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Height. Growth of Loblolly and Slash Pine Plantations in the Northern Post-Oak Belt of Texas

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Height Growth of Loblolly and Slash Pine Plantations in the Northern Post-Oak Belt of Texas[1]

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*ABSTRACT. Age accounted for over 70% of the variation in tree height of 10- to 44-year-old loblolly pine (*Pinus taeda *L.) and slash (*Pinus elliottii *Engelm.) plantations established on deep sands, moderate sands, and nonsandy soils in the Northern Post-Oak Belt of Texas. Climatic and edaphic factors, relating either directly or indirectly to the amount of moisture available for tree use, explained up to 17% of height growth variation. Height growth of the plantations was comparable to that of plantations growing in the pine-mixed hardwood forest cover type of East Texas.*

*The Northern Post-Oak Belt of Texas is an area approximately 50 to 100 miles wide located between the pine–mixed hardwood forest type to the east and the blackland prairie to the west. Soils within the belt belong primarily to the Alfisol or Ultisol soil orders. The western-most areas of the belt receive up to 20% less annual rain fall than the pine–mixed hardwood type of East Texas (U.S. Environmental Data and Information Service 1949–1982). The present forest of this area is dominated by post oak (*Quercus stellata *Wang.), blackjack oak (*Quercus Marilandica *Muench.), bluejack oak (*Quercus incana *Bartr.), and black hickory (*Carya texana *Buckl.) (Ward 1984). Loblolly pine (*Pinus taeda *L.) and shortleaf pine (*Pinus echinata *Mill.) occur naturally only in scattered locations (Wilson and Hacker 1986).*

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The possibility of converting some of the acreages in this belt to southern pine has been postulated (Bray 1904, Walker 1972). Since 1930 there have been numerous attempts to establish pine plantations in this area, the majority occurring between 1940 and 1965. All four major southern pine species, loblolly pine, shortleaf pine, slash pine, and longleaf pine (*Pinus palustris* Mill.) have been planted. This study was an attempt to evaluate the performance of loblolly pine and slash pine plantations and to quantify the relationships between height growth and various climatic and edaphic factors.

METHODS

Loblolly and slash pine plantations ranging from 10 to 44 years old located within the Northern Post-Oak Belt (Figure 1) were inventoried. Plantations were stratified into three groups based on soil texture and depth: deep sands, moderately deep sands, and nonsands (Table 1). Initial plots were located in the approximate center of each soil stratum within a plantation. At these initial plots, total tree height was measured on five dominant and codominant trees using a Suunto® clinometer. Age was estimated from these trees by using an increment borer and counting rings. Additional height measurements were taken on every tenth tree, beginning with the first tree, and in the northeast corner of the plot.

Soil samples were taken from the surface 6 in. and from 20 in. below the top of the B horizon. Total soil depth (up to 60 in.), surface soil depth (A and E horizons), and subsoil thickness (B horizon) were determined at each plot. Soil texture was determined using the standard hydrometer method described by Bouyoucos (1951).

Climatic information was obtained from existing weather stations nearest to a respective sample plantation. Data utilized included average seasonal precipitation (December through February, March through May, June through August, and September through November), average seasonal daily temperatures, and average seasonal daily minimum and maximum temperatures.

Regression equations for total tree height were derived by stepwise multiple regression techniques for each soil group. Variables used in the final equations were those combinations that yielded the best results based on R^2 values. An F statistic significance value of 0.10 was used to determine entry of a variable into the final equations.

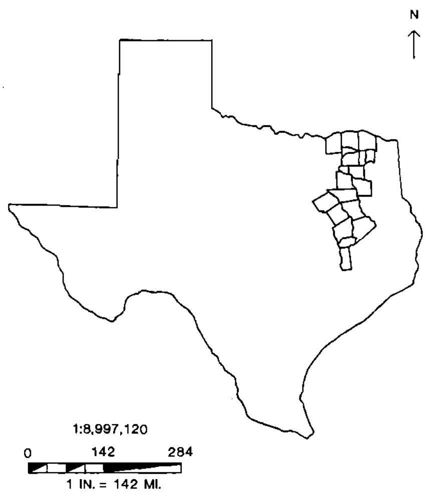

Figure 1. Counties of the Northern Post-Oak Belt of Texas.

[1] The research project was supported in part by funds made available through the McIntire-Stennis Act.

[2] Part of Doctor of Forestry dissertation by the senior author at Stephen F. Austin State University.

Table 1. Classification of soil generic subgroups into general soil groups.

Deep sands	Moderately deep sands	Nonsandy or wet
Grossarenic Paleudult	Arenic Paleudalf	Glossaquic Paleudalf
Aquic Quartzipsamment	Arenic Paleudalf	Aquic Paleudult
Grossarenic Paleustalf	Arenic Plinthic Paleudult	Typic Hapludult
Grossarenic Paleudult	Arenic Haplustalf	Typic Paleudalf
Ultic Quartzipsamment	Arenic Paleustalf	Vertic Hapludalf
Typic Quartzipsamment		Aquic Paleudalf
		Glossic Paleudalf
		Udertic Paleustalf
		Udic Haplustalf
		Plinthic Paleudult
		Arenic Paleaquult

RESULTS AND DISCUSSION

Loblolly Pine

The average tree height for 18 loblolly pine plantations established on deep sandy soils was 64.3 ft. The average age of these trees was 27 years, ranging between 11 and 43 years. Age accounted for 84% of the variation in tree height. Other variables accounted for only an additional 5% of the variation (average September through November minimum daily temperature, 3%, and thickness of the A horizon, 2%). Predicted heights utilizing average variable values corresponded approximately with site index 95 for second growth loblolly pine (Figure 2). Slope coefficients for both loblolly and slash pines are summarized in Table 2.

The average tree height for 14 loblolly pine plantations on moderately sandy soils was 62.9 ft. The average age of these trees was 26 years, with the youngest being 18

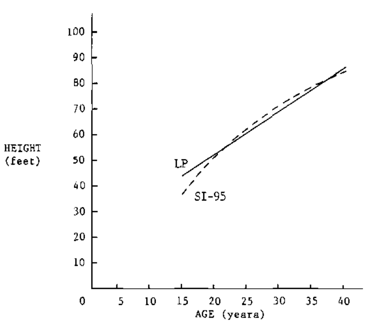

Figure 2. Predicted heights (LP) of loblolly pine on deep, sandy soils compared to site index 95 curve (USDA 1976).

$$HGT = 132.045 + 1.686\,AGE - 1.927\,SNMN - .191\,AHOR\ (SNMN = 54°, AHOR = 53'')$$

and the oldest being 29. Age accounted for 62% of the variation in height with silt plus clay content of the A horizon accounting for an additional 8%. Shorter trees were associated with increasing silt plus clay contents. Predicted heights using an average silt-plus-clay content of 21% corresponded approximately with a site index of 95 (Figure 3). Increasing silt-plus-clay contents in the A horizon would decrease expected height growth.

A total of 33 loblolly pine plantations were found on soils classified as nonsandy. The average height of these trees was 61.8 ft. Plantations ranged in age from 10 to 43 years, with 26 being the average. Age accounted for the majority of variation in tree height (71%). Climatic variables accounted for an additional 12% of the variation: June through August average daily temperature (9%), and September through November rainfall (3%). Predicted heights using average values for climatic variables approximated those heights found with site indices 90 and 95 (Figure 4). Increasing June through August temperatures would decrease height growth (primarily due to moisture stress) as would increased September through November precipitation (due to poor soil aeration).

Slash Pine

Seventeen slash pine plantations growing on deep sandy soils were sampled. The average tree height of these plantations was 71.3 ft. The age of these plantations ranged from 23 to 40 years, with an average age of 29. Age was positively correlated with height (accounting for 63% of the variation) as was spring rainfall (10%). However, June through August precipitation was negatively correlated with tree height (7%). Predicted tree heights, using average values for spring and summer rainfall, approximated the 90 to 95 site index curves (Figure 5).

Only 10 slash pine plantations were located growing on moderately deep sandy soils. The average height of these trees was 73.3 ft. The average age of these plantations was 30 years, ranging from 20 to 40 years. Age accounted for the vast majority of variation in tree height (83%), while the calculated variable age squared accounted for an additional 12%. The plantations grew rapidly for about 30 years and then experienced a significant decline in the rate of height growth No environmental variable was statistically significant in effecting height growth of slash pine on this soil type. Predicted heights compared well with the site index 95 curve (Figure 6).

Average tree height for the 13 slash pine plantations inventoried on nonsandy soils was 66.4 ft, with an average age of 29 years. The youngest plantation was 15 and the oldest was 44 years old. Age accounted for 71% of the variation in tree height while total soil depth accounted for an additional 12%. Trees growing on shallow soils were significantly shorter than trees growing on deeper soils. Predicted tree heights, using the average value for soil depth, compared favorably with site indices of 85 to 90 (Figure 7).

CONCLUSIONS

Environmental factors associated with climate and soil are known to affect tree growth (Coile 1952, Zahner 1958, Jackson 1962, Carmean 1975, and Foster 1985) This study indicated that numerous environmental factors played a role in the height and growth of loblolly and slash pines planted in the Post-Oak Belt of Texas. However, over 70% of

Table 2. Final slope coefficients of tree height for slash (SP) and loblolly (LP) pines by soil groups.

Variable	Deep sands SP	Deep sands LP	Moderate sands SP	Moderate sands LP	Nonsandy SP	Nonsandy LP
CONSTANT	−6.409 (.63)[a]	132.045	−57.246	16.009	−5.370	558.352
AGE	0.999	1.686 (.84)	7.130 (.83)	1.997 (.62)	1.448 (.71)	1.350 (.71)
AGESQ[c]	NS[b]	NS	−0.089 (.12)	NS	NS	NS
MMRAIN[d]	5.521 (.10)	NS	NS	NS	NS	NS
JARAIN[e]	−2.816 (.07)	NS	NS	NS	NS	NS
SNRAIN[f]	NS	NS	NS	NS	NS	3.234 (.03)
JAT[g]	NS	NS	NS	NS	NS	−6.09 (.03)
SNMN[h]	NS	−1.927 (.03)	NS	NS	NS	
AHOR[i]	NS	−0.191 (.02)	NS	NS	NS	
DEPTH[j]	NS	NS	NS	NS	0.536 (.12)	NS
SCA[k]	NS	NS	NS	−0.251 (.08)	NS	NS

[a] Partial index of determination = percentage units when multiplied by 100
[b] Variable not significant at the .10 level
[c] Age squared
[d] March through May precipitation
[e] June through August precipitation
[f] September through November precipitation
[g] Average daily temperature June through August
[h] Average daily minimum temperature September through November
[i] Thickness of surface
[j] Soil depth to C horizon
[k] Silt-plus-clay percent in the A horizon

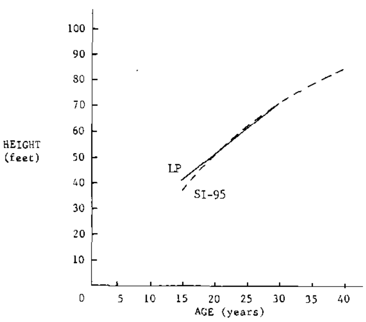

Figure 3. Predicted heights (LP) of loblolly pine on moderately deep sandy soils compared to site index 95 curve (USDA 1976).

$$HGT = 16.009 + 1.99\,AGE - .251\,\text{SCA}\ (SCA = 21\%)$$

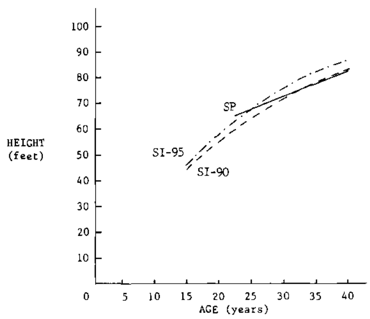

Figure 5. Predicted heights (SP) of slash pine on deep sandy soils compared to site index 90 and 95 curves (USDA 1976).

$$HGT = -6.409 + .999\,AGE + 5.521\,MMRAIN - 2.816\,JARAIN\ (MMRAN = 12.8'',\ JARAIN = 8'')$$

height growth seems to be determined by tree age.

The most important limiting factor in establishment of southern pine plantations in the Post-Oak Belt is poor initial seedling survival. But once the plantations have been established, their growth is comparable to pine growing in the pine–mixed hardwood type of East Texas.

Many opportunities exist in the Northern Post-Oak Belt to convert the post oak–blackjack oak cover type to southern pines. Much of the land in this zone is considered marginal for agricultural uses. Planting southern pines (principally loblolly pine) on such land

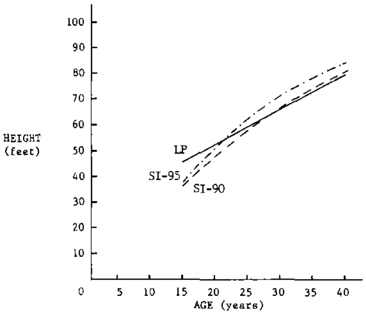

Figure 4. Predicted heights (LP) of loblolly pine on nonsandy soils compared to site index 90 and 95 curves (USDA 1976).

$$HGT = 558.352 + 1.35\,AGE - 6.095\,JAT - 3.234\,\text{SNRAIN}\ (JAT = 81°,\ SNRAIN = 11.4'')$$

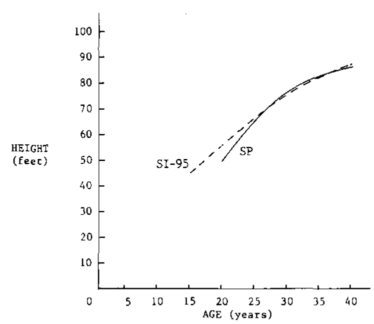

Figure 6. Predicted heights (SP) of slash pine on moderately deep sandy soils compared to site index 95 curve (USDA 1976).

$$HGT = -57.246 + 7.13\,AGE - .089\,AGESQ$$

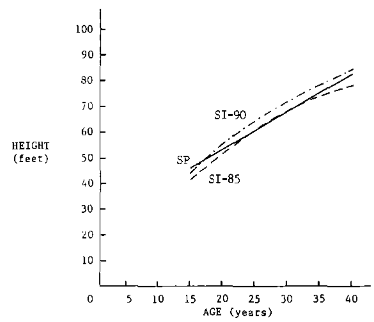

Figure 7. Predicted heights (SP) of slash pine on nonsandy soils compared to site index 85 and 90 curves (USDA 1976).

$$HGT = 5.370 + 1.448\,AGE + .536\,DEPTH\ (DEPTH = 56'')$$

could be a viable land-use alternative. □

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A Simple Competition Assessment System Associated with Intensive Competition Control in Natural Loblolly–Shortleaf Pine Seedling Stands[1]

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*ABSTRACT. A simple competition assessment system was evaluated as part of an intensive competition control study in a natural, even-aged stand of loblolly–shortleaf pine (*Pinus taeda *L.–*P. echinata *Mill.) seedlings in southern Arkansas. Four levels of competition control were maintained annually for 3 years as follows: (1) no competition control, (2) woody competition control, (3) herbaceous competition control, and (4) total control of nonpine vegetation. The competition assessment system is based on a correlation of total height to groundline diameter (gld) for loblolly pine seedlings that are less than 6 ft tall. The correlation indicated that if seedling gld's are not within +10 mm of total seedling height (in feet) multiplied by 10, then the seedlings would most likely show a positive growth response to competition control.*

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In loblolly pine management, considerable emphasis is placed on site preparation to facilitate natural or artificial regeneration of cutover lands. Traditionally, operational site-preparation treatments are considered to be successful if they result in well-stocked stands of loblolly pine seedlings that grow in height at a rate equal to or exceeding that of reinvading competition, at least until the time of crown closure when the pines dominate the site. However, there has been increasing evidence in the last 10 years that supplemental control of competing vegetation during the time between pine establishment and crown closure can produce substantial pine growth gains in both height and diameter (Haywood and Tiarks 1981, Nelson et al. 1981, Knowe et al. 1985, Tiarks and Haywood 1986, Zutter et al. 1986, Bacon and Zedaker 1987, Miller et al. 1987).

In studies where the effects of various components of competition (woody and herbaceous) have been examined, competition from herbaceous species rather than woody species has been found to contribute to significant loss in pine growth through the first 5 years following pine establishment. Results from these intensive competition control studies represent unique standards of pine growth response to which operational treatments can be compared.

The problem faced by forest landowners in light of these research findings is how to assess a potential response from competition control in stands of pine re-

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