DETERMINING STOCKING LEVELS IN YOUNG, MIXED HARDWOOD STANDS IN THE NORTH CAROLINA PIEDMONT

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Abstract—Upland Piedmont hardwood stands represent an important forest type in North Carolina and the Southeastern United States. Many of these forests are being converted to other land uses. A solution to maintaining these forest types lies in increasing productivity and profitability of this resource. This implies a shift from traditional, extensive management to more intensive silviculture, including pre-commercial thinning. However, there is a lack of information available to managers for assessing stocking levels and to guide decisionmaking in these upland stands. A preliminarily model for identifying full stocking is presented.

INTRODUCTION

Forest managers are continually seeking ways to increase production and efficiency of forests. Southern hardwoods are generally managed under an even-aged silvicultural system, with clearcutting often prescribed as the regeneration method. Even-aged regeneration methods commonly regenerate 10,000 to 40,000 stems per acre (Johnson and Krinard 1988, Romagosa and Robison 2003, Young and others 1993). Given that current rotations produce a few hundred harvestable stems per acre, it seems apparent that 10,000 or more stems per acre at establishment is well overstocked.

Density reductions through release cuttings and precommercial thinnings have been shown to increase diameter growth (Miller 2000), height growth (Schuler and Robison 2002), both height and diameter growth (Johnson and others 1997, Newton and others 2002), and, in some instances, neither (Trimble 1973). However, as Kochenderfer and others (2001) note, the greatest gains in value arise from improved species composition following thinnings.

Works by Kellison and others (1981), Resovsky (1984), and others have indicated that many Piedmont mixed hardwood stands are largely overstocked. Thinning trials have been installed on a variety of sites in the South, often without specific understanding of relative density and the effects of species composition as stands age (Roach 1977, Stout and Nyland 1986). Chisman and Schumacher (1940) illustrated the species effect in their classic work on tree-area ratios. In their example, they showed that pines and hardwoods occupied different amounts of space as a function of diameter.

Traditional theories of stand regulation advocate holding stand-level stocking at a point where individual tree growth is optimized while still fully occupying the site. This level is commonly termed the B-line on stocking guidelines. Even at 1 to 3 years of age, southern hardwood stands have been shown to respond to precommercial thinning (Schuler and Robison 2002). However, information on desirable stocking levels (i.e., 70 percent versus 100 percent) in young stands remains sparse.

Stocking guides have been produced for a number of forest types and species throughout the United States, and some developed elsewhere are being applied in upland Piedmont stands (Gingrich 1967). None have been developed specifically for young upland Piedmont hardwoods.

Most stocking adjustments in stands less than pole-sized are performed using a best guess approach to residual stocking because there are no guidelines presently available. Existing stocking guides do not provide information on trees less than 3 inches in d.b.h. (Gingrich 1967). Without guidelines to judge the relative level of stand density, these treatments may be ineffective, detrimental, or, at least, inconsistent. This research provides a preliminary guide to relative stocking levels for young natural, mixed hardwood stands in the Piedmont as part of an ongoing effort to understand stand dynamics of these sites.

METHODS

We inventoried 46 plots in upland Piedmont mixed hardwood stands in North Carolina, recording species and diameter of individual stems greater than breast height to provide the basis for estimating the A-line (100 percent stocking). Plot size was variable depending on average tree size, which ranged from about 0.3 to 6 inches quadratic stand diameter (QSD). Plots were selected based on the following criteria:

1. Free-growing since regeneration (e.g., clearcut)
2. Composed of commercially valuable species
3. No indication of disturbance (e.g., wind throw)
4. No silvicultural treatments since stand establishment
5. Apparent full stocking (e.g., obvious mortality present).

The A-line was estimated by two techniques, first by using the classic tree area ratio (TAR) method (Chisman and Schumacher (1940):

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Tree Area (milacres) = $B_0(N) + B_1(\Sigma D) + B_2(\Sigma(D^2))$, (1)

where N and D represent number of stems per unit area and diameter (in inches), respectively, and B_0, B_1, B_2 are regression coefficients.

Secondly, a modification of the TAR by Roach (1977) and Stout and Nyland (1986) was used, which includes a technique to account for species composition:

Tree Area (milacres) = $\Sigma_i (B_{oi} N_i + B_{1i} \Sigma_j D_{ij} + B_{2i} \Sigma D^2_{ij})$, (2)

where N_i is the number of trees per unit area of the i^{th} species, D_{ij} is the diameter of the j^{th} tree of the i^{th} species on the plot, and B_{oi}, B_{1i}, and B_{2i} are regression coefficients.

RESULTS AND DISCUSSION

The TAR model for all species combined fit the data reasonably well (r^2=0.88), but with some dispersion of data points (fig. 1). Fit improved greatly when a species composition component with 5 groups was included (table 1; r^2 = 0.96). Species groups were selected to be consistent with the North Carolina State University Hardwood Research Cooperative growth and yield model for southern hardwoods (work in progress). Quadratic mean diameters represented in both models ranged from about 0.3 to 6 inches. Parameter estimates are listed in table 2.

The predicted stocking level for the combined species model averaged 92 percent with a standard deviation over 35 percent. Accuracy of the predicted stocking levels for the species group model was improved, where stocking averaged 96 percent with a standard deviation less than 20 percent. This model, which included species groups, improved predictions by accounting for differences in growing space requirements of various species groups. There were substantial differences in growing space needs depending on species composition, e.g., yellow-poplar (A) versus white oak (C) groups (fig. 2). The hickory species group (D) behaved much differently than the others. Its shape was more parabolic over the range of data, which we were unable to explain at this time. Nonetheless, since hickory has such a small component in these stands, its impact was probably minimal on the overall model.

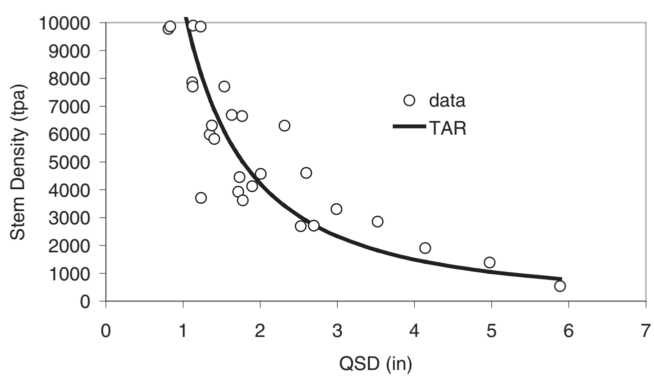

Figure 1—Stem-density predictions using combined species TAR model. Note that data less than 1 inch was not shown for illustration purposes.

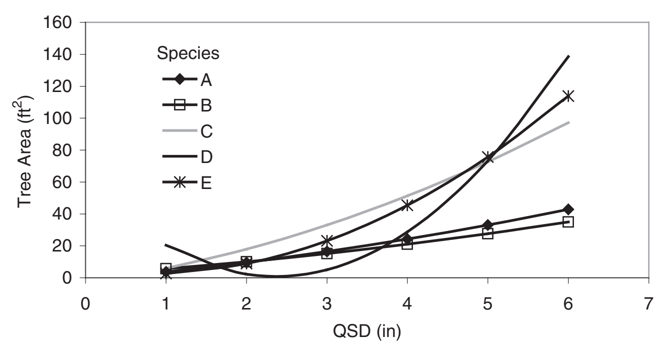

Figure 2—Tree-area curves for different species groups showing the growing space requirement under full stocking conditions. Members of each species group are identified in table 1.

Table 1—Species groupings used for TAR equation and compositional breakdown for selected Piedmont forest stands

Species group	Percent basal area of all plots	Included species
A	51.9	Yellow-poplar (*Liriodendron tulipifera* L.), sweetgum (*Liquidambar straciflua* L.), blackgum (*Nyssa sylvatica* Marsh.), and red maple (*Acer rubrum* L.)
B	24.4	Red oak[a] (*Quercus rubra* L.), redbud (*Cercis canadensis* L.), ash (*Fraxinus* spp.), elm (*Ulmus* spp.), and pine (*Pinus* spp.)
C	6.3	White oak[b] (*Q. alba* L.), black cherry (*Prunus serotina* Ehrh.), sycamore (*Platanus occidentalis* L.)
D	3.1	Hickory (*Carya* spp.), willow oak (*Q. phellos* L.)
E	14.3	Miscellaneous, mainly dogwood (*Cornus florida* L.), and all others

TAR = tree area ratio.

[a] Includes black oak (*Q. velutina* Lamarck), scarlet oak (*Q. coccinea* Muench.), S. red oak (*Q. falcata* Michx.)

[b] Includes post oak, (*Q. stellata* Wang.) and chestnut oak (*Q. prinus* L.).

Table 2—Parameter estimates for TAR model for combined species and species-grouped models

Parameter	Combined species	Species-grouped model				
		A	B	C	D	E
B_0	0.02863	-0.0296	0.0408	-0.0694	1.3601	0.1014
B_1	0.04908	0.1027	0.0740	0.1686	-1.1331	-0.1314
B_2	0.02727	0.0110	0.0086	0.0358	0.2394	0.0917

TAR = tree area ratio.

Other stocking guides developed specifically for use in this region (Brenneman 1983), or those often applied (Gingrich 1967) generally predict densities much lower than those suggested here. This may be due to tallied size-class differences among guides. Our tallies included all stems greater than breast height. The Gingrich guide starts at 1-inch d.b.h., whereass others focus on merchantable size classes and ignore small stems.

The utility of the approach here is that it can be applied to young stands with smaller stems and higher densities than current stocking guides accommodate. Foresters may use this type of guide to determine percent stocking and whether stands have attained desired density or to make informed density control decisions for precommercial treatments.

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