Net Production Relations of Two Tree Species in Southern Oklahoma[1]

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Similar productivity studies have been primarily confined to the Eastern Deciduous Forest (Whittaker 1961, 1965, 1966; Whittaker, Cohen, and Olson 1963; Hosner and Leaf 1962; Weigert and Evans 1964). To ascertain the productivity of woody vegetation common to the prairie biome, two native and abundant tree species were selected. The two species chosen for this productivity investigation were *Diospyros virginiana* (Persimmon) and *Quercus stellata* (Post Oak).

The selected study area was located in central Marshall County about 8½ miles north of the University of Oklahoma Biological Station in Sec. 4 and 5, T 7 S, R 5 E, on Duck Creek and Goodland Limestone soils. All plants studied were within a radius of 500 meters.

Net production, for the purpose of this paper, refers to the dry weight of organic matter produced per year exclusive of that lost by respiration, and biomass refers to the dry weight of living and dead organic matter present when the trees were studied.

METHODS

Ten trees of good form were selected for each species and analyzed in the manner discussed by Whittaker (1961, 1962, 1963, 1965, and 1966). For each log, diameters were measured at the basal end and midpoints, and bark thickness and wood increments were measured to 0.01 inch on four radii on discs cut from the end. For each branch the distance below the growing tip, the basal diameter, and age were recorded. Age was determined by counting the girdle scars on the branch and, because of the llama-like growth in the *Quercus stellata*, by counting the annual rings noted from discs cut from the basal ends of the branch. In addition, five sample branches were randomly chosen from each tree to represent different sizes and positions in crowns; for these sample branches live and dry weights of wood with bark, of current twigs with leaves, and branch length and numbers of current twigs were determined. Dimensions of the stump, of the bole at breast height, and of the leader or terminal current twig of the tree were measured. No measurements were taken on flowers or fruits due to their absence.

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Separate collections were made from each of the upper, middle, and lower positions in selected tree crowns of (1) 50 leaves representing several trees for determination of blade and petiole weights and blade areas; (2) 10 twigs representing 10 trees for determination of distribution of dry weight in blades, petioles, and twigs, and numbers of current leaves; (3) 10 twigs representing 10 trees for chlorophyll determination, following techniques outlined by Whitaker and Garfine (1962). Percent absorption was read in a Model 340 Bausch and Lomb spectrophotometer at the University of Oklahoma Biological Station at 645, 652, and 663 mu. Arnon's (1949) formula was used for determination of leaf chlorophyll.

Volume and weight of wood, bark, and current annual wood growth were computed for each log, and stem bark growth was estimated as described by Whittaker (1966). Log volumes were based on middiameters and wood volume increments on average annual wood radial increments per year for the last five years at the ends of the logs.

The sample branches were used to construct regressions of dry weights of branch wood and bark, and of current twigs and leaves, on basal diameter. The total branch population from 10 trees of each species, with branch dry weights estimated from the regressions, was used to compute the regression of branch dry weight on branch age. All three regressions used least squares solutions in the form $y = ax^b$, $\log y = A + b \log x$, in which y is the dry weight, x is branch basal diameter or age, and A and b are constants. Also, the regressions were used to estimate the branch wood and bark production (from the relation $\Delta y = by/x$, in which y is branch dry weight, x is branch age, and b the growth exponent) and current twig and leaf production for all branches of a tree.

The criterion used for selection of which representatives within each species would be studied was based upon the main trunk diameter at breast height of the living trees, with a maximum diameter fluctuation of 3 mm from a predetermined midpoint.

RESULTS AND DISCUSSION

The twofold greater wood radial increment at breast height and the greater height and total shoot production in the younger *Diospyros* indicates that *Diospyros* is a more rapidly growing tree species than *Quercus stellata* in the limestone site studied.

The percent biomass distribution of the two tree species appears similar even though the total number of branches per tree in *Q. stellata* (Table I) was more than two times as great as in *Diospyros*. A possible explanation for the similarity in percent biomass may be offered in that only 6.8% of the observed more vigorous *Diospyros* branches were nonviable compared to 26.9% nonviable branches in *Quercus*.

The greater observed vigor of branches in the *Diospyros* was substantiated by the data which shows that *Diospyros* had a higher total net production distribution of branch wood and bark even with the almost twofold less number of living branches per tree than *Q. stellata*.

The high percent of stem bark biomass in *Q. stellata* is thought due to the bark's strong resistance to decay and sloughing of the cork layers, resulting in a minimal loss of the outer bark. The slightly higher percent biomass distribution in stem wood and bark and branch wood and bark and the slightly lower percent in current twigs and leaves was anticipated for the older *Q. stellata* because of the annual increase in wood and bark biomass as woody organisms age. The twofold greater stem bark biomass in *Q. stellata* when compared with *Diospyros* can be expected to continue with age since *Q. stellata* maintained a twofold greater stem bark net production.

TABLE I. SUMMARY OF DATA FROM ANALYSIS OF TEN TREES EACH OF TWO SPECIES IN A SOUTHERN OKLAHOMA PRAIRIE.

Item	*Diospyros virginiana*	*Quercus stellata*
A. Mean tree dimensions		
Age (years)	15.0	23.2
Height (m)	4.25	3.63
Diameter at breast height (cm)	5.62	5.73
Wood diameter at breast height (cm)	4.85	4.30
Number of branches	25.1	61.1
Number of living branches	23.4	44.6
Wood radial increment at breast height (cm/yr)	0.194	0.096
Total shoot biomass (dry kg)	6.08	9.15
Total shoot production (dry kg)	2.14	1.76
B. Branch regression constants		
Branch wood and bark dry weight from age (g, years) *b*	2.4925	2.1554
A	0.0537	—0.3972
Branch wood and bark dry weight from basal diameter (g, years) *b*	2.8849	2.4611
A	—1.5218	—1.2562
Current twig and leaf dry weight from basal diam. (g, cm) *b*	1.7661	1.9839
A	—0.2666	—0.9563
C. Biomass distribution (percent)		
Stem wood	46.2	42.3
Stem bark	9.2	19.9
Branch wood and bark	25.7	27.1
Current twigs and leaves	18.9	10.7
D. Net production distribution (percent)		
Stem wood	15.4	18.0
Stem bark	2.8	5.8
Branch wood and bark	28.6	20.5
Current twigs and leaves	53.2	55.7
E. Leaf and twig relations		
Current twig dry weight (g)	0.178	0.085
Current leaf dry weight (g)	0.082	0.149
percent in: twigs	20.4	9.2
blades	75.0	88.1
petioles	4.6	2.7
Number of leaves per twig	8.49	5.61
Leaf blades area[a] (cm^2)		
Upper	12.16	20.61
Lower	11.84	19.26
Mean[b]	11.37	20.22
Leaf blade dry weight/ area (mg/cm^2)		
Upper	8.61	7.67
Lower	5.25	7.25
Mean[b]	7.21	7.37

TABLE I, continued

Leaf blade chlorophyll[a] ($\mu g/cm^2$)	25.4	25.8
F. Biomass accumulation ratio	2.84	5.20

[a]All leaf area based on one side of blade only
[b]Mean of upper, lower, and middle leaves

Leaf and twig relations between *Q. stellata* and *Diospyros virginiana* show areas of variability as well as uniformity. The more accelerating branch vigor in the *Diospyros* was further verified by the twigs which show a more than twofold greater dry weight per twig when compared to *Q. stellata.* Although leaf blade area and leaf dry weight was greater in *Quercus* than in *Diospyros,* when comparing the mean of leaves sampled of each species, the leaf blade dry weights per area (mg/cm^2) were similar. However, the data does indicate that the leaf blade area and the leaf blade dry weight vary considerably more from upper to the lower canopy positions in *Diospyros* than in *Quercus.* The possible ecological significance of the low blade dry weight/area in the lower canopy of *Diospyros* when compared to *Quercus* may be none, yet it should be evaluated in further research relative to its possible value as an establishment indicator in selected plant communities. An analysis of the leaf blade ($\mu g/cm^2$), using the Arnon formula, showed the chlorophyll concentration of the two species to be comparable, with chlorophyll content being higher in the upper foliage of both species studied. Results based on this study and earlier productivity studies do not appear to show a strong correlation between chlorophyll concentration in leaves and net productivity.

The biomass accumulation ratio of the two species studied, a ratio which does increase with age in living trees, shows a greater difference than hypothesized on the basis of comparing species of similar stature and age. Apparently *Diospyros* should be considered an earlier maturing species than *Q. stellata* based on *Diospyros'* lower biomass accumulation ratio.

SUMMARY

The major characteristics of *D. virginiana* were greater wood radical increments, more vigorous branch and trunk growth, and earlier maturity when compared to *Q. stellata,* with a greater sloughing of the bark and greater variation of leaf sizes and weights between upper and lower canopy positions. The major characteristics of *Q. stellata* were over-all smaller wood radical increments, the production of two to three times greater number of branches (many of which were dead or lacked vigorous growth) and a main trunk with a thicker and tougher outer bark when compared with *D. virginiana,* with numerous second growths noted on branches resulting from llama-like extensions of apical stems and leaves which varied little in size or weight throughout the canopy.

In conclusion, *Diospyros virginiana* appears to have a greater net productivity than *Quercus stellata* on Duck Creek and Goodland limestone soils in Sothern Oklahoma when the trees are well established, less than 25 years old, and prevailing under environmental conditions suitable for favorable growth.

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