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Abstract-Bottomland hardwood forests, growing on the flood plains of rivers and streams, comprise about 14 percent (1.6 million acres) of the total commercial forest land in East Texas. These stands represent high values for a variety of forest uses such as timber production and wildlife habitat. However, information on these forests is not as complete as that of the southern U.S. For this study, data from 445 ten-factor variable radius inventory points were used to characterize stand structure, species composition and the general condition of bottomland hardwood forest throughout East Texas. The importance of this information and its impact on management practices is discussed.

INTRODUCTION

Bottomland hardwood forests, growing on the flood plains of rivers and streams, comprise approximately 14 percent (1.6 million acres) of the total commercial forest land in East Texas. Properly managed, these forests could provide quality lumber, veneer and pulp, along with providing good wildlife habitat for a variety of species. Historically, bottomland hardwood forests of East Texas have been declining in area at an average annual rate of 0.8 percent. This lose is primarily due to conversion to pine plantations, increased logging activities, and land development. The Conservation Reserve Program has helped limit this decline by encouraging landowners to reforest their bottomlands (Sims 1989). Within the last 15 years the southern United States has seen an increase in the demand in hardwood products for both domestic and export markets. Since 1975, the world demand for US hardwood logs, veneer, and lumber has quadrupled (Araman 1989).

Historically, East Texas bottomland forests had been subjected to high-grading practices leaving forest composed of primarily undesirable tolerant species and trees of poor form. Bottomland hardwoods in East Texas have long been considered low-quality, with little or no commercial value. As such, the majority of these forests have received little or no management since high-grading years before. The increase in hardwood markets has helped in changing the outlook for these resources. Several forest products industries are now beginning to look more seriously at their bottomland hardwoods. However, the low quality stigma remains. Most of the research performed on bottomland hardwoods in the south often did not involve stands in East Texas and consequently little is actually known about the structure or composition of these forests. The objective of this paper was to explore the stand structure and species composition of the bottomland hardwood forests of East Texas.

METHODS

During the summers of 1993, 1994, and 1995 bottomland hardwood stands were sampled within ownership of Temple-Inland, Champion, International Paper and USDA Forest Service. Sample stands were located in Angelina, Anderson, Cherokee, Hardin, Houston, Jasper, Nacogdoches, Newton, Orange, Sabine, San Augustine, Shelby, and Trinity counties. Eighty-four study sites were chosen to represent bottomland hardwood stands common to the region. Within these stands 443 temporary sample points were systematically located using a three by five chain grid. All trees being recorded as "in" using a 1 O-factor prism were utilized in this study. Data such as species, diameter at breast height (d.b.h.), total tree height, merchantable height, crown width, and log grades were recorded. An increment core was also extracted for age determination and growth analysis.

Analysis included estimates of stocking using Goelz's (1995) stocking guide for southern bottomland hardwoods and Putnam and others (1960) stocking classification system. Goelz developed the stocking guide using the data of Putnam and others (1960). The form of the guide was taken from Gingrich (1967), except the B-line is based on Putnams's suggested residual stocking rather than minimum full stocking. Putnam's classification system is based on species preference, log grade, crown class, and tree vigor. In use, the system classifies trees as preferred stock, reserve stock, cutting stock, or cull stock. These classes can then be used to establish the cutting priority in commercial thinnings or other partial cuttings.

RESULTS

A total of 4913 trees from 34 general species were sampled during the three year measurement period. Table 1 shows the number of samples and the percent of occurrence for each of the 34 species. Because of low observations for some of the species, the sample was reduced to seven overall species groups of Oaks, Sweetgum, Blackgum, Elm, Ash, Pine, and Miscellaneous (table 2). The Miscellaneous category is made up primarily low occurrence and non-commercial species. As shown in table two, over 61 percent of the sample is made up of oaks. If the oaks and sweetgum are combined, over 75 percent of the bottomland hardwood forests are composed of the most commercially viable species. The miscellaneous group is the only other group containing ten percent or more of the total number of species. This group is composed mainly of understory commercially undesirable species.

The 3027 trees in the oak group was divided into their individual species to show the distribution (table 3). Sixty-eight percent of the oak population is made up of willow, cherrybark, and water oaks. These three oak species are also some of the most commercially desirable oaks in the region.

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Table I-Number of trees and percent of total sample by species observed

Species	Number of trees	Percent of sample	Species	Number of trees	Percent of sample
Ash	109	2.22	Magnolia	4	0.08
Basswood	3	0.06	Maple	88	1.79
Beech	19	0.39	Nuttall oak	10	0.20
Black walnut	4	0.08	Overcup oak	285	5.80
Blackgum	243	4.95	Pawpaw	2	0.04
Cherry bark oak	565	11.50	Pine	94	1.91
Cypress	22	0.45	Post oak	10	0.20
Eastern redbud	1	0.02	Red oak	5	0.10
Elm	110	2.24	River birch	13	0.26
Gum bumelia	5	0.10	Sugarberry	27	0.55
Hawthorne	3	0.06	Cow oak	142	2.89
Hickory	126	2.56	Sweetbay	13	0.26
Holly	32	0.65	Sweetgum	813	16.55
Honey locust	3	0.06	Sycamore	8	0.16
Hophorn beam	33	0.67	Water oak	540	10.99
Horn beam	111	2.26	White oak	101	2.06
Laurel oak	350	7.12	Willow oak	1,019	20.74
Total				4,913	100.00

Table P-Number of trees and percent of total by reduced species groups

Species group	Number of trees	Percent of occurrence
Oaks	3,127	61.6
Sweetgum	813	16.5
Blackgum	248	5.0
Elms	110	2.4
Ash	108	2.2
Pine	94	1.9
Miscellaneous	513	10.4
Total	4,913	100.0

Table 3-Number of trees and percent of total of oak species

Species	Number of trees	Percent of occurrence
Willow oak	1,019	33.7
Cherrybark oak	56	18.7
Water oak	540	17.8
Laurel oak	350	11.6
Overcup oak	285	9.4
Cow oak	142	4.7
White oak	101	3.3
Nuttall oak	10	.3
Post oak	10	.3
Southern red oak	5	.2
Total	3,027	100.0

The number of trees sampled by one inch diameter classes is shown in Figure 1. A high percentage of the sample is from sawtimber size trees. This number could be somewhat misleading due to the sampling method of using prism points which may discriminate against smaller diameter trees. When these numbers are converted to per acre values the expected "reverse J shaped" curve indicative of an uneven or all aged forest occurs (fig. 2). The aforementioned size discrimination is evident on the extreme left side of Figure 2, where there appears to be a smaller number of smaller diameter trees.

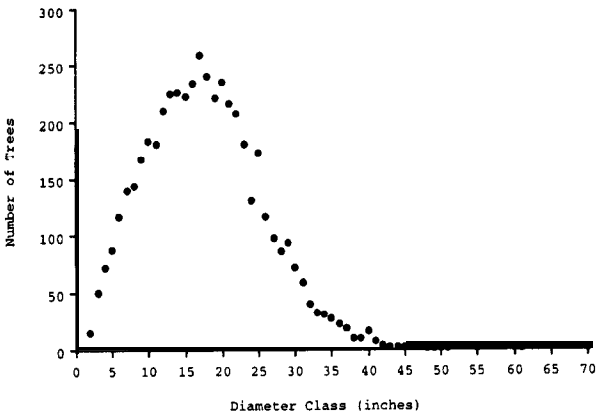

Figure l-Number of sample trees by one inch diameter classes.

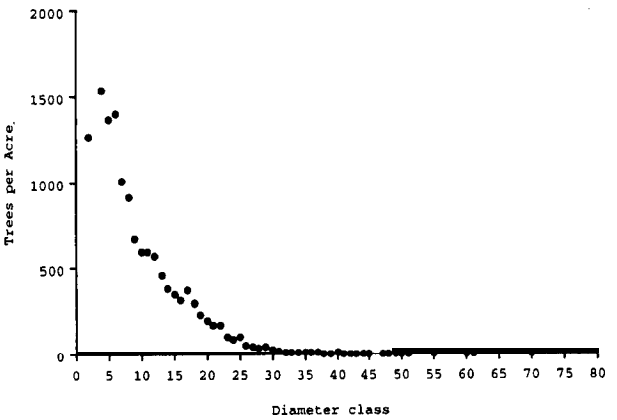

Figure P-Trees per acre values by one inch diameter classes.

Average trees within each species group are all within sawtimber size (table 4). Pine, oaks, and sweetgum had the largest average diameters and the greatest heights. With the exception of the pine group, ranges for both diameter and height spanned from small, probably young trees to large fully mature trees. The smallest pine tree sampled was in the sawtimber diameter class. The elm and miscellaneous groups contained the smallest diameters and shortest trees.

Stocking

Stocking estimates were calculated for each of the 84 sampled stands using the following equation developed by Goelz (1995):

$$Stocking = 0.01373(TA) + 0.096(TA[DqMean]) + 0.00378(TA[DqMean^2]) \quad (1)$$

Where:
TA = Trees per acre
DqMean = Quadratic mean diameter

Fifty percent of the stands sampled had greater than 100 percent stocking (table 5). Almost 36 percent of the stands were stocked at a level between 80 and 99 percent, meaning approximately 86 percent of the stands were either fully or overstocked.

Tree Classification

Each tree in the sample was classified using Putnam and others (1960) tree species classification system. Over 75 percent of the trees in the sample were in the class A species group and 16 percent in the class B Group. The class A group can be composed of species such as water, willow, white or cherrybark oaks, Pines, and sweetgum. Class B groups might be composed of overcup and southern red oaks, blackgum, or Tupelo. Approximately seven percent of the trees sampled fell into the less or undesirable C and D groups.

Each tree within each of the 84 stands was subjected to the species classification system to determine the mean stocking level by species class (tables 6 and 7). The average stand in the East Texas bottomland hardwood

Table 4—Means and ranges for DBH and heights by species groups

Species groups	Mean d.b.h.	Range	Mean height	Range
	Inches		Feet	
Oaks	19.79	2.5 - 70.5	89.67	8 - 163
Sweetgums	15.65	2.9 - 61.0	83.77	16 - 141
Blackgum	13.37	2.1 - 39.1	66.10	15 - 135
Elm	11.96	3.0 - 28.5	58.22	16 - 125
Ash	14.69	2.6 - 35.4	74.42	25 - 150
Pine	21.74	9.6 - 34.9	97.97	50 - 133
Miscellaneous	12.12	1.6 - 38.8	58.10	9-127

Table 5—Stocking levels of all stands sampled

Stocking	Number of stands	Percent of sample
Percent		
> 100	*42*	*50.0*
80-99	*30*	*35.7*
< 80	*12*	*14.3*
Total	*84*	*100.0*

Table 7-Mean stocking by species classification

Species class	Mean stocking	Range	Percent of mean stocking
		Percent	
A	75.95	*39.10 - 127.18*	*69.75*
B	*16.27*	*2.11 - 54.94*	*14.95*
C	*6.77*	.95 - *35.67*	*6.22*
D	9.90	*1.25 - 30.45*	*9.09*
Total	108.89		100.00

Table 6-Number of trees and percent of sample within four species classification groups

Tree classification group	Number of trees	Percent of occurrence
A	*3,757*	*76.5*
B	*808*	*16.4*
C	*172*	*3.5*
D	*176*	*3.6*
Total	4,913	100.0

forest contains just under 76 percent of the most commercially desirable class A tree species and approximately 16 percent of the class B species. Less than 17 percent of the average stand is comprised of the class C and D species. Also the average stand is overstocked with a mean stocking percentage of approximately 109 percent.

DISCUSSION

It appears that most bottomland hardwood stands in East Texas are overstocked and are in need some management decisions. Although these stand may be overstocked they at least appear to be overstocked with more commercially desirable species. The myth of East Teas bottomland hardwood being undesirable and of poor quality may be in jeopardy. Although this study did not address tree quality issues, at least with high quality species there should be an adequate seed source for future stands. Good seed sources combined with proper management decisions may lead to improved stand and tree quality.

Bottomland stands in East Texas are commonly referred to as "mixed" bottomland hardwoods. With 80 percent of the trees sampled being oaks and gums, perhaps "oak-gum" forest may be a better descriptor.

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