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Initial Investigation of Height-Diameter Relationships of Dominant Trees in the mixed Hardwood Bottomland Forests of East Texas

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INITIAL INVESTIGATION OF HEIGHT-DIAMETER RELATIONSHIPS OF DOMINANT TREES IN THE MIXED HARDWOOD BOTTOMLAND FORESTS OF EAST TEXAS

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Abstract—Three to five dominant trees from each of 445 ten-factor variable radius inventory points were utilized to evaluate the height- diameter relationships of 13 species or genera found on bottomland hardwood sites throughout east Texas. Regression analysis was performed using the linear model such that height = $\beta_0 + \beta_1$ x (d.b.h.). The species were placed into six groups: (1) pines (*Pinus taeda* and *P. enchinata*); (2) water oak/willow oak/white oak/swamp chestnut oak (*Quercus nigra*)/(*Q. phellos*)/(*Q. alba*)/(*Q. michauxii*); (3) blackgum/laurel oak/overcup oak (*Nyssa sylvatica*)/(*Q. laurifolia*)/(*Q. lyrata*); (4) ash/maple (*Fraxinus* spp.)/(*Acer* spp.); (5) hickories (*Carya* spp.), and (6) elms (*Ulmus* spp.), or were analyzed as individual species: (7) cherrybark oak (*Q. pagoda*) and (8) sweetgum (*Liquidambar styraciflua*) based on similar intercepts and slopes of the regression lines. The coefficients of the model were estimated and residual analysis conducted for each species group.

INTRODUCTION

There are about 180 million acres of commercial forest land in the Southern United States, 50 percent of which can be classified as being composed of hardwoods. Bottomland hardwood forests, growing on the flood plains of rivers and streams, comprise 14 percent (1.6 million acres) of the total commercial forest land in east Texas. These forests provide quality timber along with wildlife habitat. In east Texas, the area classified as bottomland hardwood has decreased by about 12 percent in the last 15 years, due primarily to the logging of accessible mature stands, shifts to croplands, and the development of man-made lakes (McWilliams and Lord 1988).

The demand for hardwood products, both within the United States and for export, is increasing (McWilliams 1988, Hair 1980). The pulp and paper industry is utilizing more hardwoods in an effort to increase the quality of their product. In addition, the demand for high-quality logs for lumber, plywood, and veneer is increasing. Since 1975, the world demand for U.S. hardwood logs, veneer, and lumber has quadrupled (Araman 1989). Hardwood harvesting rates are increasing while the supply is decreasing (Tansey 1988, Birdsey 1983).

Adequate information on bottomland hardwood growth and management has not kept pace with the knowledge we have on southern pines. (Porterfied 1972). Most of the research performed on bottomland hardwoods in the South to determine growth and yield information and management strategies of these species (Barrett 1995, Burns and Honkala 1990, Baker and Broadfoot 1979) often did not involve stands located in east Texas. The best management practices for the species found in these ecosystems in east Texas have not been determined, and growth equations, volume and yield tables, and site index curves for many southern hardwood species are lacking. This information gap is of such high priority to the National Hardwood Lumber Association, that resolution of this gap is one of their priorities for 1996. Since many of these questions can not be resolved in a single year, there will be a priority over the next decade to obtain the necessary information from which proper management decisions can be made.

There is a need to obtain information on what species are found in the bottomlands of east Texas as well as the stand structure of these bottomlands. Basic height and diameter relationship information on the dominant trees in these stands will provide some of this information. The objective of this study was to evaluate the dominant tree height-diameter relationships of the major species in the mixed bottomland hardwood forests of east Texas.

METHODS

The study areas were chosen to represent bottomland hardwood stands common to the region and data was collected from numerous sites within Angelina, Nacogdoches, Newton, Sabine, San Augustine, and Shelby Counties in the summers of 1993, 1994, and 1995. Sample points were systematically located within the study areas. Distance between points was three chains, and distance between transect lines was five chains. Initially the tallest five trees sampled with a 10-factor prism were utilized in this study, and the species, total height (to nearest foot) breast height (d.b.h. to nearest tenth of a foot) were recorded for each of these sampled trees. Species included cherrybark oak (*Quercus pagoda*), willow oak (*Q. phellos*), water oak (*Q. nigra*), laurel oak (*Q. laurifolia*), white oak (*Q. alba*), overcup oak (*Q. lyrata*), swamp chestnut oak (*Q. michauxii*), sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa sylvatica*), and pines (*Pinus taeda* and *P. enchinata*). A variety of hickories (*Carya* spp.), elms (*Ulmus* spp.), ash (*Fraxinus* spp.), and maples (*Acer* spp.) were also recorded. Additional species were initially included in the sample, but since they each totaled less than 10 individuals across all of the sample points, they were excluded from the analysis.

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Statistical analysis followed Oswald and others (1994). Preliminary analysis indicated that the relationship between tree height and d.b.h. of the dominant trees was linear. Therefore, the following equation was used for each of the above species:

$$\text{Height} = \beta_o + \beta_1 \times (\text{d.b.h.}). \quad (1)$$

Based on the similarity of the intercepts and slopes of the regression lines for each species, some of the species were placed into species groups. The equation (1) was then fitted to each species group. Otherwise, the species were evaluated individually. Residual analysis was also conducted for each model.

RESULTS AND DISCUSSION

Among the 2,165 dominant trees sampled, 73.7 percent were oaks (*Q.* spp.) with willow oak (26.1 percent), cherrybark oak (15.5 percent), and water oak (14.0 percent) being the dominant species (table 1). Only sweetgum (15.2 percent) approached these oaks in frequency. The tallest species tended to be cherrybark, white, willow and water oaks, while those with the largest d.b.h. were swamp chestnut oak and cherrybark oak. As is usually found on these sites, the maples, ash, and blackgum had the smallest mean diameters, while maple was the shortest in mean height.

The equation (1) was fitted to each species with more than 10 individuals over all of the plots. Based on similarity of the intercepts and slopes of the regression lines for each species, the species were placed into six species groups : Pines, water oak/willow oak/white oak/swamp chestnut , blackgum/laurel oak/overcup oak, ash/maple, hickories, and elms, or were analyzed as individual species: cherrybark oak and sweetgum. Then the equation (1) was refitted to the groups and the resulting models obtained:

(1) Ash/maple: HT = 54.40 + 1.82(d.b.h.) with N = 42, R^2 = 0.39, and C.V. = 18.1 percent
(2) Blackgum/laurel oak/overcup oak: HT = 63.05 + 1.30(d.b.h.) with N = 327, R^2 = 0.35, and C.V. = 13.7 percent
(3) White oak/swamp chestnut oak/willow oak/water oak: HT = 76.27 + 1.10(d.b.h.) with N = 990, R^2 = 0.26, and C.V. = 12.1 percent
(4) Cherrybark oak: HT = 82.59 + 1.08(d.b.h.) with N = 334 , R^2 = 0.26, and C.V. = 13.7 percent
(5) Pine spp: HT = 67.46 + 1.45(d.b.h.) with N = 81, R^2 = 0.39, and C.V. = 9.7 percent
(6) Sweetgum: HT = 60.02 + 1.95(d.b.h.) with N = 328, R^2 = 0.47, and C.V. = 12.6 percent
(7) Hickory spp.: HT = 69.87 + 1.23(d.b.h.) with N = 43, R^2 = 0.16, and C.V. = 16.5 percent
(8) Elm: HT = 19.50 + 3.07(d.b.h.) with N = 12, R^2 = 0.57, and C.V. = 18.9 percent

Equation (1) was also fitted to the total number of trees (2,165) to provide an overall equation for the relationship between height and diameter of all of the dominant trees:

HT = 69.78 + 1.36(d.b.h.) with R^2 = 0.33, and C.V. = 13.67

Table 1—Total number of trees, averages, and ranges of tree diameter and height of the dominant trees

Species	No. trees	Mean d.b.h.	Range	Mean height	Range
			Inches		*Feet*
Fraxinus spp.	33	18.9	7.1-35.4	92.9	45-150
Nyssa sylvatica	59	18.1	6.6-39.1	85.8	58-135
Ulmus spp.	13	20.7	11.8-28.3	83.2	45-125
Carya spp.	44	21.7	9.3-38.8	95.7	53-127
Pinus spp.	82	22.1	9.6-34.4	99.5	76-133
Acer spp.	10	18.8	12.4-26.7	75	55-92
Liquidambar styraciflua	329	19.7	4.0-40.2	98.6	16-141
Quercus pagoda	335	25.2	2.5-70.5	109.9	20-163
Q. lyrata	116	22.9	10.4-38.9	93.5	60-124
Q. michauxii	70	25.9	12.5-55.3	98.3	67-128
Q. nigra	303	22.4	7.7-43.4	101.4	46-153
Q. alba	52	22.4	10.9-37.3	101	70-130
Q. phellos	566	22.9	7.5-60.0	102	51-144
Q. laurifolia	153	19.8	4.8-48.6	88.7	58-136
Total	2165	21.6	2.5-70.5	94.7	20-163

Although the R^{2}'s of the models appear low, the primary purpose of the study was to evaluate the relationship between height and diameter of the dominant trees, not for prediction. The simulations using the above models for the groups are illustrated in figure 1.

The dominant oak species (cherrybark, willow, and water) all have good-to-excellent growth rates, are intolerant to shade, and are intermediate to very intolerant to periodic flooding. Cherrybark is the best of the red oaks in the region, while water and willow oaks can be favored through management on the flats (Barrett 1995). The other highly frequent species, sweetgum, needs release for best growth and form, but shows medium growth rates when compared to the above oaks. Some of the other species found in this study, specifically the hickories and ashes, can be managed for, as they can provide good-quality products for a variety of uses when found on better sites. The two pine species will most likely become even less of a component of these stands with harvesting and succession. Even-aged management in the form of clearcuts or modified shelterwood (Loftis 1990), or with uneven management through group-selection, are common management tools used in other bottomland hardwoods in the South (Barrett 1995), and should be effective in producing a high-quality product while maintaining the stand structure found on these sites.

CONCLUSIONS

Stands similar to those utilized in this study are found throughout east Texas. Many of these stands have been mis-managed, poorly managed, or not managed for a number of years. These same stands had been high-graded in the past, and are now made up of a variety of species,

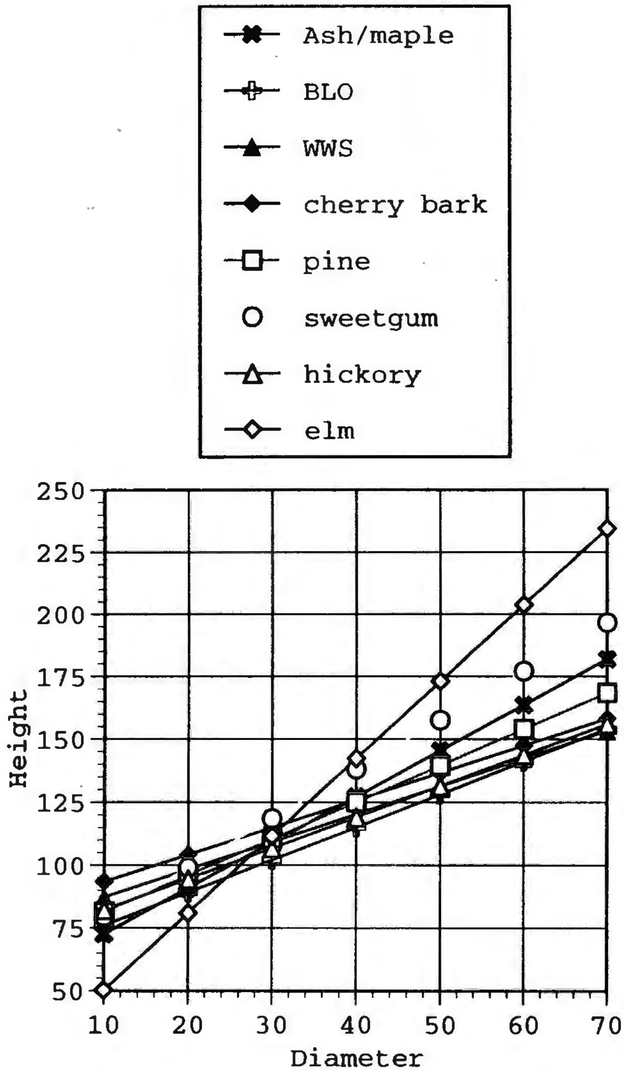

Figure 1—Simulation models of eight species groups.

many of which do not have traditional market value. With the increase in demand for hardwood by the pulp and paper industry, these species—traditionally an impediment to harvesting, regeneration, and management—make these stands more attractive for management. As can be seen from this study, these stands can and do produce good individual stems of high-quality species such as cherrybark and some of the other oaks, as well as sweetgum and occasionally loblolly pine. More information is needed on stand structure, age/height/diameter relationships and site productivity before the necessary management guidelines can be developed.

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