Determining Root Space Requirements for Florida Street Trees

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ABSTRACT

Urban street trees provide many benefits to the community, but managers must balance these benefits with the costs of maintaining the trees and the surrounding infrastructure. When large shade trees are planted in small spaces, damage can be caused to adjacent sidewalks and streets, as well as to the trees. Despite knowing the typical heights and diameters at breast height for common street trees, researchers and practitioners do not know the usual sizes of the base of such trees, which is where conflict between trunk, roots, and infrastructure occurs. One way to estimate the size of the base of the tree is to directly measure the trunk flare diameter, but this is a difficult measurement to obtain and too time-intensive for typical municipal street tree inventories. We hypothesized that a significant allometric relationship exists between the diameters at breast height and at the trunk flare for two common, large street trees in Florida: live oak (*Quercus virginiana*) and laurel oak (*Quercus laurifolia*). We collected data on 205 trees total, measuring the diameters at the two locations on the trunk, as well as recording planting space dimensions, tree defects, infrastructure damage, and environmental characteristics like groundcover and crown light exposure. After analyzing the data, we produced equations for estimating trunk flare diameter and planting space requirements for both species. These findings can guide future tree planting and management decisions and potentially reduce some of the conflicts that occur between these trees and the built landscape.

OBJECTIVES AND METHODS

1. Investigate the relationship between trunk diameter at two different heights by creating models for estimating trunk flare diameter based on diameter at breast height.
2. Create an equation that can be used to estimate root space requirements for these species.

We randomly selected live oaks (*Quercus virginiana*) and laurel oaks (*Quercus laurifolia*) from an existing inventory dataset of street trees in Tampa, Florida. We collected data on 104 live oaks and 101 laurel oaks. To measure trunk flare diameter, we used flags to delineate the points at which trunk tissue transitioned to root tissue and to guide a measuring tape around the base of the tree in an approximately circular shape **(Figure 1)**. We converted the circumference to diameter afterwards. In addition to measuring diameters, we recorded planting space dimensions, tree defects, infrastructure damage, and environmental characteristics like groundcover and crown light exposure. We also noted whether the trunk flare shape was circular or not to check for any variance in trunk flare diameters during analysis.

Figure 1. Image of the field method for measuring the circumference of the trunk flare. The same person took this measurement each time to ensure precision.

To analyze the data, we ran linear regression models of the relationship between trunk flare diameter and diameter at breast height for each species. Early models included additional factors like trunk flare shape, groundcover, presence of root defects, and distance to closest infrastructure in order to test for interactions. After analyzing the data, we produced equations for estimating trunk flare diameter and used these findings and those from the literature to develop planting space requirements for both species.

RESULTS

We found 42 instances of cracked infrastructure (roads, sidewalks, and curbs), 41 instances of sidewalk lifting or curb pushing, and 12 instances of recently repaired or replaced infrastructure adjacent to the tree. We found 37% of the live oaks and 38% of the laurel oaks were associated with damage of some kind. Most factors did not significantly affect the size of trunk flare diameter in the models. Groundcover, crown light exposure, irrigation, and distance to infrastructure only increased the R^2 value in the models by 0.01 or less, so we concluded that the simplest models including only trunk flare diameter and diameter at breast height were the optimal ones for use in this study.

After checking for these interactions, we further investigated the simple relationship between TFD and DBH. We found a strong relationship between TFD and DBH **(Figure 2 and 3)**, meaning we can confidently estimate TFD from DBH using the equations derived from the models, which are listed below:

Live oak: TFD = 1.48 + 1.68 x DBH

Laurel oak: TFD = 7.55 + 1.91 x DBH

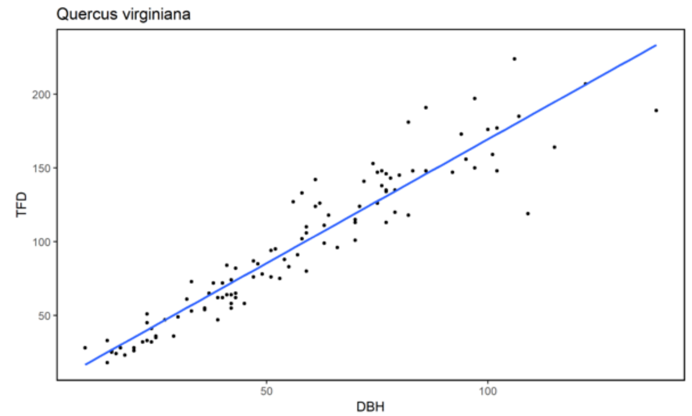

Figure 2. Simple linear regression showing the relationship between live oak (Q. virginiana) diameter at breast height (DBH) and trunk flare diameter (TFD). $R^2 = 0.89$, $p < 2e^{-16}$.

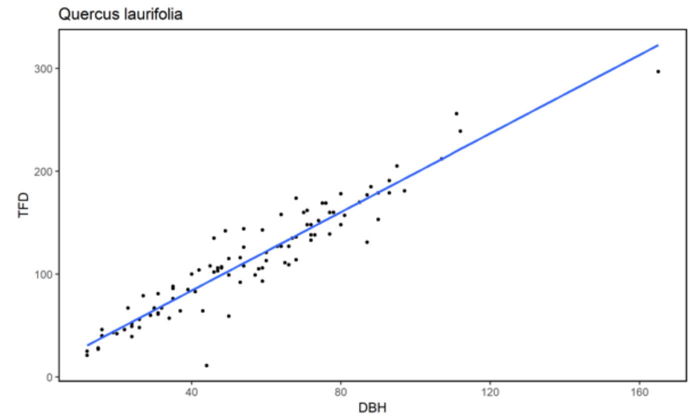

Figure 3. Simple linear regression showing the relationship between laurel oak (Q. laurifolia) diameter east height (DBH) and trunk flare diameter (TFD). $R^2 = 0.89$, $p < 2e^{-16}$.

In addition to these equations, we developed an equation for estimating planting space requirements for the large oak species in our study based on the assumptions that we want the oaks to live to maturity with no conflict with infrastructure **(Figure 4)**. We looked at the largest DBH values observed in the field and used this to estimate maximum TFD. The results were similar for both species, so we were able to use one equation for both trees. Based on literature on conflict between large trees and infrastructure, we used a safe minimum distance between trunk flare and infrastructure of 4 feet. Overall, we determined the minimum planting strip requirement for our oaks is 15 feet.

$$\text{Planting strip width requirement} = \frac{\text{TFD}}{12\ \text{in/ft}} + 8\ \text{ft}$$

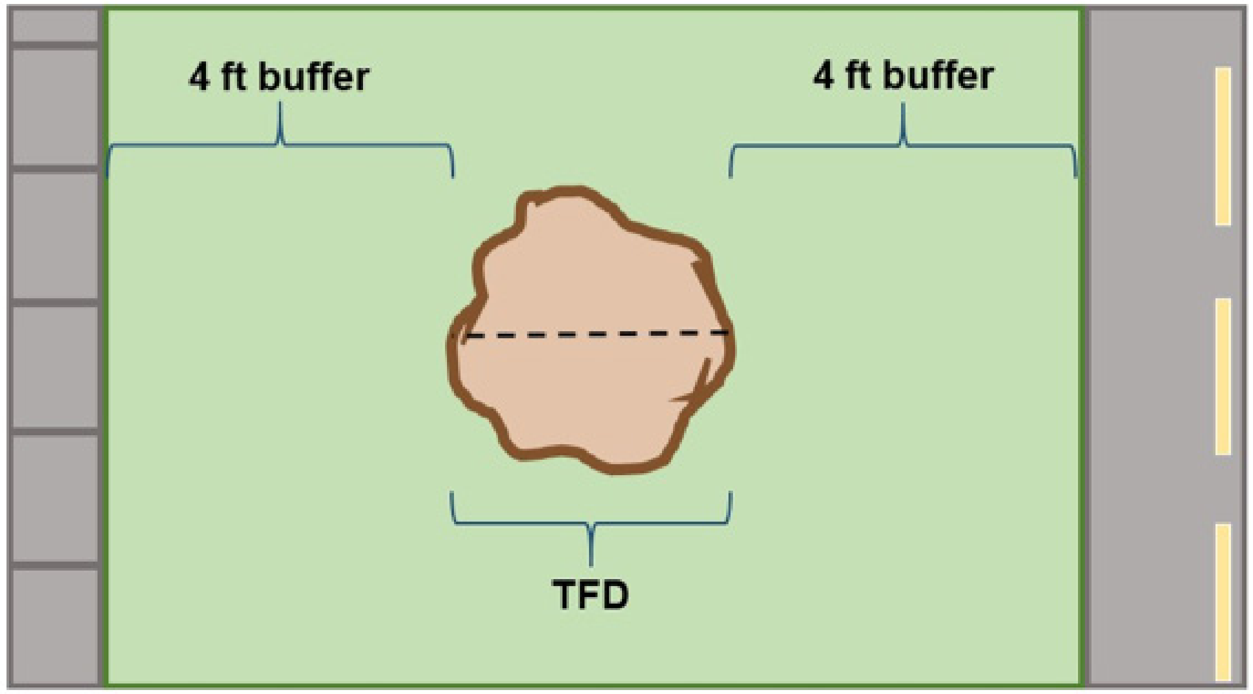

Figure 4. Schematic of how to derive a planting space requirement using the maximum TFD and a recommended 4 feet between the trunk flare and infrastructure.

CONCLUSIONS

We are currently drafting a manuscript for publication in a peer-reviewed journal. In the meantime, we have been able to share our results with a local urban forestry working group comprised of city arborists, urban foresters, and municipal and county natural resource specialists. The group provided positive feedback on the presentation, as they were eager for science-backed information to help them make urban tree management decisions. One member even said there is the potential to codify the planting space requirement for their county, meaning this project could be quickly translated into research-based changes in local laws. Having the information from this study will also help practitioners communicate with other departments when planning planting projects and construction work around trees.

Practitioners can apply these equations to determine planting space requirements, identify locations where conflict could be happening, and even estimate stump sizes for grinding after removals. We found that the recommended planting space for the studied oaks is 15 feet, yet many planting strips in Tampa and throughout Florida are far under 15 feet. These oaks are regularly planted in small planting spaces, only to cause damage in the future and/or to be removed right as they are reaching the size at which they provide maximum benefits and return on investments. This research supports what arborists and urban foresters already suspected and could provide a talking point for changing the way urban plantings are designed, resulting in more sustainable urban forests.

Finally, this project created the momentum for our group to work with researchers in other states to look at trees in their regions. The project has also provided Ms. Hilbert with invaluable experience leading a research project from start to finish. This project has given her the opportunity to conduct applied research with many opportunities for extension and collaboration with professionals from diverse backgrounds.