Forest Ecology and Management, 14 (1986) 205—210
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

COMPARISON OF BIOMASS EQUATIONS FOR PLANTED VS. NATURAL LOBLOLLY PINE STANDS OF SAWTIMBER SIZE

D.H. VAN LEAR[1], M.A. TARAS[1], J.B. WAIDE[2] and M.K. AUGSPURGER[1]

[1] *Department of Forestry, Clemson University, Clemson, SC 29631 (U.S.A.)*
[2] *U.S. Forest Service, Coweeta Hydrologic Laboratory, Franklin, NC (U.S.A.)*

(Accepted 17 October 1985)

ABSTRACT

Van Lear, D.H., Taras, M.A., Waide, J.B. and Augspurger, M.K., 1986. Compar biomass equations for planted vs. natural loblolly pine stands of sawtimb *For. Ecol. Manage.*, 14: 205—210.

Equations predicting biomass of components of sawtimber-size trees in a near-m loblolly pine (*Pinus taeda* L.) plantation were compared to similar equations uneven-aged natural loblolly pine stand. Combined analysis of the two sites r that curves estimating total tree, stem wood, stem bark, branches, and foliage + b weights were significantly different, while curves predicting biomass for tot and foliage were similar. Biomass equations differ because of variations in tre ponent ratios and taper associated with site and stand conditions.

INTRODUCTION

Interest in estimating above-stump biomass of trees has increase matically in the last decade for two major reasons. First, more cor utilization is considered by many as a necessity to meet increasing de for timber (Taras and Clark, 1974). Secondly, ecologists and fore scientists are concerned about effects of biomass removal on nutrient and site productivity (Leaf, 1979). Regardless of the source of in there is an obvious need to be able to predict biomass of trees am components.

Biomass equations for a loblolly pine plantation growing on a quality site in the Piedmont of South Carolina have recently been put (Van Lear et al., 1984). These equations use diameter breast height (as the independent or concomitant variable and are the only equ available in the literature for older loblolly pine plantations, alt equations do exist for younger plantations (Nemeth 1972; Nelso Switzer, 1975). Taras and Clark (1974) earlier developed biomass tions based on $(DBH)^2$ and total height for natural uneven-aged lo pine trees in Alabama. Since we also had unpublished biomass equ

0378-1127/86/$03.50

for mature plantation-grown loblolly pine based on $(DBH)^2$ and total he: a comparison of these equations was undertaken. This paper presents re: of that comparison.

METHODS

Field procedures used in sampling 41 loblolly pine trees in a nat uneven-aged stand on the Oakmulgee District of the Talladega Nati Forest in Alabama have been described by Taras and Clark (1974). same methodology was used for sampling 16 plantation-grown trees du February and early March on the Clemson Experimental Forest in Piedmont of South Carolina (Van Lear et al., 1984). Characteristic sample trees from both studies are shown in Table 1. For both sites, ab ground biomass is actually referring to above-stump biomass. Stump hei were approximately 15 cm.

TABLE 1

Characteristics of sample trees at the Clemson and Alabama sites

DBH class (cm)	Number of trees sampled	DBH[a] (cm)	Total height[a] (m)	Average taper (*D/H*)
Clemson site: 41-year-old plantation				
<18	3	14.1 (12.7-15.5)	16.1 (15.6-16.8)	0.88
18—27	6	22.6 (18.8-26.9)	19.7 (17.4-22.8)	1.15
27—36	5	30.8 (27.4-34.0)	22.5 (21.1-23.5)	1.37
>36	2	38.2 (37.8-38.6)	24.8 (24.3—25.4)	1.54
Alabama site: uneven-aged stand 31—47 years old				
15	3	15.2 (14.2—16.5)	15.9 (14.6-17.4)	0.96
20	3	20.1 (19.6—20.6)	18.3 (16.8-19.8)	1.09
25	7	25.4 (24.9—26.2)	22.9 (16.2-25.9)	1.11
30	4	30.7 (30.2-31.2)	23.8 (21.6-26.8)	1.29
35	6	35.6 (35.1-36.1)	26.8 (24.7-28.6)	1.32
40	6	40.9 (40.1-41.7)	28.0 (25.0-29.3)	1.46
45	6	45.5 (44.7-46.7)	27.7 (25.6—29.3)	1.64
50	6	51.1 (50.3—51.8)	30.8 (28.6—32.6)	1.66

[a]Mean and range.

Regression equations were developed to predict dry weights of the stump biomass of various tree components. Equations were of the

$$Y = aX^b$$

where Y = total tree or tree component weight, and $X = D^2 H$, whe: DBH in m and H = total height in m.

Similarities or differences between biomass curves for the various ponents were tested by examining parametric hypotheses concerni: exponents for each component curve for the two sites. The hypc were as follows:

H $(a^1 = a^2)$
H $(b^1 = b^2)$
H $(a^1 = a^2$ and $b^1 = b^2)$

The hypotheses were tested using the principle of conditional which compares residual errors from the conditional model with the r(errors from the model with no conditions imposed (Neter and Wass< 1974). Failure to reject the hypothesis $(a^1 = a^2$ and $b^1 = b^2)$ infe the two sites had similar curves for that given biomass component.

RESULTS AND DISCUSSION

Combined analysis of the Clemson and Alabama sites indicate equations estimating total tree, stem wood, stem bark, branches, and : plus branches were different (Table 2). Curves predicting biomass fo stem and foliage at the two sites were not significantly different. A n of factors contribute to those differences.

Biomass equations using D^2H as the independent variable would pected to differ from area to area, especially if the comparison is be

TABLE 2

Equations for predicting biomass of tree components for a 41-year-old loblol plantation (Clemson site) and a natural uneven-aged loblolly pine stand (Alabar

Tree component	Site: Clemson	Site: Alabama
Total tree*	$195.48\ (D^2H)^{1.13}$	$194.04\ (D^2H)^{0.99}$
Total stem	$175.73\ (D^2H)^{1.03}$	$164.92\ (D^2H)^{0.98}$
Stem wood*	$156.70\ (D^2H)^{1.06}$	$142.85\ (D^2H)^{1.00}$
Stem bark*	$18.25\ (D^2H)^{0.78}$	$21.56\ (D^2H)^{0.81}$
Foliage	$4.63\ (D^2H)^{1.23}$	$9.29\ (D^2H)^{0.77}$
Branches*	$16.38\ (D^2H)^{1.75}$	$19.83\ (D^2H)^{1.15}$
Foliage + branches*	$20.82\ (D^2H)^{1.67}$	$28.60\ (D^2H)^{1.06}$

*Indicates that equations are significantly different at the 0.05 level.

natural stands and plantations or. between good and poor quality si In this comparison, the Alabama trees were growing in an uneven-a natural stand while the Clemson trees were growing in an even-aged plaı tion. Stocking levels and competition are more variable during developm of natural uneven-aged pine stands as compared to plantations. Small dii eter trees in uneven-aged stands tend to be in the younger age classes. You er trees have a greater proportion of their biomass in foliage and branc than do older trees. Thus, the distribution of biomass among tree cc ponents would differ between trees from the two sites because of stock and age differences, and these differences would be reflected in biom equations.

Trees growing in stands as divergent as these have different average ta] Taper, in this paper, is defined as the diameter at DBH in cm divided the height of the tree in m (Snowdon et al., 1981). Average taper o tree of 31 cm diameter (Table 1) is greater (1.37 vs. 1.29) for the Clem site. Similarly, average taper of a 36–38 cm tree is about 17% greateı Clemson. It was not possible to compare tapers of trees larger than cm diameter because trees of this size were not sampled at the Clem site. However, the data indicate that the ratio *D/H* continues to incre as tree diameter increases.

Site quality affects tree taper and, therefore, the statistics of biorr equations. The Alabama stand was apparently growing on a higher qua site than was the Clemson plantation (average height of a 38 cm D tree at the Alabama site was 27.4 m compared to 24.8 m at Clemsc Young trees in the natural uneven-aged stand grew more slowly beca

TABLE 3

Comparisons of predicted biomass for components of loblolly pine trees based u the Clemson and Alabama D^2H regression models

Tree component	Tree DBH (cm)	Tree height (m)	Biomass (kg)	
			Alabama	Clemson
Total tree	25	21	254.0	265.8
Stem to 5 cm top			215.3	232.5
Stem wood to 5 cm top			187.5	209.1
Stem bark to 5 cm top			26.9	22.6
Needles			11.5	6.5
Branches			27.1	26.4
Total tree	35	24	564.4	661.2
Stem to 5 cm top			474.5	533.6
Stem wood to 5 cm top			420.0	491.5
Stem bark to 5 cm top			51.6	42.3
Needles			21.3	17.4
Branches			68.5	108.1

of surrounding overstory trees; thus, overhead competition in the nat stand neutralized site differences and made biomass predictions for t of small to medium diameter similar for most components (Table 3). I where an assumed height of 21 m (the height of a 25-cm tree at the Clem site) is included in the D^2H factor, biomass predictions for total tree, st and branch components are similar for the two sites. However, when diameter is increased to 35 cm and a height of 24 m is assumed (a the height of a 35 cm tree at the Clemson site), biomass predictions di widely between the Clemson and Alabama sites, indicating different terns of growth between the two areas. Predicted total tree biomass these larger trees differed by 17% for the two sites when using the equations. Other tree components differed even more.

CONCLUSIONS

Biomass prediction equations based on D^2H as the independent vari differ for most tree components between natural uneven-aged lobl pine stands and plantations. These differences are the result of differer partitioning of growth among tree components and because of tree ti variations associated with site and stand conditions. For these reas regional equations based on diameter only may introduce large error biomass estimation.

ACKNOWLEDGEMENTS

This research was sponsored in part by the Biomass Energy Syst Division, U.S. Department of Energy, under contract W-7405-eng-26 \ Union Carbide Corporation.

REFERENCES

Leaf, A.L. (Editor), 1979. Proc. Impact of Intensive Harvesting on Forest Nut Cycling. SUNY College of Environ. Sci. and Forestry, School of Forestry, Syrac NY, 421 pp.

Nelson, L.E. and Switzer, G.L., 1975. Estimating weights of loblolly pine trees and t components in natural stands and plantations in central Mississippi. Miss. Agr. Exp. Sta. Tech. Bull. 73, 15 pp.

Nemeth, J.C., 1972. Dry matter production and site factors in young loblolly *(P taeda* L.) and slash pine (*Pinus elliottii* Engelm.) plantations. Ph.D. Diss., N.C. £ Univ., Raleigh, NC, 95 pp.

Neter, J. and Wasserman, W., 1974. Applied Linear Statistical Models. Richard O. Ir Homewood, IL, 842 pp.

Snowdon, P., Waring, H.D. and Woollons, R.C., 1981. Effect of fertilizer and v control on stem form and average taper. Aust. For Res., 11: 209–221.

Taras, M.A. and Clark, A., III, 1974. Aboveground biomass of loblolly pine in a n
uneven-aged sawtimber stand in central Alabama. TAPPI For. Biol. Conf.
pp. 107-116.
Van Lear, D.H., Waide, J.B. and Teuke, M.J., 1984. Biomass and nutrient cont
a 41-year-old loblolly pine (*Pinus taeda* L.) plantation on a poor site in South Ca
Forest Sci., 30: 392–403.