaves generally had as much, and usually more, mineral than twigs in all seasons. Twig tips seasonally contained more ash than twig bases.

High ash content of forages is very important to deer, especially in skeletal formation and for well-developed and hardened antlers on bucks (*8*). As tissues matured, leaves of all species but pine were generally a better source of minerals than twigs.

Calcium

The percentage of calcium in leaves of all species, except pine, increased significantly from spring to summer (fig. 7). In American beautyberry and yellow jessamine, this increase continued as the year progressed; in other species the content varied little following growth maturation. With growth extending well into summer for young loblolly pine, calcium in needles varied little from spring to autumn; the level did increase in late autumn or winter.

Calcium trends in twig tips were generally similar to those in leaves. In sweetgum, blackgum, yellow jessamine, and sweetleaf, the percentage of calcium increased as twigs matured, and levels tended to be highest in autumn and winter. Variations between seasons were small for American beautyberry, greenbrier, and pine. The only significant seasonal differences in percentage of calcium in twig bases were in the evergreen species, where fall and winter levels were generally higher than those of spring.

Differences in seasonal distribution of calcium among plant fractions varied considerably. Leaves of American beautyberry,

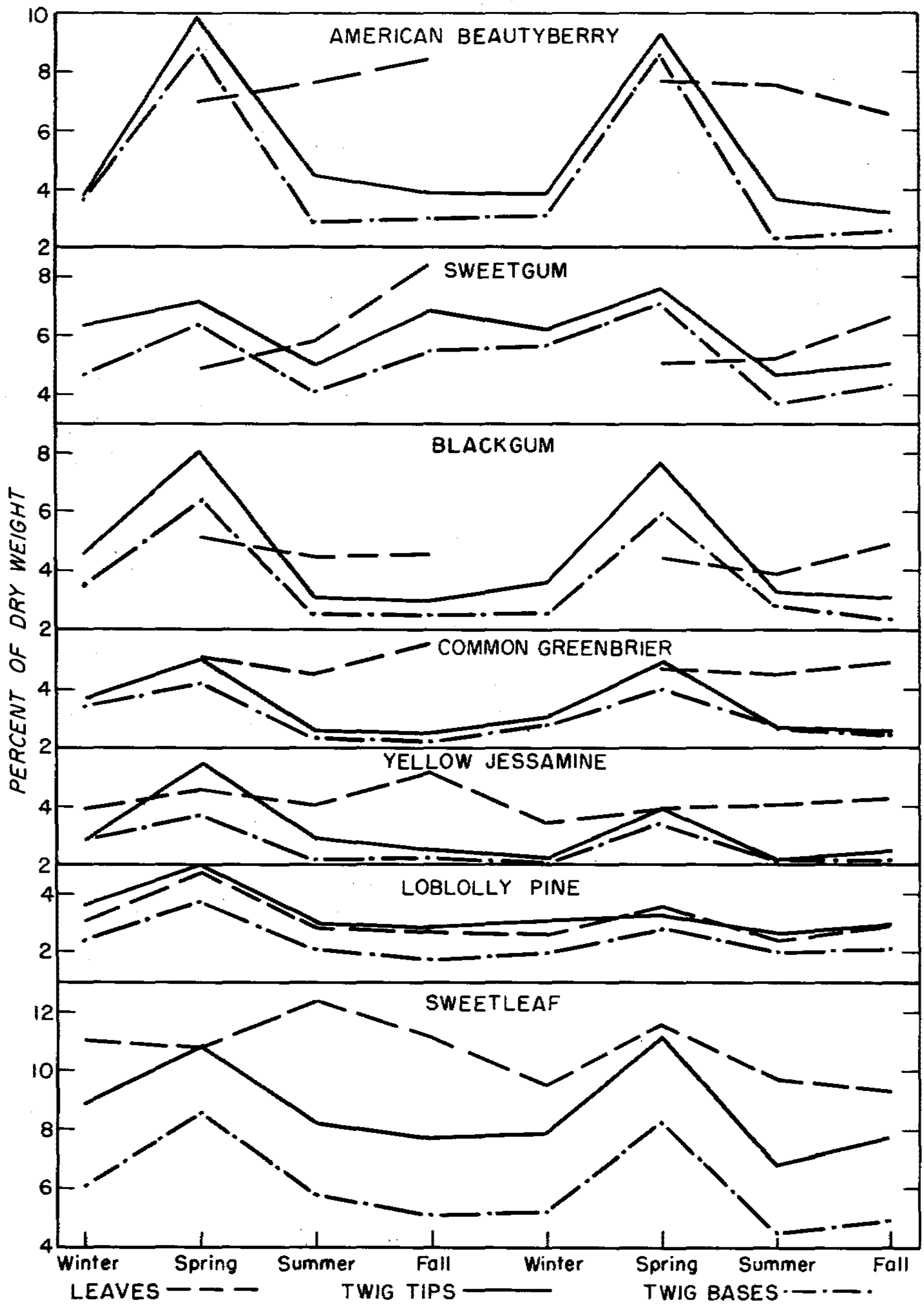


Figure 6.–*Seasonal ash contents of plant parts, 1960-1961.*

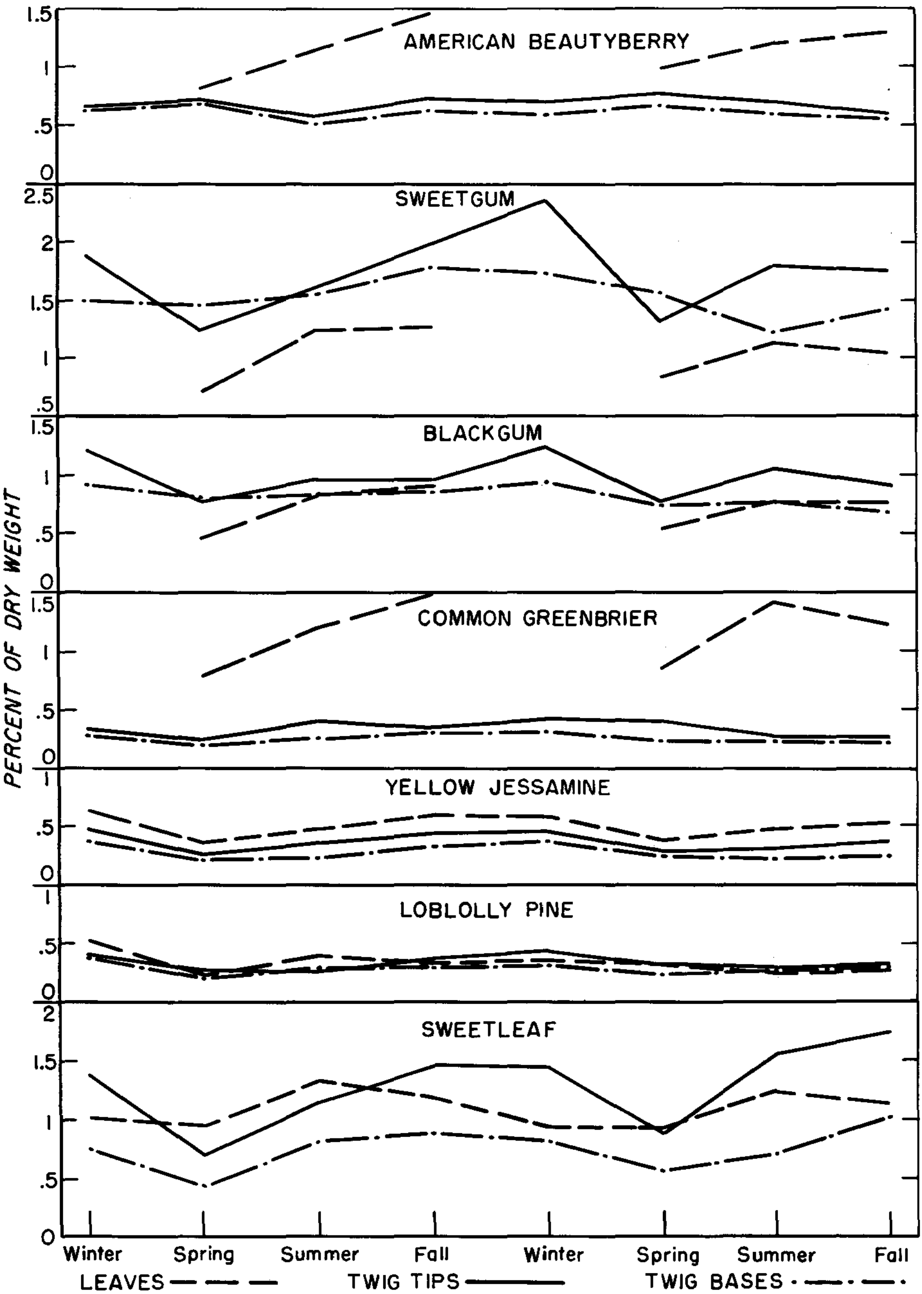


Figure 7.—*Seasonal calcium contents of plant parts, 1960-1961.*

greenbrier, and yellow jessamine contained more than twigs at all seasons in which leaves were present. Those of sweetgum, blackgum, and sweetleaf tended to contain less calcium than twigs, and especially twig tips. Seasonal levels differed little among the plant fractions of pine.

Twig tips of sweetgum, blackgum, yellow jessamine, and sweetleaf generally contained more calcium at all seasons than the slightly older and more fibrous twig bases. Levels did not vary by season between stem fractions of American beautyberry, greenbrier, or loblolly pine.

Calcium is required by deer for skeletal and antler development. Dietary requirements are not well known, but feeding trials (*20*) have indicated that the daily calcium requirement for optimum deer growth is about 0.64 percent of the ingested dry matter. About 0.25 to 0.30 percent appears to be the minimum for animal maintenance.

Southern range plants apparently are seldom deficient in calcium. Leaves and twigs, and especially twig tips, of American beautyberry, sweetgum, blackgum, and sweetleaf, as well as the leaves of greenbrier, generally provided sufficient calcium at all seasons for deer growth. Maintenance requirements were met in all seasons by yellow jessamine leaves. The twig tips of this species and those of greenbrier contained maintenance levels from summer to winter. All pine tissues and the twig bases of greenbrier and yellow jessamine were the poorest sources of dietary calcium; they generally provided maintenance levels only in autumn and winter.

Phosphorus

Seasonal trends in the phosphorus content of all species were similar and appeared to be closely associated with plant growth (*13*). High levels in spring dropped appreciably with the cessation of growth. Similar findings have previously been reported (*3*). Like protein, phosphorus tends to accumulate in actively growing tissues, with considerable transmovement from twigs into newly developing leaves. A portion of the phosphorus moves back into the twigs as leaf tissues become senescent (*16*).

The percentage of phosphorus was highest in the spring in all tissues of all species except pine, whose twig tips contained the most in the winter (fig. 8). With growth maturation, levels declined sharply, and the content generally varied little thereafter in leaves and stems of American beautyberry, sweetgum, and greenbrier, and in twigs of blackgum and yellow jessamine. In leaves of blackgum and yellow jessamine and in leaves and twigs of pine and sweetleaf, phosphorus content usually reached a low in midsummer, after which it increased significantly.

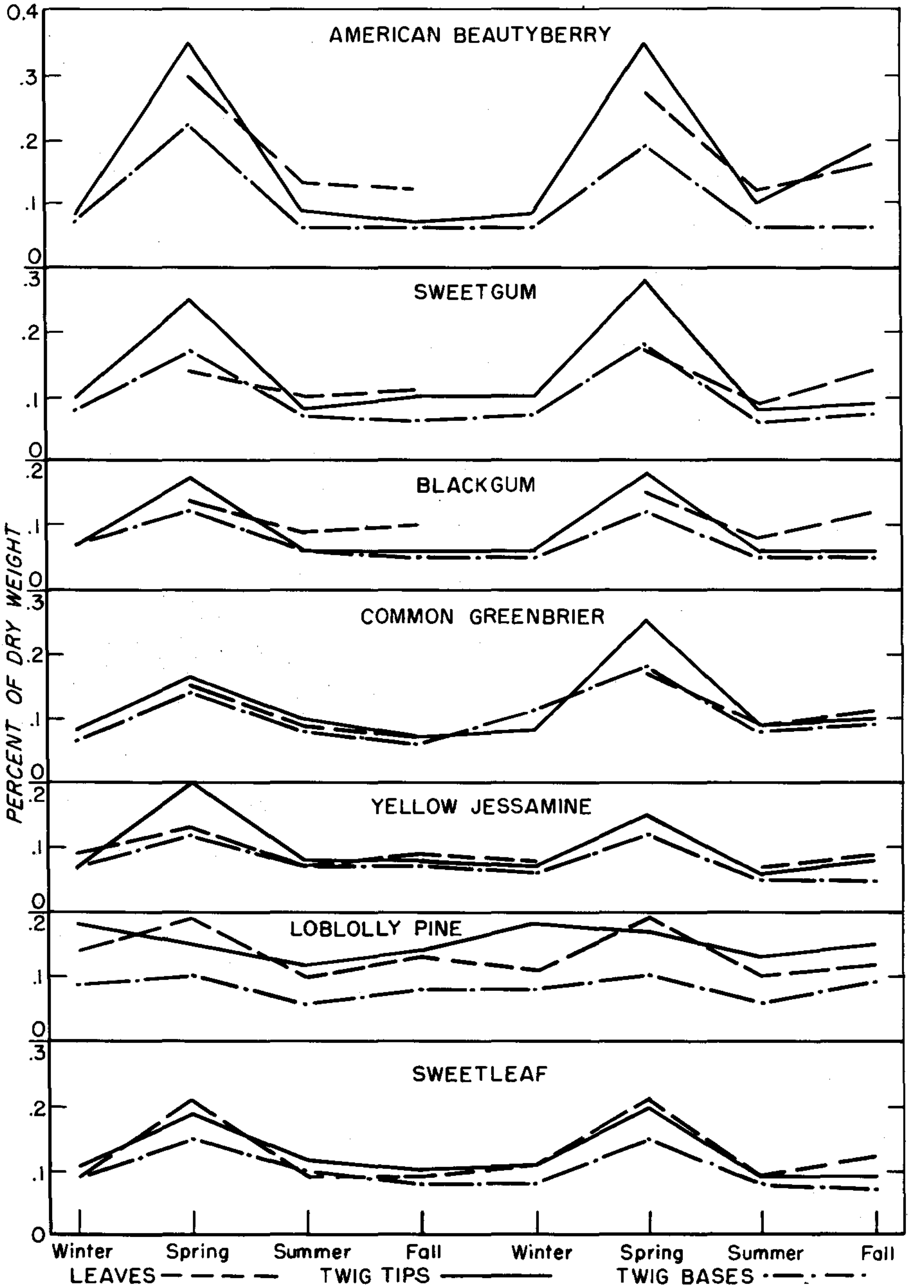


Figure 8.–*Seasonal phosphorus contents of plant parts, 1960-1961.*

In the spring, twig tips of most species provided more phosphorus than leaves, and leaves provided more than twig bases. With growth maturation, leaves generally contained about as much, and often more, phosphorus than twigs, especially twig bases.

Twig tips of evergreens were a better source of phosphorus than twig bases at all seasons, but in deciduous species, tips were superior to bases only in the spring.

Dietary phosphorus is extremely important to deer. It is essential for bone development, growth, reproduction, and lactation.

The dietary requirements for deer, while not precisely known, appear to be about 0.56 percent of the daily dry-matter intake for optimum growth, and about 0.25 to 0.30 percent for maintenance (*20*).

All species in the present study were low in phosphorus, which is characteristic of southern forages (*3, 4, 5, 12, 18*). Values of 0.56-percent phosphorus were never provided by either leaves or twigs. Only in spring did leaves and twig tips of American beautyberry and twig tips of sweetgum provide enough for deer maintenance.

Calcium-Phosphorus Ratio

Calcium and phosphorus utilization appear to be closely interrelated (*20*). A deficiency of one mineral seems to be better tolerated if the other is present in adequate amounts. Phosphorus, however, is assimilated at a reduced rate when it occurs in the presence of large amounts of calcium or vice versa (*2, 21, 27, 28, 29*). Hence, the ratio of calcium to phosphorus in feeds is significant. For livestock forage, the most desirable ratio is from 2:1 to 1:2.

Importance of the Ca:P ratio is reduced and efficiency of utilization of the elements is increased by the presence of sufficient vitamin D (*21*). A ratio higher than 2:1 can, therefore, be tolerated without ill effects. According to Mitchell and McClure (*22*), a ratio as high as 5.5:1 may be acceptable. Biswell *et al.* (*2*) concluded that the ratio probably never gets out of proportion for cattle exposed to abundant sunshine for vitamin D production.

In the present data the Ca:P ratios were generally lower in spring than at other seasons. In spring, ratios in leaves ranged from 1.3:1 for pine to 5.3:1 for greenbrier. In twig tips they varied from 1.4:1 in yellow jessamine to 5.0:1 in sweetgum. In basal twigs, the ratio ranged from 1.3:1 in greenbrier to 8.6:1 in sweetgum.

After tissue maturation, Ca:P ratios usually widened considerably and varied little seasonally from summer to winter. During this period, the most favorable ratio in leaves, 2.3:1, was in pine needles. The most unfavorable was in leaves of greenbrier in summer—15.7:1. Ratios in twigs ranged from 2.2:1 in summer tips of pine stems to 29.5:1 in stem bases of sweetgum.

Ca:P ratios in twig tips tended to be slightly more desirable than those in leaves at all seasons. Those of twig bases were generally the least desirable.

SUMMARY

Most changes in chemical makeup of the seven species were associated with tissue growth and maturation. In spring, leaves and twigs were most succulent, and their dry-matter fraction was highest in protein, ash, and phosphorus, and lowest in crude fiber. By midsummer, contents of moisture, protein, ash, and phosphorus had declined appreciably, while crude-fiber content increased. Tissues, especially twigs, remained fibrous, and nutrient levels usually varied little from summer through winter. The ether-extract content was low and fluctuated little seasonally. Nitrogen-free extract and calcium levels fluctuated sporadically and varied considerably by species. Calcium content tended to increase as tissues matured.

Over most of the year, leaf tissues were more succulent, higher in protein, crude fat, NFE, ash, calcium, and phosphorus, and considerably lower in crude fiber than twigs. The superior nutrient quality of leaves emphasizes the importance of broad-leaved evergreens on southern deer ranges. Leaves of these species are more nutritious than fibrous twigs in late fall and winter, when the quality of other forage is relatively low. Twig tips contained a higher percentage of nutrients than slightly older portions of stems.

Although the nutritional requirements of southern deer are unknown, it appeared that sufficient protein for animal maintenance, and in some instances for body growth, was present in leaves and twigs in spring. After tissues matured in early summer, only leaves contained protein levels believed necessary for deer maintenance. Calcium appeared to be adequate in most plant parts and species at all seasons. Phosphorus was generally deficient throughout the year.

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DETAILED TABLES

Table 1.—*Chemical composition of American beautyberry* (Callicarpa americana)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.	*Percent of ovendry weight*							*Ratio*
Spring	Leaves	25.9	22.4*[1] a[2]	5.5*[1] b[2]	12.4	52.4	7.4	0.90*[1] c[2]	0.28+[1] a[2]	3.2:1
	Twig tips	16.8	19.4+ a	3.3*,+ a	20.0	47.8	9.6	.74*,+ a	.35* a	2.1:1
	Twig bases	18.5	12.0# a	2.1+ a	34.6	42.6	8.6	.66+ a	.20# a	3.3:1
Summer	Leaves	32.6	12.1* b	6.8* a,b	17.2	56.2	7.6	1.15* b	.13* b	8.8:1
	Twig tips	41.8	6.4+ b	1.8+ a	35.0	52.6	4.1	.63+ a	.09+ b	7.0:1
	Twig bases	45.7	4.3# b	1.8+ a	42.0	50.0	2.6	.55+ a	.06# b	9.2:1
Fall	Leaves	34.0	10.8* b	7.9* a	14.2	59.7	7.4	1.37* a	.14* b	9.8:1
	Twig tips	49.2	5.4+ b	1.7+ a	36.4	53.0	3.6	.65+ a	.08+ b	8.1:1
	Twig bases	51.8	4.1+ b	1.2+ a	43.0	48.8	2.8	.58+ a	.06+ b	9.7:1
Winter	Leaves	...	...	...	...	...	...	...	...	...
	Twig tips	58.2	6.2*	2.2*	36.2	51.7	3.8	.67*	.08+	8.4:1
	Twig bases	57.9	4.9+	1.8*	44.3	45.6	3.4	.60*	.07*	8.6:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$). For example, in spring, summer, and fall, leaf tissues contained more protein than twigs.

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons. For example, leaves contained significantly more protein in spring than in summer and fall, but leaf protein levels in summer and fall did not differ significantly.

Table 2.–*Chemical composition of sweetgum* (Liquidambar styraciflua)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.	- - - - - - - -	- - - - - - - -	*Percent of*	*ovendry weight*	- - - - - - - -	- - - - - - - -	- - - - - - - -	*Ratio*
Spring	Leaves	29.8	11.8*[1] a[2]	3.0*[1] a[2]	9.8	70.6	5.0	0.78+[1] b[2]	0.16+[1] a[2]	4.9:1
	Twig tips	21.4	10.9* a	3.2* a	11.4	67.0	7.4	1.29* b	.26* a	5.0:1
	Twig bases	20.0	7.7+ a	2.4* a	20.1	63.0	6.8	1.51* a	.17+ a	8.9:1
Summer	Leaves	36.4	9.0* b	2.2* a	10.0	73.2	5.5	1.17+ a	.10* b	11.7:1
	Twig tips	36.6	4.1+ b	2.7* a	25.4	63.0	4.8	1.72* a	.08*,+ b	21.5:1
	Twig bases	38.2	2.7+ b	1.6* a	33.8	58.1	3.9	1.38+ a	.06+ b	23.0:1
Fall	Leaves	35.6	8.9* b	2.3* a	11.0	70.3	7.5	1.15# a	.12* b	9.6:1
	Twig tips	41.2	4.0+ b	2.7* a	24.9	62.5	6.0	1.87* a	.09*,+ b	20.8:1
	Twig bases	43.2	2.9+ b	1.2* a	33.4	57.4	5.0	1.59+ a	.07+ b	22.7:1
Winter	Leaves	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	Twig tips	43.8	5.5*	2.6* a	24.2	61.3	6.3	2.12*	.10*	21.2:1
	Twig bases	44.4	4.4*	1.9* a	32.0	56.5	5.2	1.61*	.08*	20.1:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$).

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons.

Table 3.–*Chemical composition of blackgum* (Nyssa sylvatica)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.	- - - - - - - -	- - - - - - - -	*Percent of*	*ovendry*	*weight*	- - - - - - - -	- - - - - - - -	*Ratio*
Spring	Leaves	29.2	11.9*[1] a[2]	2.6*[1] b[2]	11.7	69.0	4.8	0.51+[1] b[2]	0.15+[1] a[2]	3.4:1
	Twig tips	19.8	8.5+ a	2.6* a	20.4	60.6	7.8	.78* b	.18* a	4.3:1
	Twig bases	23.2	5.7# a	1.8* a	35.4	51.0	6.2	.78* a	.12# a	6.5:1
Summer	Leaves	37.4	9.2* b	3.8* a,b	14.6	67.9	4.2	.80+ a	.09* c	8.9:1
	Twig tips	45.6	3.4+ b	2.4* a	35.0	56.0	3.2	1.10* a	.06+ b	16.8:1
	Twig bases	48.2	2.6+ b	2.3* a	43.6	49.2	2.7	.81+ a	.06# b	13.5:1
Fall	Leaves	42.4	8.9* b	5.2* a	14.2	66.7	4.8	.83*,+ a	.11* b	7.5:1
	Twig tips	52.6	3.5+ b	2.3+ a	36.4	54.7	3.0	.94* a	.06+ b	15.7:1
	Twig bases	53.8	2.9+ b	2.2+ a	43.6	49.2	2.4	.77+ a	.05+ b	15.4:1
Winter	Leaves	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	Twig tips	48.2	4.2*	3.0*	36.6	52.2	4.1	1.23*	.07*	17.6:1
	Twig bases	49.3	3.3+	2.2*	44.0	47.5	3.0	.94+	.06*	15.7:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$).

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons.

Table 4.—*Chemical composition of common greenbrier* (Smilax rotundifolia)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.	*- - - - - - - - Percent of ovendry weight - - - - - - - -*							*Ratio*
Spring	Leaves	24.9	12.7*[1] a[2]	4.1*[1] b[2]	20.8	57.4	5.0	0.82*[1] b[2]	0.16*[1] a[2]	5.1:1
	Twig tips	25.0	9.8+ a	1.9+ a	43.6	39.6	5.0	.33+ a	.20* a	1.6:1
	Twig bases	25.0	7.5# a	1.6+ a	46.4	40.3	4.1	.22+ a	.16* a	1.4:1
Summer	Leaves	34.5	10.1* b	4.8* b	20.2	60.6	4.5	1.30* a	.09* b	14.4:1
	Twig tips	41.7	4.8+ b	1.4+ a	52.0	39.1	2.6	.26+ a	.09* b	2.9:1
	Twig bases	40.8	4.2+ b	1.2+ a	53.0	39.2	2.5	.32+ a	.08* b	4.0:1
Fall	Leaves	36.2	9.2* b	6.1* a	19.8	59.6	5.2	1.36* a	.09* b	15.1:1
	Twig tips	44.8	5.3+ b	1.3+ a	53.4	37.4	2.6	.30+ a	.08* b	3.8:1
	Twig bases	45.0	4.6+ b	1.2+ a	55.0	36.8	2.4	.27+ a	.07* b	3.8:1
Winter	Leaves	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	Twig tips	47.8	7.0*	1.9*	50.3	37.4	3.4	.38*	.08*	4.8:1
	Twig bases	46.9	5.9*	1.9*	50.6	38.6	3.1	.30*	.08*	3.8:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$).

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons.

Table 5.—*Chemical composition of yellow jessamine* (Gelsemium sempervirens)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.	- - - - - - - -	- - - - - - - -	*Percent*	*of ovendry*	*weight*	- - - - - - - -	- - - - - - - -	*Ratio*
Spring	Leaves	30.0	11.8*[1] a[2]	6.9*[1] b[2]	12.2	64.8	4.2	0.37*[1] d[2]	0.12+[1] a[2]	3.1:1
	Twig tips	29.5	8.8+ a	5.0+ a	31.2	50.3	4.6	.28+ d	.17* a	1.6:1
	Twig bases	31.0	6.8# a	3.3# a	40.8	45.5	3.6	.21# c	.12+ a	1.8:1
Summer	Leaves	36.8	9.2* b	8.1* a,b	14.5	64.2	4.0	.49* c	.08* c	6.1:1
	Twig tips	48.2	4.2+ b	3.3+ b	38.1	51.8	2.6	.35+ c	.07* b	5.0:1
	Twig bases	45.8	3.8+ b	2.4+ a	42.6	49.0	2.2	.23# c	.06+ b	3.8:1
Fall	Leaves	38.2	9.5* b	9.8* a	14.0	62.0	4.7	.56* b	.09* b	6.2:1
	Twig tips	44.3	4.6+ b	3.6+ a,b	38.0	51.3	2.5	.42+ b	.08+ b	5.2:1
	Twig bases	46.2	3.6+ b	2.6+ a	45.0	46.6	2.2	.29# b	.06# b	4.8:1
Winter	Leaves	42.1	9.3* b	9.4* a	12.8	64.8	3.6	.61* a	.09* b	6.8:1
	Twig tips	53.6	5.3+ b	3.6+ a,b	37.4	51.1	2.5	.47+ a	.07+ b	6.7:1
	Twig bases	52.7	4.3+ b	2.8+ a	41.8	48.7	2.4	.38# a	.06# b	6.3:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$).

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons.

Table 6.—*Chemical composition of young loblolly pine* (Pinus taeda)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.	*Percent of ovendry weight*							*Ratio*
Spring	Leaves	26.4	10.7*[1] a[2]	4.1+[1] c[2]	26.0	55.0	4.2	0.28*[1] b[2]	0.19*[1] a[2]	1.5:1
	Twig tips	20.8	7.7+ b	6.5* b	24.0	57.6	4.2	.29* b	.16+ b	1.8:1
	Twig bases	22.0	4.8# a	5.5*,+ b	32.4	54.0	3.3	.23* b	.10# a	2.3:1
Summer	Leaves	31.8	7.6* c	5.8* b,c	27.0	57.0	2.6	.33* b	.10+ c	3.3:1
	Twig tips	33.0	5.0+ c	6.9* b	33.8	51.4	2.8	.28* b	.13* d	2.2:1
	Twig bases	34.4	2.8# b	5.2* b	43.4	51.6	2.0	.28* a,b	.06# c	4.7:1
Fall	Leaves	33.5	8.2* b,c	7.4* b	26.7	54.9	2.8	.31* b	.12+ b	2.6:1
	Twig tips	34.8	5.7+ c	6.8* b	36.9	47.7	2.9	.35* a,b	.14* c	2.5:1
	Twig bases	34.3	3.2# b	4.4+ b	47.2	43.2	2.0	.31* a,b	.08# b	3.9:1
Winter	Leaves	41.4	8.9* b	10.4+ a	21.4	56.4	2.8	.45* a	.12+ b	3.8:1
	Twig tips	44.2	8.8* a	12.7* a	26.6	48.6	3.4	.42* a	.18* a	2.3:1
	Twig bases	43.5	4.7+ a	9.7+ a	38.6	44.8	2.2	.35* a	.08# b	4.4:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$).

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons.

Table 7.–*Chemical composition of common sweetleaf* (Symplocos tinctoria)

Season	Plant fraction	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash	Calcium	Phosphorus	Ca:P
		Pct. of fresh wt.			*- - - - - Percent of ovendry weight - - - - -*					*Ratio*
Spring	Leaves	19.2	16.1*[1] a[2]	2.8*[1] c[2]	16.4	53.6	11.2	0.93*[1] b[2]	0.21*[1] a[2]	4.4:1
	Twig tips	16.1	11.1+ a	1.8* a	25.9	50.2	11.0	.80* b	.20+ a	4.0:1
	Twig bases	18.2	7.7# a	1.8* a	36.2	46.0	8.4	.51+ b	.15# a	3.4:1
Summer	Leaves	25.8	11.7* b	4.2* b	13.6	59.5	11.0	1.28* a	.09+ c	14.2:1
	Twig tips	31.6	5.3+ b	1.1+ a	32.2	53.9	7.5	1.35* a	.11* c	12.3:1
	Twig bases	33.6	4.1# b	.9+ a	40.8	49.0	5.2	.75+ a,b	.09+ b	8.3:1
Fall	Leaves	27.6	11.2* b	6.3* a	13.2	59.0	10.2	1.16+ a,b	.10* b	11.6:1
	Twig tips	35.6	5.2+ b	1.6+ a	28.6	56.8	7.8	1.61* a	.10* d	16.1:1
	Twig bases	37.8	4.0# b	1.0+ a	40.7	49.4	5.0	.94+ a	.08+ c	11.8:1
Winter	Leaves	31.4	10.1* c	6.1* a	11.2	62.4	10.2	.98+ b	.10+ b	9.8:1
	Twig tips	39.0	5.9+ b	1.8+ a	28.6	55.4	8.4	1.41* a	.11* b	12.8:1
	Twig bases	40.4	4.8# b	1.4+ a	41.0	47.0	5.6	.88+ a	.09# b	9.8:1

[1]Within a season, means followed by the same symbol do not differ significantly ($P > 0.05$).

[2]For individual plant fractions, means followed by the same letter do not differ significantly ($P > 0.05$) between seasons.