THE INFLUENCE OF SITE FACTORS ON THE GROWTH OF URBAN TREES

by A.J. Vrecenak, M.C. Vodak, L.E. Fleming

Abstract. Nine tree species in four central New Jersey communities were studied to determine the relationship of site factors with the growth of trees in urban areas. The four site variables included: house setback from the road; the presence of competing vegetation; the width of the tree lawn; and the amount of permeable surface beneath the tree crown. Tree growth was measured using a growth ratio index, the ratio of DBH to age for a given tree. The results indicated that although for several species there is a significant linear relationship between growth ratio index and these site factors, the R^2 values for the nine species ranged between less than 0.01 and 0.14, indicating that a maximum of 14% of the variation in growth of these species can be explained by the linear models chosen.

Résumé. Neuf espèces d'arbres dans quatre municipalités du centre du New Jersey furent étudiées afin de déterminer la relation entre les facteurs du site et la croissance des arbres en milieu urbain. Les quatre variables du site étaient: la marge de recul de la maison, la présence d'autres végétaux, la largeur de la banquette, et la quantité de surface perméable sous la cime de l'arbre. La croissance des arbres fut mesurée à l'aide d'un indice de croissance, le ratio du DHP sur l'âge pour un arbre donné. Les résultats indiquent que bien que pour plusieurs espèces il y a une relation linéaire entre l'indice de croissance et ces facteurs du site, les valeurs R^2 pour les neuf espèces varient entre .01 et .14, indiquant qu'un maximum de 14% de la variation en croissance de ces espèces peut être expliqué par les modèles linéaires choisis.

Growth of trees in urban areas is subject to many constraints, not the least of which is an often restricted planting zone. Street trees are expected to grow under relatively hostile environmental conditions on less than optimal growing sites. The soil is often covered with asphalt or concrete surfaces. Other vegetation, including trees, shrubs and turfgrass, competes for the limited space available and the "tree lawn", that space between the sidewalk and the road, is frequently inadequate to accomodate a tree over time.

One of the concerns of urban tree managers has been the perceived decline in tree vigor and growth as a result of this restricted planting zone for urban trees. There are various recommendations for minimum size planting strips, minimum spacing for street tree placement and minimum exposed surface area for trees placed into paved areas. Based on observation, Perry (4) noted that tree growth and site quality are related. Patterson et al. (3) reported that 80% of urban plant problems can be attributed to a poor soil environment. A survey of municipal and highway arborists by Gerhold and Steiner (2) indicated that 97% of respondents felt that growing space restrictions were important to species selection. Ninety four percent of the respondents used information about distance to paved areas and 69% used information about soil characteristics in their selection of species. Only 21% kept any records of planting site characteristics to relate them to plant performance, however. Much information is apparently being passed on from one partitioner to another based on recollection and subjective evaluations.

In this study, data were collected and analyzed for over 600 trees of nine different species *(Acer platanoides, Acer rubrum, Acer saccharinum, Acer saccharum, Fraxinus sp., Gleditsia triacanthos, Platanus x acerifolia, Quercus palustris, Tilia sp.)* in four communities in central New Jersey. Within each community and species population, trees were randomly selected, sampling every seventh tree for relatively common species, such as Norway maple, or every third tree for less common species such as pin oak. Fifty to 80 trees per species were selected for sampling over the entire study.

Four easily measured site factors were chosen to evaluate their effect on tree growth. These included: the distance from the road to the house

New Jersey Agricultural Experiment Station, Publication No. D-12148-2-89, supported by U.S. Hatch Act funds. The research was supported by U.S. Forest Service Cooperative Agreement No. 23-771, NE Forest Expt. Sta.

(house setback); the presence or absence of competition (competition); the amount of open space between the sidewalk and the curb surrounding the tree (sidewalk extension); and the percent of permeable surface beneath the tree crown (pervious surface).

House setback was measured using 10-foot interval categories. Competition was measured as either present, if the crown of the sample tree was within the crown dripline of another nearby tree, or absent if it was not. The sidewalk extension was measured in two-foot intervals. Where a tree was surrounded by concrete, it was recorded as "0", and all extensions greater than 8 feet were contained in one group. Pervious surface within the dripline of the tree crown was measured in 25% intervals, with 100% indicating a completely pervious surface area beneath the tree crown.

A core sample was removed from each tree using an increment borer to determine the number of

Table 1. Degree of correlation between four site variables and the growth Ratio Index (dbh/age). Summary of the PROC RSQUARE SAS procedure evaluating various combinations of models and the PROC GLM SAS procedure to determine the intercept (a) and the coefficients (b, c, d) of the selected models. These models were selected using the R^2 value, Mallow's C(p) statistic and the number of variables being considered within each model. Model form: GRI = a + b*(variable 1) + c*(variable 2) + d* (variable 3).

Model	*Intercept*	*Variables (coefficients)*	*R^2*	*Cp*	*#Obs.*
All	0.433**	sdwk set cp (-0.001) (0.001) (0.018)	0.01	3.00	540
Acer platnoides	0.252**	sdwk set cp** (-0.009) (0.001) (0.069)**	0.14**	3.05	79
Acer rubrum	0.308**	sdwk** set ps (0.018)* (0.003) (-0.001)	0.14**	3.70	67
Acer saccharinum	0.510**	ps cp (-0.002) (0.072)	0.04	1.92	51
Acer saccharum	0.404**	sdwk ps cp (0.001) (0.003) (-0.005)	0.01	3.00	65
Fraxinus sp.	0.505**	sdwk set cp (-0.006) (0.003) (-0.044)	0.09*	3.00	61
Gleditsia Triacanthos	0.289**	sdwk set cp* (0.008) (0.001) (0.092)	0.14**	3.40	47
Platanus x acerifolia	0.416**	sdwk set cp (0.007) (0.0005) (0.055)	0.05	3.09	67
Quercus palustris	0.885**	sdwk set cp (0.005) (-0.004) (-0.066)	0.07*	3.04	66
Tilia sp.	0.529**	sdwk set cp* (0.007) (0.002) (0.089)	0.14*	3.02	37

sdwk = sidewalk extension
set = house setback
cp = competition
ps = pervious surface

* = significant at 5%
** = significant at 1%

annual growth rings and core length from inside the bark to the center of the tree. The minimum diameter at breast height (dbh) sampled was 6 inches and the maximum dbh sampled was 35 inches for this group of trees.

Using simple linear regression techniques, the four site factors, in various combinations and independently, were assessed as predictors of a variable we define as the growth ratio index (GRI). The GRI is the ratio of the dbh and age for a given tree, essentially an average yearly growth determination. Using SAS (Statistical Analysis System) (5) PROC RSQUARE, models for each of the nine species and one for the aggregate data for all species (ALL) were developed for the relationships between the site factors and the GRI.

The best models for each of the nine species and for the aggregate data are contained in Table 1. The best model for each was determined by looking at the Cp statistic, which for an adequate model should be close to the number of variables contained in that model (1, 5). The Cp statistic is a decision making tool in model selection, helping to optimize predictability while minimizing the number of independent variables included in the model. For example, in the data from this study, nine of the ten best models utilized three variables, selected based on the Cp values that were very near the value of three. The other model was a two variable one with its Cp value close to two. The Cp statistic is useful when attempting to find the best predictive model in a multiple correlation problem (1).

Of the nine models containing three variables each, six of the nine used sidewalk extension, house setback and competition as model components. The coefficients of determination (R^2) value for these models ranged from less than 0.01 up to 0.14, indicating that from less than 1% up to 14% of the variation in GRI can be explained by the use of the independent variables as predictors.

Six of the ten models have R^2 values that are significant, indicating that there is some linear relationship between the independent and the dependent variables in the models. Of the six that show significant linear correlation, sidewalk extension and house setback are contained in all six and competition is included in five of the six. The width of the sidewalk extension and the presence of competition are the only variables with coefficients significantly different from zero, and this significance is present in only four of the nine species models.

Two factors emerge from the interpretation of these results. First, the presence of sidewalk extension and house setback as components of all six models with significant linear correlation and the presence of competition in five of the six would indicate that rooting zone extent may be important to the growth of urban trees. Second, and probably more important to the interpretation of these and any other results of studies of the influences on urban tree growth, is that at best we can explain only 14% of the variation in tree growth based on these variables. The other 86% remains unexplained. Clearly there are other factors affecting the growth of urban trees.

While conferring some positive statistical benefit to the analysis of our results, the use of a large number of trees scattered across several communities may have contributed to the unexplained variation in this study. Perhaps the data sets would have been more effectively configured as discrete groups of trees contained within individual communities. Trees in various municipalities will get widely differing levels of care throughout their lives. The soils will differ from community to community also, and this will have an effect on the growth of the trees as well.

These two factors alone could have added a great deal of variation to growth responses within any of the species studied here, if we are going to use the street environment as a laboratory for this kind of study. The variation among communities may necessitate working intensively within individual communities and comparing these results to make more definitive statements on the effects of site characteristics on tree growth.

Literature Cited

1. Draper, N. and H. Smith. 1981. Applied Regression Analysis. Second Edition. John Wiley and Sons. New York.

2. Gerhold, H.D. and K.C. Steiner. 1976. Selecting Practices of Municipal Arborists. **In:** Better Trees for Metropolitan Landscapes. USDA Forest Service General Technical Report NE-22. pp. 159-166.
3. Patterson, J.C., J.J. Murray, J.R. Short. 1980. *The impact of urban soils on vegetation.* Metria Proceedings 3:33-56.
4. Perry, T.O. 1980. *The size, design and management of planting sites required for healthy tree growth.* Metria Proceedings 3: 1-14.
5. SAS Institute Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. SAS Institute Inc., Cary, N.C.

Assistant Professor, Assistant Professor and Graduate Student, respectively
Department of Horticulture and Forestry
New Jersey Agric. Experiment Sta.
Rutgers University
P.O. Box 231
New Brunswick, NJ 08903

SAFETY TRAINING FOR THE PROFESSIONAL AND THE NON-PROFESSIONAL

by Donald F. Blair

WARNING. Tree maintenance is often dangerous and hazardous. It is the responsibility of the arborist to exercise adequate precautions for safety. Be safe. Do not rely on one piece of equipment only. This tree is subject to failure if climbed improperly. All tree maintenance must be performed in compliance with ANSI Z133.1 1988 standards.

To date, I haven't seen this warning plate nailed to any trees, but the way things are going in the world of product liability and warning labels, don't be surprised if you do see it soon.

Ignoring my wry editorial, there are some good solid words to live by, literally, contained within the warning label. Philosophically, I try not to consider tree work as being either dangerous or hazardous, just peculiar (more on peculiar later). However, national safety statistics place the pursuit of arboriculture as an especially dangerous and hazardous occupation.

For your information, *peculiar* in the legal profession, refers to that which is unique and specific to a particular endeavor. Tree Work has an associated *Peculiar Risk* by virtue of the required skills and equipment necessary to permit an arborist to work safely and above ground. One might say that, "Arborists are peculiar," "Arborists do it in a peculiar manner," or "Arborists take peculiar risks."

Within arboriculture, in my experience, are two separate, parallel, unrelated expressions of tree work for hire. One is the self-styled recognized profession of arboriculture, of which we are all proud practitioners. The other is the murky underground of tree cutting for dollars. Table 1 gives a somewhat idealistic and stereotypic com-