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Dry Weight and Nutrient Accumulation in Young Stands of Cottonwood (*Populus deltoides* Bartr.)

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SUMMARY

Dry matter accumulation in young cottonwood stands was high compared to many coniferous forests. But dry matter production did not appear to be closely related to site quality over the range of sites studied. Nutrient concentrations varied with crown position and crown class and were generally higher than most reported figures for conifers. Nutrient accumulations were rapid as would be expected from the high dry matter production rate. Cottonwood at age 7 accumulated nearly as much N, P, K, and Ca as 36-year-old Dougas fir or 26-year-old *Pinus radiata.*

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Dry Weight and Nutrient Accumulation In Young Stands of Cottonwood (*Populus deltoides* Bartr.)[1]

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INTRODUCTION

In the past several years there has been an increasing amount of literature dealing with the growth of tree stands including knowledge of primary production, mineral cycling, and tree nutrition *(2,9,13)*. Consideration of the entire tree, the complete tree concept, has been proposed *(18)*. As a result of this concept and the increased interest in using weight as a basic unit of measurement for forest products, reports have been made on the weight and nutrient element contents of complete trees *(18,19)*. The objective of this study was to obtain above ground weights and nutrient element contents of young stands of eastern cottonwood. Such information should be useful in understanding the primary productivity and mineral cycling in natural ecosystems and as an aid in developing base lines for preventing damage to natural ecosystems as well as for the rehabilitation of ecosystems that have deteriorated.

METHODS

Six natural stands and two plantations of eastern cottonwood were selected for study. All stands were located in the overflow bottom of the Alabama and Tombigbee rivers in southwest-

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[1] This work supported in part through the Hardwood Forestry Research Fellowship Program.

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ern Alabama. The stands were at least 2 acres in size, fully stocked, nearly 100 per cent pure, and essentially free from understory vegetation. Periodic flooding and siltation prevented the formation of a litter layer and mineral soil was exposed over most of the stands.

Two 1/20-acre plots were established in each stand. Five dominant or codominant trees were selected at random on each plot for total height measurements. Diameters breast high outside bark (DBHOB) of all trees were recorded and grouped into three classes representing suppressed, codominant, and dominant crown classes. In August, one tree from each crown class on each plot was felled at the ground-line for stem analysis and total tree sampling *(8,11,16)*.

Total tree height, length of live crown, and DBHOB were measured and recorded. The crown was divided into upper and lower crown by measuring from the lowest limb bearing green leaves to the apex and dividing into two equal parts. All leaves, including petioles, were stripped from the branches and collected by upper or lower crown position. All branches were collected in a similar manner.

The boles of the trees were cut into 6-foot sections which were weighed in the field with a large platform balance. Four-inch discs were cut from the butt of the first bolt of each tree and from the tops of all bolts. The discs were weighed while fresh and their diameters measured in the field. Foliage, branches, and discs were transported to the laboratory for further processing.

All tree components were dried to a constant weight at 65°C and the dry weights recorded. Discs were weighed with the bark on, the bark removed, and with both bole bark and bole wood redried and reweighed. A ratio of oven-dry to fresh weight of discs was used to calculate dry weights of sample tree, bole wood, and bole bark.

Bole wood, bole bark, branches, and foliage were ground separately in a Wiley mill to pass a 40-mesh sieve. Sub-samples were analyzed for N by the Kjeldahl procedure modified to include nitrates *(12)*. Other subsamples were ashed for 4½ hours at 450°C and the ash dissolved in dilute HCl for analysis. Aliquots of these solutions were analyzed for P by the vanadate procedure (4,7); K by Beckman DU flame spectrophotometer; Mg and Ca by a Perkin-Elmer 303 atomic absorption spectrophotometer using lanthium oxide to suppress interferences *(1)*.

Stem analysis data from the 48 sample trees were used to construct volume and weight equations by standard statistical procedures *(3,14)*.

No attempt was made to determine root mass. All weights and nutrient contents in the ensuing discussion refer to above ground biomass only.

RESULTS AND DISCUSSION

Mensurational data for the sample stands are presented in Table 1. All stands were located on what appeared to be good cottonwood sites *(5)*, but a range in site quality was found. Average height of dominant and codominant trees at age 6 years was estimated from stem analyses and used as an indicator of site quality. On this basis, a two-fold difference in site quality existed between the best and the poorest sites, Table 1. The two best growing stands (Stands 1 and 2 in Table 1) were plantations. Stand 2 received weed and insect control during the first growing season while stand 1 received a weeding at the beginning of the second growing season. The control of stocking and cultural treatments may have contributed to the superior growth rates of these two stands.

TABLE 1. SUMMARY OF MENSURATIONAL DATA FOR YOUNG COTTONWOOD STANDS, ALABAMA[1]

Stand[2]	Height age 6	Height[3]	Av. DBHOB	Current age	Stems/ acre	Basal area/ acre	Total volume/ acre
	Ft.	*Ft.*	*In.*	*Yr.*	*No.*	*Sq. ft.*	*Cu. Ft.*
1	66.5a	71.8a	6.8a	7	390a	104	2,566a
2	56.8b	65.6b	5.7b	8	470a	89	2,034bc
3	55.4b	58.2cd	4.0d	7	990b	102	2,116b
4	50.1c	60.6c	4.8c	9	610a	80	1,806d
5	48.0d	60.1c	4.0d	8	1,090b	103	2,434a
6	44.2e	48.9e	2.3e	7	3,260c	88	1,872c
7	43.1e	56.0d	3.8d	8	890b	80	1,581e
8	32.4f	32.4f	1.3f	6	7,020d	82	864f

[1] Means in any one column followed by the same letter do not differ significantly at the 5% level (Duncan's Test).

[2] Ranked 1-8 based upon average height of codominant and dominant trees at age 6.

[3] Average height of codominant and dominant trees at current stand age.

Data on the 48 sample trees are shown in Table 2. Heights ranged from 15.6 to 77.8 feet, DBHOB ranged from 0.8 to 10.5 inches, and dry weights ranged from 1.6 to 477.1 pounds. Regression equations relating DBHOB to dry weight of various

TABLE 2. SUMMARY OF SIZES AND WEIGHTS FOR THE 48 SAMPLE TREES

Stand[1]	Crown[2] class	DBHOB	Height	Dry weights				
				Foliage	Branches	Bole bark	Bole wood	Total
		In.	*Ft.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1	S	2.8	35.4	.5	2.2	2.4	12.1	17.2
	S	4.1	45.4	.9	5.5	5.7	8.9	21.0
	CD	6.3	65.8	5.0	17.4	17.9	110.4	150.7
	CD	7.3	69.2	8.5	26.3	23.4	164.7	222.9
	D	8.9	74.4	15.9	40.1	37.5	250.1	343.6
	D	10.5	77.8	31.3	98.5	41.9	305.4	477.1
2	S	2.9	36.1	1.9	3.6	2.5	14.1	22.1
	S	2.7	34.0	1.6	4.2	3.1	11.0	19.9
	CD	5.4	60.7	4.1	12.1	7.7	59.4	83.3
	CD	5.8	63.7	4.9	18.2	20.5	119.1	162.7
	D	7.5	68.7	13.3	25.9	27.0	177.5	243.7
	D	8.1	69.5	17.9	69.8	39.2	263.5	390.4
3	S	2.0	29.0	.7	2.1	1.0	4.9	8.7
	S	2.3	30.0	.9	1.9	1.6	8.7	13.1
	CD	3.5	48.0	.8	10.8	5.1	8.0	24.7
	CD	4.2	52.0	1.5	6.1	6.4	17.2	31.2
	D	6.4	63.3	5.7	37.0	12.1	111.5	166.3
	D	7.5	69.3	10.0	53.3	29.2	212.5	304.7
4	S	2.6	36.4	.7	3.2	2.9	12.0	18.8
	S	2.9	46.4	1.9	2.3	4.8	23.5	32.5
	CD	5.1	56.9	2.5	19.1	12.2	56.7	90.5
	CD	4.2	52.3	2.4	7.9	6.9	40.5	57.7
	D	7.3	65.7	7.7	42.9	29.3	137.9	217.8
	D	6.5	67.3	14.1	26.1	20.2	152.1	212.5
5	S	2.5	40.4	1.2	2.9	3.3	15.7	23.1
	S	2.2	29.5	.5	1.6	1.5	9.2	12.8
	CD	4.6	56.5	1.8	11.1	6.9	44.9	64.7
	CD	4.6	55.0	1.5	8.5	6.4	46.5	62.9
	D	6.0	61.5	4.9	26.8	10.2	94.2	136.1
	D	7.9	67.5	7.7	58.5	22.1	162.1	250.6
6	S	1.6	25.0	.6	11.0	1.1	3.3	6.0
	S	1.6	26.2	.6	.8	.9	4.1	6.4
	CD	2.5	37.4	1.0	1.7	3.0	13.5	19.2
	CD	2.8	43.0	.6	1.2	3.1	17.0	21.9
	D	4.7	48.0	2.7	8.7	8.2	44.6	64.2
	D	5.0	55.3	2.7	9.7	6.3	58.8	77.5
7	S	2.5	30.7	1.1	2.3	3.2	10.3	16.9
	S	2.0	24.5	.6	.9	1.4	5.3	8.2
	CD	4.3	51.8	2.7	8.5	9.5	43.0	63.7
	CD	5.0	56.8	3.0	7.7	12.3	56.1	79.1
	D	5.8	57.2	5.5	23.0	24.0	107.4	159.9
	D	6.3	58.1	5.8	29.1	17.7	95.1	147.7
8	S	.9	15.7	.2	.3	.3	.8	1.6
	S	.8	15.6	.5	.3	.6	1.2	2.6
	CD	1.9	28.7	.7	1.0	1.6	6.0	9.3
	CD	2.4	32.9	1.6	2.7	2.2	9.4	15.9
	D	2.9	35.0	2.1	2.9	3.1	15.1	23.2
	D	3.0	33.3	2.6	5.1	3.2	16.2	27.1

[1] Ranked 1-8 based upon height of codominant and dominant trees at age 6.
[2] S = suppressed, CD = codominant, D = dominant.

components are shown in Table 3. Using these equations, the weight of foliage, branches, bole bark, and bole wood for various diameter classes were calculated and plotted as a percentage of total tree dry weight, see Figure. The proportional weight of foliage increased only slightly with tree size and branch weights remained at a rather consistent 15 to 16 per cent of total tree weight. Bole bark decreased from 33 per cent for 1-inch trees to 10 per cent for 10-inch trees while bole wood increased from 49 to 70 per cent for 1- and 10-inch trees, respectively.

TABLE 3. REGRESSION CONSTANTS, COEFFICIENTS, AND r VALUES RELATING DBHOB TO THE WEIGHT OF COTTONWOOD TREE COMPONENTS

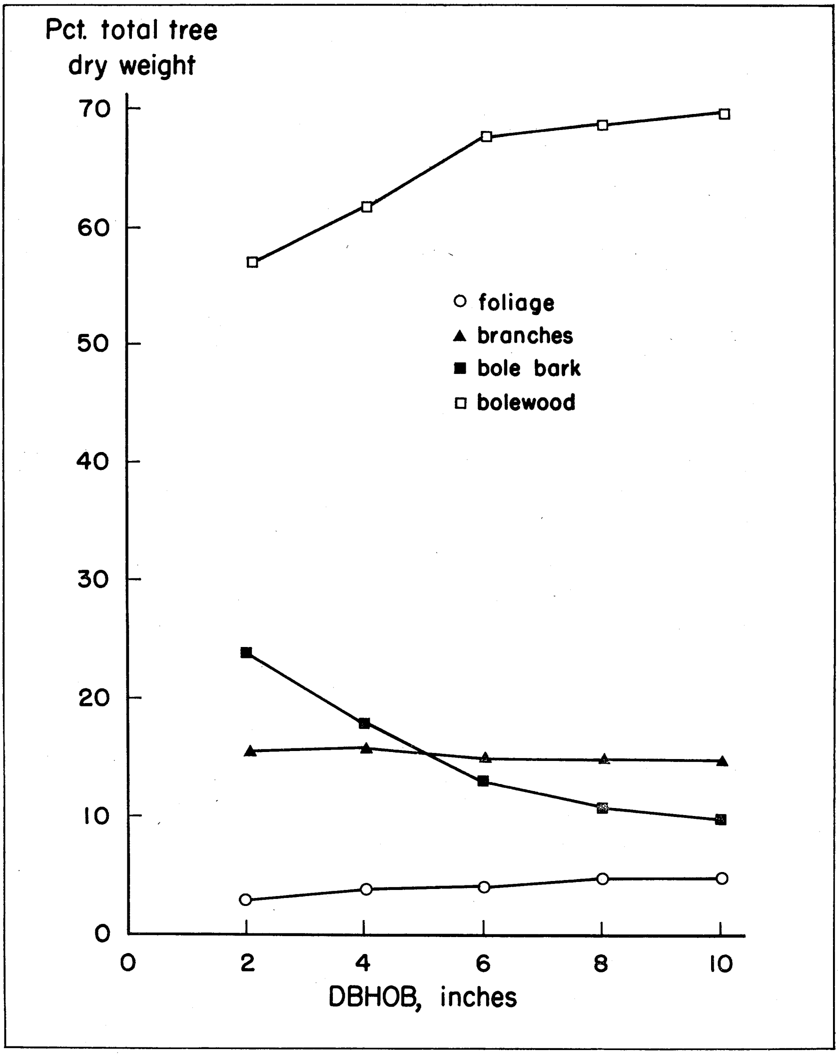
Component[1]	a	b	r	St. error estimate	St. error reg. coef.
Foliage	0.33155	0.2504	0.957	1.70730	0.00112
Branches	—0.56362	2.40148	0.971	0.15130	0.08675
Bole bark	—0.39440	2.00955	0.974	0.11970	0.08675
Bole wood	0.06151	2.42189	0.973	0.14880	0.08534

[1] Equation for estimation of foliage biomass is of the form $Y = a + bX$ where Y is weight of foliage in pounds and X is the DBHOB cubed.

Equations for estimation of branch, bole bark, and the bole wood weights are of the form $Y = a + bX$ where Y is the logarithm of the biomass in pounds and X is the logarithm of tree DBHOB.

Regression equations shown in Table 3 are the overall equations based on all 48 sample trees. When individual equations were calculated for each stand, differences between stands were observed. Differences in age and site quality were largely responsible for these variations. To obtain an estimate of total stand weight, individual stand equations were used to calculate the weight of each tree on a sample plot. The results, totaled and expanded to per acre values, are given in Table 4. Examination of these data do not suggest any strong relationships between site index based on height at age 6 and any of the dry weight values. To overcome differences in stand age, stem analyses data were used to adjust diameter distribution on each plot to age 6 and tree component weights were recalculated. Thus it was possible to estimate total dry matter at age 6 for all stands, Table 5. Dry matter production and site quality still did not appear to be related. Similar results have been obtained for other forest types *(13)*.

The cottonwood stands in this study produced large amounts of dry matter compared to many temperate forests. Satoo *(13)* reported the total biomass for a 15-year-old natural stand of *Pinus desiflora* in eastern Japan was approximately 28.5 tons



Changes in relative proportions of foliage, branches, bole bark, and bole wood with variations in tree diameter.

per acre. Stand 3, also a natural stand, equalled this dry matter production in above ground overstory alone in 7 growing seasons. Stands 1 and 6 produced even more in 7 years. Data reported by Cole, *et al.* *(6)* indicate that the mean annual accumulation of dry matter in a 36-year-old plantation of Douglas fir in Washington was 2.5 tons per acre. Twenty-six-year-old *Pinus radiata*

TABLE 4. WEIGHTS OF YOUNG COTTONWOOD STANDS ON ALLUVIAL SITES IN SOUTHWEST ALABAMA

Stand[1]	Age	Dry weights				
		Foliage	Branches	Bole bark	Bole wood	Total
	Yr.	*Ton/A.*	*Ton/A.*	*Ton/A.*	*Ton/A.*	*Ton/A.*
1	7	1.7	5.4	4.2	25.1	36.4
2	8	1.6	4.8	3.8	24.9	35.1
3	7	1.2	6.5	3.5	17.7	28.9
4	9	0.9	4.7	3.7	20.1	29.4
5	8	1.2	6.6	3.5	25.0	36.3
6	7	1.6	3.2	3.8	20.9	29.5
7	8	1.1	3.4	3.7	16.4	24.6
8	6	1.1	1.5	3.2	11.6	17.4

[1] Ranked 1-8 based upon height of codominant and dominant trees at age 6.

TABLE 5. WEIGHTS OF YOUNG COTTONWOOD STANDS ON ALLUVIAL SITES IN SOUTHWEST ALABAMA AFTER ADJUSTMENT OF ALL STANDS TO AGE 6

Stand[1]	Dry weights				
	Foliage	Branches	Bole bark	Bole wood	Total
	Ton/A.	*Ton/A.*	*Ton/A.*	*Ton/A.*	*Ton/A.*
1	1.0	3.4	2.8	15.1	22.3
2	1.2	3.3	2.6	15.6	22.7
3	0.9	5.3	2.7	13.1	22.0
4	0.5	2.2	2.0	10.5	15.2
5	0.7	3.6	2.2	15.1	21.6
6	1.3	2.4	3.0	14.8	21.5
7	0.5	1.2	1.6	9.1	12.4
8	1.1	1.5	3.2	11.6	17.4

[1] Ranked 1-8 based upon height of codominant and dominant trees at age 6.

in New Zealand accumulated 3.8 tons per acre *(10)*, and *Pinus taeda* accumulated 2.5 tons per acre for the first 30 years in Mississippi *(15)*. Cottonwood stand 1 had a mean annual accumulation of 5.2 tons per acre over the first 7 years, Table 4.

Nutrient concentrations by tree component and crown class averaged over all stands are shown in Table 6. Suppressed trees contained higher concentrations of most nutrients than dominant and codominant trees. Concentrations differed between the upper and lower halves of the crown, Table 7. These findings have been discussed in more detail in a previous paper *(17)*.

With the chemical analyses and the known dry weights for each of the 48 sample trees, Table 2, it was possible to calculate the total amount of each element in each of the sample trees. From these data, regression equations relating DBHOB to element content were developed, Table 8. Substituting the diameter tallys for each plot into the proper equations produced the data

TABLE 6. AVERAGE CONCENTRATIONS OF NUTRIENT ELEMENTS AND ASH IN TREE COMPONENTS OF SUPPRESSED, CODOMINANT, AND DOMINANT COTTONWOOD TREES ON ALLUVIAL SITES IN SOUTHWEST ALABAMA

Tree component	Crown[1] class	Dry Weight					
		N	P	K	Ca	Mg	Ash
		Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Foliage	Suppressed	2.02	0.18	1.26	2.89	0.32	13.40
	Codominant	2.01	0.19	1.22	2.40	0.32	11.28
	Dominant	2.08	0.20	1.22	2.66	0.29	10.26
Branches	Suppressed	.56	.08	.46	1.26	.10	4.14
	Codominant	.50	.08	.40	.89	.09	3.19
	Dominant	.44	.07	.35	.79	.08	3.19
Bole bark	Suppressed	.63	.07	.49	2.24	.16	7.79
	Codominant	.58	.07	.47	2.14	.15	7.06
	Dominant	.55	.07	.45	2.11	.14	6.63
Bole wood	Suppressed	.11	.03	.18	.14	.03	.79
	Codominant	.10	.02	.14	.12	.03	.67
	Dominant	.10	.02	.13	.11	.03	.64

[1] Differences between crown classes were significant ($P<0.05$) for every element and every component. Some of the averages are identical due to rounding to the second decimal.

TABLE 7. AVERAGE CONCENTRATIONS OF NUTRIENT ELEMENTS AND ASH IN FOLIAGE AND BRANCHES OF COTTONWOOD TREES ON ALLUVIAL SITES IN SOUTHWEST ALABAMA BY POSITION IN CROWN

Tree component	Crown[1] position	Dry Weight					
		N	P	K	Ca	Mg	Ash
		Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Foliage	Upper	2.09	.20	1.30	2.16	.29	10.82
	Lower	1.98	.19	1.18	2.78	.33	12.48
Branches	Upper	.52	.08	.42	.94	.09	3.31
	Lower	.47	.07	.38	1.02	.09	3.47

[1] Differences between the upper and lower halves of the crown were significant in all instances ($P<0.05$). Certain means are identical due to rounding to the second decimal.

in Table 9 showing the total nutrient content for each of the eight cottonwood stands.

The content for most elements differed between stands in the same order that biomass differed, Table 4. Between 20 and 30 per cent of the nutrients were in the foliage, 20 to 26 per cent were in the branches, 29 to 39 per cent were in the bole bark, and 20 to 26 per cent were in the bole wood.

Nutrient accumulations in young cottonwood stands were very high compared to reported values for certain coniferous forests. Harvesting of bole wood and bark by clear cutting cottonwood Stand 1 would remove 92 pounds N, 15 pounds P, 102 pounds K, and 283 pounds Ca per acre. Corresponding figures

TABLE 8. REGRESSION CONSTANTS, COEFFICIENTS, AND r VALUES RELATING DBHOB TO THE NUTRIENT ELEMENT CONTENT OF COTTONWOOD TREE COMPONENTS[1]

Component	Element	a	b	r	St. error estimate	St. error reg. coef.
Foliage	N	−2.41487	1.86129	0.905	0.22520	0.12915
	P	−3.43891	1.85411	0.884	0.25250	0.14480
	K	−2.68245	1.92429	0.924	0.20440	0.11723
	Ca	−2.21156	1.61349	0.881	0.22250	0.02759
	Mg	−3.12074	1.63181	0.893	0.21180	0.12146
Branches	N	−2.77723	2.21007	0.960	0.16450	0.09433
	P	−3.35467	2.60164	0.889	0.34480	0.19775
	K	−2.85032	2.18691	0.966	0.15040	0.09626
	Ca	−2.39373	2.08857	0.950	0.17670	0.10137
	Mg	−3.44257	2.11315	0.926	0.22230	0.12751
Bole bark	N	−2.60052	1.97355	0.955	0.15680	0.08992
	P	−3.51157	1.91279	0.956	0.15010	0.08611
	K	−2.70467	1.91279	0.967	0.13440	0.07709
	Ca	−1.99883	1.91835	0.928	0.19760	0.11333
	Mg	−3.18780	1.95763	0.925	0.20650	0.11841
Bole wood	N	−2.87001	2.31243	0.965	0.16210	0.09298
	P	−3.27775	1.84934	0.863	0.27890	0.15997
	K	−2.58974	2.09396	0.962	0.15240	0.08739
	Ca	−2.76708	2.28029	0.969	0.15010	0.08608
	Mg	−3.40909	2.23082	0.950	0.18780	0.10772

[1] Equation of the form $Y = a + bX$ where Y is the logarithm of element weight in pounds and X is the logarithm of tree DBHOB.

for the previously mentioned 36-year-old Douglas fir stand *(6)* would be 111 pounds N, 17 pounds P, 85 pounds K, and 104 pounds Ca per acre. For 26-year-old *P. radiata* the values are 114 pounds N, 16 pounds P, 225 pounds K, and 140 pounds Ca per acre *(10)*. By the time cottonwood Stand 1 reaches the same age, its nutrient content should greatly exceed the nutrient content of these conifers.

Although timber harvest will remove appreciable amounts of nutrients from the site, there appears to be little danger that the soil fertility will be significantly reduced. The surface 6 inches of soil supporting Stand 1 contained 14 pounds available P, 360 pounds exchangeable K, and 9,324 pounds of exchangeable Ca per acre *(17)*. Flood waters annually deposit several inches of this fertile alluvial soil on the site which should more than compensate for the nutrients removed by the cottonwood. However, continuous cropping of cottonwood on lands not subject to flooding and deposition could lead to a rapid depletion of the nutrient supply of the soil.

TABLE 9. NUTRIENT ELEMENT AND ASH CONTENTS OF YOUNG COTTONWOOD STANDS ON ALLUVIAL SITES IN SOUTHWEST ALABAMA

Stand[1]	Age	Tree component	N	P	K	Ca	Mg	Total[2]	Ash
	Yr.		*Lb./A.*	*Lb./A.*	*Lb./A.*	*Lb./A.*	*Lb./A.*	*Lb./A.*	
1	7	Foliage	72	8	46	88	7	221	381
		Branches	48	6	36	90	7	187	319
		Bole bark	44	5	35	223	10	317	648
		Bole wood	48	10	67	60	13	198	338
		Total	212	29	184	461	37	923	1,686
2	8	Foliage	69	7	48	89	9	222	341
		Branches	35	7	35	80	8	165	220
		Bole bark	37	6	47	159	10	259	493
		Bole wood	51	11	61	54	11	188	297
		Total	192	31	191	382	38	834	1,351
3	7	Foliage	54	5	31	43	8	141	229
		Branches	56	7	45	84	9	201	307
		Bole bark	45	5	35	130	10	225	436
		Bole wood	44	6	41	39	9	139	235
		Total	199	23	152	296	36	706	1,207
4	9	Foliage	54	4	30	50	7	145	246
		Branches	45	5	31	82	9	172	270
		Bole bark	46	4	33	148	12	243	523
		Bole wood	39	5	49	45	11	149	241
		Total	184	18	143	325	39	709	1,280
5	8	Foliage	49	4	28	49	8	138	241
		Branches	62	8	41	73	9	193	329
		Bole bark	46	4	30	123	10	213	487
		Bole wood	47	7	64	59	10	187	335
		Total	204	23	163	304	37	731	1,392
6	7	Foliage	47	6	28	77	8	166	350
		Branches	28	6	37	72	6	149	233
		Bole bark	36	6	41	167	10	260	522
		Bole wood	33	13	66	53	12	177	301
		Total	144	31	172	369	36	752	1,406
7	8	Foliage	47	4	26	44	3	124	212
		Branches	35	4	23	65	9	236	234
		Bole bark	58	4	29	151	11	253	549
		Bole wood	35	4	41	41	9	130	188
		Total	175	16	119	301	32	643	1,183
8	6	Foliage	84	9	42	100	15	250	489
		Branches	30	7	24	83	9	153	237
		Bole bark	35	6	30	131	11	436	213
		Bole wood	25	12	40	28	9	114	182
		Total	174	34	136	342	44	730	1,353

[1] Ranked 1-8 based upon height of codominant and dominant trees at age 6.
[2] Summation of N, P, K, Ca, and Mg.

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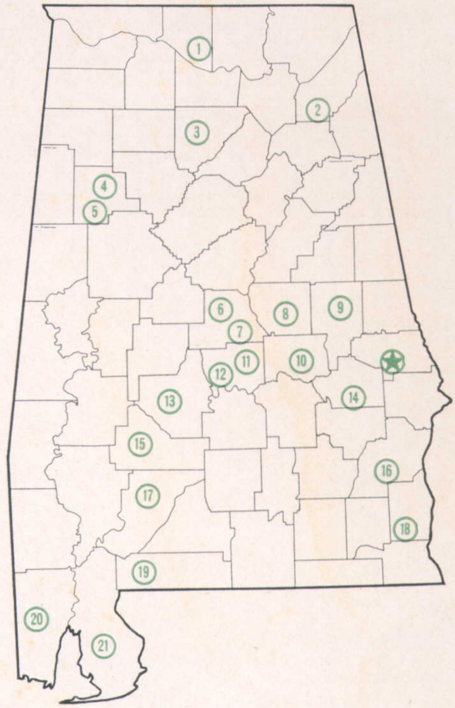
AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.