HEIGHT-DIAMETER RELATIONS OF MAPLE STREET TREES

by David J. Nowak[1]

Abstract. Height and diameter measurements were taken for silver, sugar and Norway maple street trees in Rochester and Syracuse, New York. Mature silver maples proved to be the tallest of the three species. Average sugar maple' height was consistently taller than Norway maple' height until diameters reached 28 inches. Average mature tree height for all three species level off in the mid to upper 70-foot range. Tree age estimates were derived from the literature. After about the age of 35 years, silver maples appear to dominate the maples in terms of tree height. Height-diameter and height-approximate age curves are given.

Des mesures de hauteurs et de diamètres étaient prises pour les érables argentés, à sucre et de Norvège en situation d'arbres de rues à Rochester et à Syracuse, New York. L'érable argenté à maturité s'avérait être le plus grand des trois espèces. La hauteur moyenne de l'érable à sucre était conséquemment plus grande que la hauteur moyenne de l'érable de Norvège jusqu'à ce que les diamètres 28 pouces (71 centimètres). La hauteur moyenne des arbres à maturité pour les trois espèces s'élève dans les 75 à 80 pieds de hauteur. Les estimations pour l'âge des arbres étaient dérivés de la littérature. Après l'âge de 35 ans environ, les érables de argentés semblent dominer les érables en terme de hauteur d'arbre. Les courbes hauteur-diamètre et hauteur-âge approximatif sont données.

In urban areas, tree height is an important consideration in deciding what species to plant and/or where to plant them. Species height can influence views, maintenance costs (e.g., utility wire clearance), distance of windbreak efficacy, solar access and energy conservation (e.g., 3, 15). Considering that many urban tree inventories measure tree diameter without regard to tree height, height-diameter relations are necessary for estimating heights.

Maple trees are rated as the most common trees in the urban United States and are particularly abundant in the northeastern and north central U.S. (2, 7, 8, 10). Three of the most common maples are Norway maple *(Acer platanoides)*, sugar maple *(Acer saccharum)* and silver maple *(Acer saccharinum)*. For this study, height and diameter measurements were taken in Rochester and Syracuse, New York, to compare the height-diameter relations of these three popular species. Height-age estimates for each species are also computed.

Methods

In Rochester (1980 pop. 241,741) and Syracuse (1980 pop. 170,105), New York, a three-stage sample scheme was applied to areas of the cities with a medium to high density of older trees (16). These areas were chosen using aerial photographs and ground observations. This type of sampling excluded the older, central areas of both cities because they had low tree densities. Within this sample, street tree height and diameter measurements were taken for 1955 Norway maples (1218 from Syracuse; 737 from Rochester), 865 silver maples (520 from Syracuse; 345 from Rochester), and 541 sugar maples (326 from Syracuse; 215 from Rochester). Stem diameter was measured at a height of 4.5 feet with a dbh tape and recorded to the nearest inch. Height was measured by clinometric triangulation techniques and recorded to the nearest foot.

Standard deviation of height versus diameter was plotted for each species and by visual inspection it was determined that the variances were homogenous enough not to warrant weighted least squares method of analysis.

Regression analysis was performed to determine if (1) the height-diameter relationship of the three species can be considered to be approximately the same; (2) the better fitting regression function is either linear ($y=b_0+b_1x$) or quadratic ($y=b_0+b_1x+b_2x^2$) and (3) the regression functions differ between Rochester and Syracuse, New York.

The range of diameters over which the regressions were calculated varied among the three species. For Norway maple, the sample diameters ranged from 1 to 37 inches; sugar maple: 3 to 37

1. Current Address: c/o Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, 1960 Addison St., Box 245, Berkeley, CA 94701

inches; and silver maple: 3 to 41 inches.

Predicted values of height, and confidence and prediction limits were calculated for each one-inch diameter class and graphed for all three species (Figures 1-3). Confidence limits are used to set bounds for estimating the true mean of the population, while prediction limits set bounds when predicting individual values (12). That is, there is a 95% probability that the true mean height for given diameter is within the 95% probability that the true mean height for given diameter is within the 95% confidence limits, and 95% probability that any individual tree height for a given diameter is within the 95% prediction limits. The width of the prediction limits represents the variability of the population and the heights of the individual trees of the population will generally fall within these limits.

To compare the height-diameter relationships among the three species, diameter ranges where average tree height was significantly different from another species were calculated (Figure 4). These differences are observed where confidence intervals do not overlap.

To allow the reader to approximate tree age from the diameters given, age-diameter formulas were used that were derived from street tree data collected in Central New Jersey (1). These data are constrained by limited diameter ranges. For silver maple, the age-diameter regressions were calculated for diameters 6 – 35 inches (r^2 = 0.43); for sugar maple: 6 – 28 inches (r^2 = 0.57); and for Norway maple: 6 – 27 inches (r^2 = 0.42). The age-diameter formulas should not be applied to diameters outside of these ranges.

Comparisons of height-approximate age relations were computed and graphed but statistical differences in height among species could not be calculated because the age data were derived from regression formulas.

Results

The height-diameter regressions for each of the three species were significantly different from one another (alpha = 0.01). Each species' height-diameter regression also proved to be quadratic

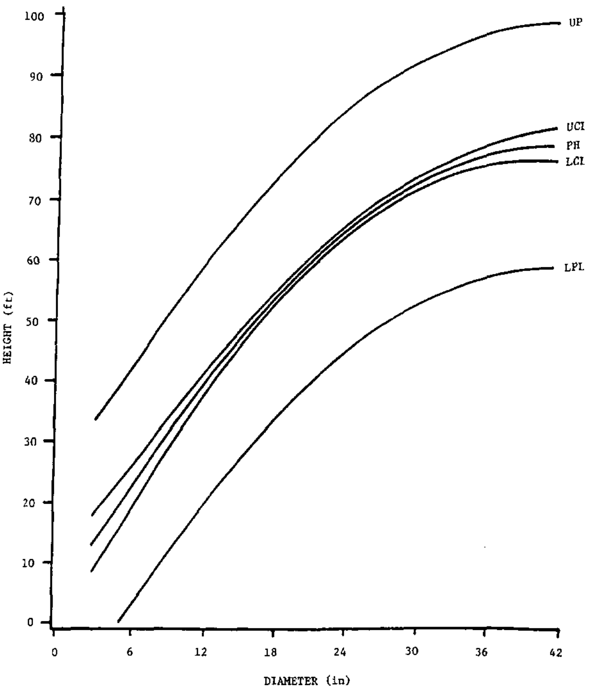

Figure 1. Silver maple height-diameter relationship. H = predicted height. Approximate age is derived from age-diameter relationships given in Fleming (1).

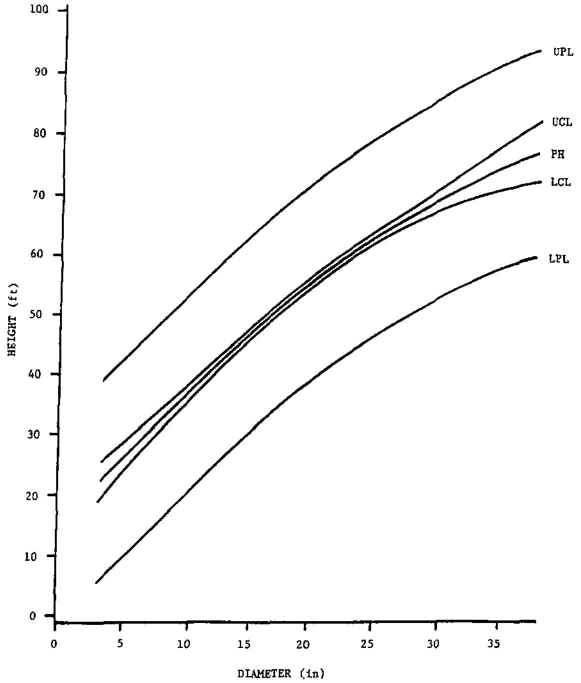

Figure 2. Sugar maple height-diameter relationship. H = predicted height. Approximate age is derived from age-diameter relationships given in Fleming (1).

(alpha = 0.01) (Table 1).

Regression functions were significantly different between Rochester and Syracuse for Norway and silver maples (alpha = 0.01). However, the differences between the regression functions were limited to trees greater than 24 inches in diameter with trees in Rochester averaging approximately five feet taller than trees in Syracuse.

Because of the limited differences in the regression functions between the cities and the need for simplified formulas (i.e., not city specific), the city data were combined for a single regression formula. Estimates of average Norway and silver maple heights for trees greater than 24 inches in diameter will tend to underestimate Rochester tree heights by approximately three feet and overestimate Syracuse tree heights by approximately two feet.

Norway maple' predicted height is significantly lower than sugar maple' height between 3 and 28 inches and significantly lower than silver maple' height from approximately 12 to 34 inches in diameter (Figure 4). Sugar maple was the tallest for small diameter trees (3-9 inches) while silver maple proved the tallest for mid to large diameter trees (19-31 inches). Norway maple's predicted height is never significantly higher than any of the other two species (Figure 4).

For trees larger than 34 inches in diameter, no differentiation between predicted heights of the three species could be determined. In these larger diameter classes, all species' predicted heights level off in the mid to upper 70 foot range (Figure 4).

When comparing tree height with approximate tree age sugar maple appears to have the fastest height growth when young, but after about 35 years, silver maple dominates the maples in terms of tree height. There is a relatively small height difference between sugar and Norway maples and this difference diminishes with age. No statistical analysis of height-age relations could be made and these interpretations are derived from height-diameter confidence limits established in this study.

Discussion

Cultural practices, especially pruning, greatly influence tree height in urban areas. Differences in

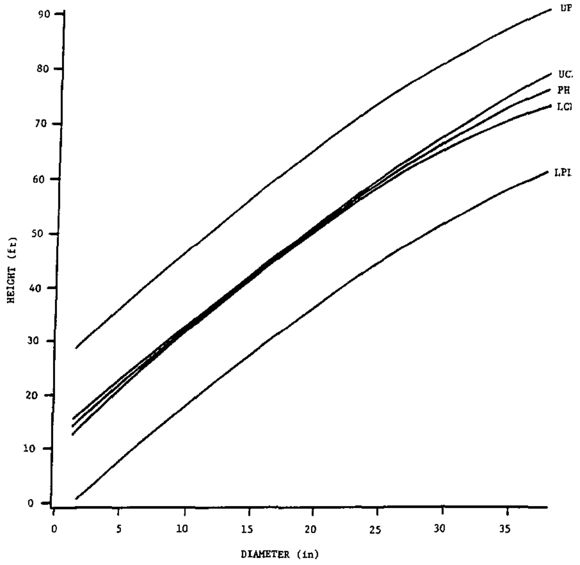

Figure 3. Norway maple height-diameter relationship. H = predicted height. Approximate age is derived from age-diameter relationships given in Fleming (1).

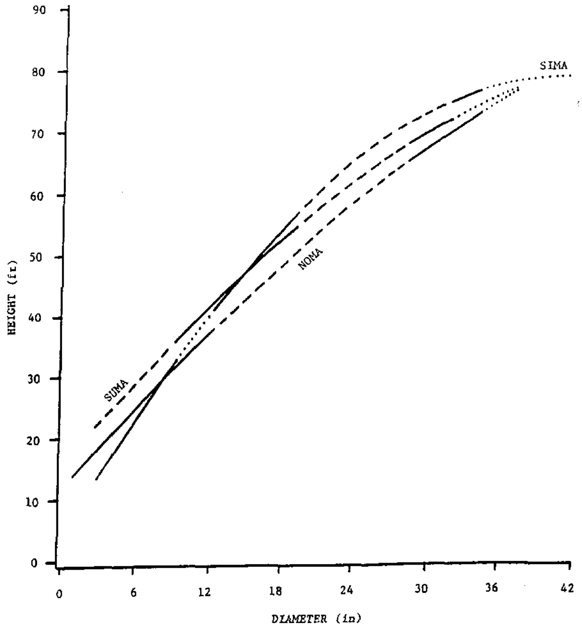

Figure 4. Comparison of silver, sugar and Norway maple predicted heights. Dots (···) indicate diameter where species is not significantly different from either other species. Solid line (——) indicates diameter where species is significantly different from one other species. Hash marks (- -) indicate diameter where species is significantly different from both other species.

individual tree pruning is likely the major reason for the wide prediction limits of all three species. The amount of pruning and other cultural practices performed on these trees are not known. Thus, these regression formulas represent average height values for a street tree population with a range of cultural practices.

Table 1. Coefficients for the least squares regression of species height on diameter (see Figures 1-3).

	Coefficients					
Species	b_1	b_2	b_3	r^2	s^2y/x	*n*
Silver maple	2.9	3.65	-0.0442	0.56	102.37	865
Sugar maple	15.0	2.50	-0.0226	0.67	69.38	541
Norway maple	11.5	2.37	-0.0170	0.72	56.34	1955

The model is $y = b_1 + b_2d + b_3d^2$ where y = tree height (ft.) and d = diameter outside bark at 4.5 feet (in.)

The average differences in tree height between the cities for larger diameter Norway and silver maples are likely due to differences in utility wire placement and associated pruning. In Syracuse, most utility lines are located overhead along the street (14). However, in Rochester, many overhead utility wires are away from the street and located in backyards (Shannon, personal communication, 1990). Thus, street trees in Syracuse would be expected to have more utility wire pruning.

If a tall maple is appropriate, silver maple appears to be the best, averaging about 15 feet taller than sugar and Norway maples for trees approximately 60 years old. Sugar and Norway maples will eventually reach the same heights as silver maples, but at a slower rate. The difference between sugar and Norway maples is relatively small in terms of their effect on views, utility wire clearance, etc., averaging only 10 feet at approximately 20 years of age and diminishing to no difference at approximately 70 years of age.

Just as individual tree heights vary for trees of the same diameter, so do individual tree ages. Considering the lack of statistical bounds on the height-approximate age curves, and the relatively low r^2 values of the age-diameter formulas, the approximate ages given in the height-approximate age curves should only be used as a rough indication of tree age.

Average tree life-span is also an important factor in deciding which tree to plant. Average street tree life-span in Syracuse, New York has been estimated as 73.2 years for silver maple; 56.5 years for sugar maple and 54.6 years for Norway maple (13). Thus, the smaller maple species would not be expected to live as long as silver maple.

Along with cultural practices, individual tree heights can vary due to differences in climatic, edaphic, and biotic factors (e.g., genetics, age, competition, etc.) (9). From this study, mature silver maple heights range between 60 and 100 feet; sugar maple between 60 and 95 feet; and Norway maple between 60 and 90 feet. These findings are consistent with literature reporting mature tree heights (4, 6), with the exception of silver maple which Hudak (6) lists as between 90 and 130 feet. Literature describing maples in the southwestern U.S. though, indicate that maples there attain a smaller height at maturity (i.e., 50-80 for silver maples; 40-60 ft. for sugar and Norway maples) (5, 11).

Acknowledgments. The raw data used in this study were originally collected for various other analyses, but were never analyzed for height-diameter relations. I thank Dr. Paul Manion for generously supplying me with data employed in this study. I also thank Drs. Rowan Rowntree, Norman Richards, Gerald Walton and Tiberius Cunia for their assistance with this study.

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USDA Forest Service
NE Forest Experiment Station
Syracuse, New York 13210

ABSTRACTS

SMIT, BARBARA. 1989. **Water stress.** Am. Nurseryman 170(4):103-104, 106, 108.

Those who care for plants can make more informed water-management decisions if they understand why water is so important to plants, how plants use it and what conditions lead to plant water deficits. Water is a major constituent of plants, accounting for 80-90 percent of the fresh weight of herbaceous plants and 50 percent of many woody plants. Water has a unique chemical nature, and most components of plant cells need it to maintain their molecular structure. To live, plants obviously need a water transportation system. There is a continuous water column from the soil into the roots and through the plant to the leaves. The most obvious cause of plant water deficits is a lack of adequate water in the soil, due to inadequate precipitation (or drought). Competition among plants can also diminish the amount of water available. Though soil is the plant's primary source of water, the driving force behind water uptake is transpiration. Finally, root zone conditions affect a plant's water status by determining how quickly roots can take up water.

ROSENFELD, SPENCE. 1989. **The roots of success.** Arbor Age 9(7):12-14, 16.

What are the major problems facing the tree care industry today? How about this list of problems familiar to any tree care company: Hiring, turnover, absenteeism, poor production, equipment abuse, safety problems, lack of training, and insurance rates. To survive in business now and in the 1990s, we must meet these problems as challenges and face them head-on. Fortunately, all of these problems are interrelated and can be addressed from a common perspective. They are all "people problems" and can begin to be resolved when we take an honest look at ourselves and how to relate to our most valuable resource: people. We must understand our people, the learning process, and what motivation is all about. We must step back and allow our employees to be responsible, stand on their own, and fulfill their potential. We can only be there to guide and direct. We can't make it happen. The roots of success lie in resolving our problems with employees. On a very practical level, we must promote safety, train aggressively, inspire motivation, and encourage teamwork.