How Much Space Does My Shade Tree Need? Planting Space Recommendations for Medium and Large Trees in Florida Cities.

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How Much Space Does My Shade Tree Need? Planting Space Recommendations for Medium and Large Trees in Florida Cities[1]

Deborah R. Hilbert, Andrew K. Koeser, Brooke L. Moffis, JuWanda G. Rowell, and Drew C. McLean[2]

Trees provide urban landscapes with shade, beauty, and habitat. They can also help lessen the effects of flooding and urban heat buildup while storing carbon dioxide, a major greenhouse gas. When planted in the wrong place, however, trees can damage urban infrastructure like sidewalks. Most of a tree's roots, including the large structural roots, occur within the top two feet of soil. In urban settings, this means as the roots grow, they can displace or crack nearby sidewalks, roads, and curbs (Randrup et al. 2001). On the other hand, root-cutting activity that commonly occurs with the installation and repair of infrastructure can result in tree instability, decline in health, or even death (Benson et al. 2020). Shade trees such as live oaks (*Quercus virginiana*) are commonly planted in small planting areas, only to be removed a decade or so later when they begin damaging infrastructure or declining in health given limiting planting space.

Premature tree removal represents a significant economic and environmental loss. When determining the economic value of urban trees, one must consider the resources spent growing and maintaining the trees (e.g., nursery production costs, water, transportation, mulch, etc.), as well as the benefits they provide. When a tree is planted in the landscape, it can take years before its ecosystem services (e.g., carbon storage, shade, and stormwater mitigation) outweigh the earlier costs associated with production and planting. Once this point is reached, tree benefits continue to increase as the tree grows. By supporting the growth of healthy, long-lived trees, communities can save substantial amounts of money. For example, recent research on Florida's urban tree canopy has shown that the urban forest in the Tallahassee metropolitan area provides an estimated value of $300 million each year by reducing air pollution, stormwater runoff, and carbon dioxide (Mclean et al. 2020). If practitioners could adjust planting practices and provide adequate space to support tree health and survival, they could increase tree benefits, including the positive effects trees have on human health and well-being (Wolf et al. 2020).

To maximize the benefits provided by urban trees, we need better-informed tree selection and larger planting spaces with the capacity to support big-canopy trees (particularly street trees). Information is available for recommended soil volume for urban trees in planting pits, which is the amount of soil in an area needed to support a tree's root system. However, minimum soil volume recommendations do not look directly at the conflict that occurs between infrastructure and the base of the tree when root space is

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not limited (e.g., in the space between a road curb and a sidewalk). This article provides a new piece of the puzzle by presenting recommendations on how far a tree should be planted from infrastructure using data from field measurements. This article focuses specifically at ground-level infrastructure like sidewalks and streets, not belowground utilities.

This fact sheet is intended to help arborists, urban foresters, landscape designers, landscapers, and anyone else responsible for the planting of trees in developed areas make informed decisions regarding the planting width requirements of the trees they select.

Figure 1. Residential trees like these in Pinellas County provide many benefits.
Credits: Deborah R. Hilbert, UF/IFAS

Figure 2. Sidewalk damage caused by a large southern live oak (*Quercus virginiana*).
Credits: Deborah R. Hilbert, UF/IFAS

Figure 3. A large laurel oak (*Quercus laurifolia*) planted in a narrow planting strip. The lighter-colored pavement squares on the left were most likely replacements due to tree root damage.
Credits: Deborah R. Hilbert, UF/IFAS

Applying Urban Tree Research to Planting Space Recommendations

Prior research conducted by UF/IFAS scientists and colleagues looked at the size of common street trees at two different areas of the trunk: 4.5 feet off the ground (a common forestry measurement called diameter at breast height, or DBH) and ground level (a measurement called trunk flare diameter, or TFD) (Figure 4). It is tricky to measure the diameter of the trunk flare, so researchers created equations allowing users to predict TFD by plugging in the more common measurement, DBH (Hilbert et al. 2020; North et al. 2015). This research focused on medium- and large-stature trees (Table 1), but future work will look at small-stature trees such as crapemyrtle (*Lagerstroemia indica*) and Japanese privet (*Ligustrum japonicum*).

Figure 4. Researchers measured the diameters of trees at breast height (A) and at trunk flare (B) to create predictive equations.
Credits: Deborah R. Hilbert, UF/IFAS

For this article, we looked at the maximum diameter at breast height of common urban trees by searching through champion tree registers. This gave us an idea of how large a species' trunk can grow in natural conditions (i.e., the maximum genetic potential of the trees). Then we plugged those DBH values into a series of equations from our abovementioned research (Hilbert et al. 2020) to calculate these species' TFDs. To determine recommended planting space, we added 4 feet of buffer to either side of the trunk flare to account for large supportive roots that (while hidden below the soil surface) could still lift or crack sidewalks (Hauer et al. 2020; Johnson & North 2016; Perry 1992). The figures below help explain this.

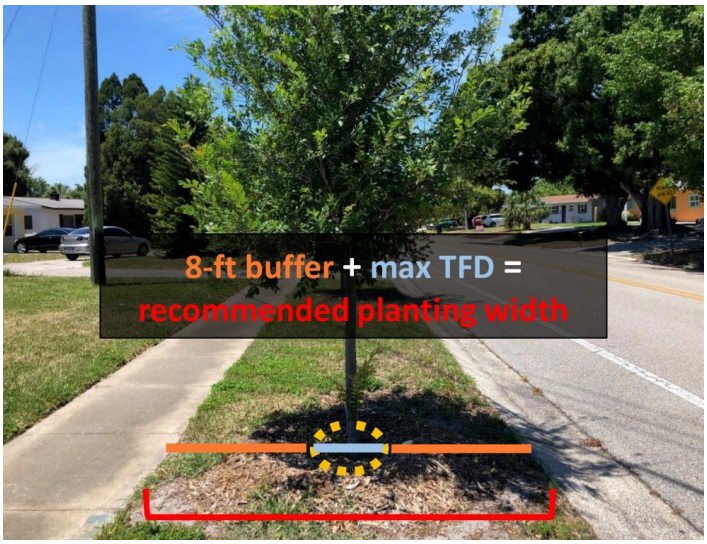

Figure 5. A Chinese elm tree (*Ulmus parvifolia*) in a planting strip between street and sidewalk. Recommended planting strip width is 8 feet of buffer (4 feet on each side) plus the expected trunk flare diameter (TFD). For this Chinese elm, that would be 10 feet total. (Figure not to scale.)
Credits: Deborah R. Hilbert, UF/IFAS

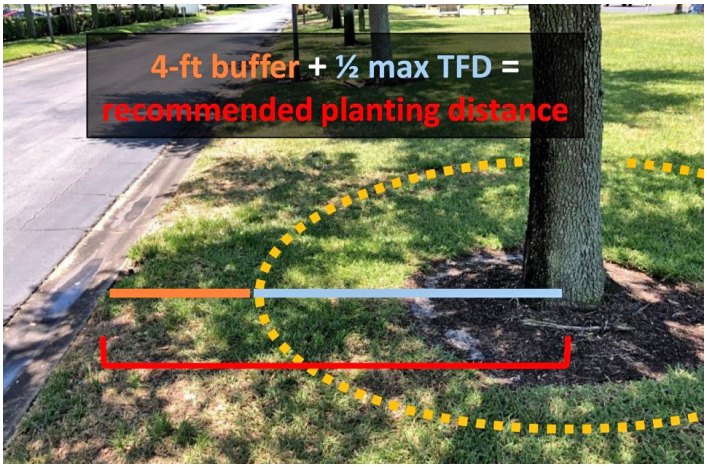

Figure 6. Live oak (*Quercus virginiana)* in a lawn adjacent to a street. Recommended planting distance is 4 feet of buffer plus half of the expected mature trunk flare diameter (TFD). For this live oak, that would be 13 feet total. (Figure not to scale.)
Credits: Deborah R. Hilbert, UF/IFAS

How to Use the Planting Space Recommendation Tables

The tree species in Table 1 and Table 2 are medium- and large-stature trees featured in the planting lists for 8 communities representing north, central, and south Florida (i.e., Fort Lauderdale, Gainesville, Miami, Minneola, Ocala, Pensacola, Tallahassee, and Tampa). Table 1 outlines species information including hardiness zones (north, central, and south Florida), status as a Florida native tree, mature tree height and spread, drought tolerance (high, moderate, and low), and the DBH from state champion tree registers.

Table 2 outlines the planting space recommendations for these species. "Planting Distance" tells you how far to plant a tree from a single road, driveway, sidewalk, etc. "Planting Width" gives the necessary width of a planting strip, such as the space between a road and sidewalk or the width of a median. See Figures 5 and 6 for help visualizing this. "Max Genetic Potential" refers to the space needed to support a tree that will grow to the diameter of the referenced champion tree. Because few trees grow to their full genetic potential, we included columns to show the planting width required to support a tree that grows to be 75%, 50%, or 25% of the maximum size listed in Table 1.

Table 3 can be used if the species you are interested in is not featured in Tables 1 and 2, or if you simply want to accommodate a tree to a given DBH (i.e., 10 in, 20 in, 30 in, or 40 in). Using this table requires some research and only applies to medium and large shade trees, not small trees. To determine the species' typical habitat, visit the USDA PLANTS database and look at its "wetland indicator" status for the Atlantic and Gulf Coastal Plain region (or whatever region your state falls within). Additionally, it may be helpful to use a champion tree register to make sure you are not selecting an expected diameter that is beyond the maximum genetic potential of the species.

Future research will need to look at how these planting space recommendations should be modified when technology like suspended sidewalks is used. We suspect the 4-foot planting buffer can be reduced if suspended sidewalks are used because large, supportive roots are situated below infrastructure in these designs. By following planting space recommendations, damage to urban infrastructure can be minimized while supporting the growth of healthy, long-lived shade trees. When planted for long-term success, mature shade trees provide ecological, financial, and environmental benefits to communities for many years.

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Habitat Designation and Species Information

FIRST CHOICE

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UF/IFAS Environmental Horticulture Department. "Tree selection for urban and suburban landscapes." Visited May 11, 2020. https://hort.ifas.ufl.edu/woody/selection.shtml

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SECOND CHOICE (USED IF THE ABOVE THREE DID NOT HAVE THE INFORMATION, SUCH AS FOR SOME NON-NATIVES)

CABI. 2020. *Invasive Species Compendium*. Wallingford, UK: CAB International. Visited April 24, 2020. www.cabi.org/isc

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Table 1. Species information for common medium and large native Florida trees, used to create planting space recommendations.

Botanical Name	Common Name	Zones (N, C, S)[w]	Mature Height	Mature Spread	Drought Tolerance[x]	Max DBH of Champion[y]	Computed Max TFD
Acer rubrum	red maple	N, C	60–75 ft	25–35 ft	mod	57.0 in	7.6 ft
Betula nigra	river birch	N	40–50 ft	25–35 ft	mod	33.4 in	4.7 ft
Bursera simaruba	gumbo limbo	C, S	25–50 ft	25–50 ft	high	33.1 in	3.6 ft
Carpinus caroliniana	American hornbeam	N	20–30 ft	20–30 ft	mod	14.0 in	1.9 ft
Carya glabra	pignut hickory	N, C	50–65 ft	30–40 ft	high	44.9 in	4.9 ft
Celtis laevigata	sugarberry	N, C, S	50–70 ft	50–60 ft	high	82.5 in	11.7 ft
Chrysophyllum oliviforme	devilwood	S	35–45 ft	18–25 ft	high	23.2 in	3.1 ft
Coccoloba diversifolia	pigeon plum	S	20–40 ft	20–35 ft	high	26.8 in	2.9 ft
Coccoloba uvifera	seagrape	C, S	35–50 ft	20–30 ft	high	47.7 in	5.2 ft
Ficus citrifolia	shortleaf fig	S	25–50 ft	30–40 ft	high	79.0 in	8.6 ft
Fraxinus pennsylvanica	green ash	N	60–70 ft	45–50 ft	high	39.1 in	4.2 ft
Gordonia lasianthus	loblolly bay	N, C	35–60 ft	10–15 ft	mod	52.2 in	7.4 ft
Liquidambar styraciflua	sweetgum	N, C	60–75 ft	35–50 ft	mod	51.0 in	6.8 ft
Liriodendron tulipifera	tulip poplar	N	80–100 ft	30–50 ft	mod	62.4 in	6.8 ft
Lysiloma latisiliquum	wild tamarind	S	30–60 ft	30–50 ft	high	58.6 in	6.3 ft
Magnolia grandiflora	southern magnolia	N, C	60–80 ft	30–40 ft	mod	73.9 in	9.9 ft
Magnolia virginiana	sweetbay magnolia	N, C	40–50 ft	15–25 ft	low	43.6 in	6.2 ft
Nyssa biflora	swamp tupelo	N, C	35–45 ft	25–35 ft	mod	50.3 in	7.1 ft
Nyssa sylvatica	water tupelo	N, C	65–75 ft	25–35 ft	high	26.1 in	3.5 ft
Piscidia piscipula	Jamaican dogwood	C, S	25–50 ft	25–50 ft	high	43.6 in	4.7 ft
Platanus occidentalis	American sycamore	N	75–90 ft	50–70 ft	high	75.8 in	10.7 ft
Prunus caroliniana	Carolina laurel cherry	N, C	25–40 ft	15–25 ft	high	19.1 in	2.1 ft
Prunus serotina	black cherry	N, C	60–90 ft	35–50 ft	high	45.5 in	4.9 ft
Quercus falcata	southern red oak	N, C	60–80 ft	60–70 ft	high	102.2 in	11.1 ft
Quercus geminata	sand live oak	N, C, S	50–90 ft	30–50 ft	high	70.4 in	7.6 ft
Quercus laurifolia	laurel oak	N, C, S	60–70 ft	35–45 ft	mod	68.8 in	10.9 ft
Quercus nigra	water oak	N, C, S	50–60 ft	60–70 ft	high	63.3 in	8.4 ft
Quercus phellos	willow oak	N, C	60–75 ft	40–50 ft	high	18.2 in	2.6 ft
Quercus shumardii	Shumard oak	N, C	55–80 ft	40–50 ft	high	52.2 in	7.0 ft
Quercus texana[z]	Texas red oak	N	60–80 ft	35–50 ft	mod	65.0 in	9.2 ft
Quercus virginiana	southern live oak	N, C, S	60–80 ft	60–120 ft	high	130.9 in	18.5 ft
Sassafras albidum	sassafras	N, C	30–60 ft	25–40 ft	high	30.9 in	3.3 ft
Simarouba glauca	paradise-tree	S	40–50 ft	25–30 ft	mod	34.7 in	3.8 ft
Swietenia mahagoni	mahogany	S	40–60 ft	40–60 ft	high	59.6 in	6.5 ft
Taxodium ascendens	pondcypress	N, C	50–60 ft	10–15 ft	high	80.0 in	11.3 ft
Taxodium distichum	baldcypress	N, C, S	60–80 ft	25–35 ft	high	178.3 in	25.3 ft
Tilia americana	American linden	N	50–80 ft	35–50 ft	mod	25.2 in	2.9 ft
Ulmus alata	winged elm	N, C	45–70 ft	30–40 ft	high	40.4 in	4.4 ft
Ulmus americana	American elm	N, C	70–90 ft	50–70 ft	high	61.1 in	8.1 ft

[w] N, C and S stand for north, central, and south Florida.
[x] "mod" stands for moderate.
[y] "Max DBH of Champion" refers to the maximum diameter at breast height found in the state and big tree registers. This is the number that was plugged into equations to create the planting space recommendations.
[z] Diameter for *Quercus texana* was obtained from the Texas Big Tree Registry because Florida data was not available.

Table 2. Planting space recommendations based on big-tree records and equations from UF/IFAS researchers. The final three sections provide the planting space recommendations for trees if they were to reach 75%, 50%, or 25% of the champion tree diameter.

Botanical Name	Common Name	Max Genetic Potential[w]		75% of Max Genetic Potential		50% of Max Genetic Potential		25% of Max Genetic Potential	
		Planting Distance[x]	Planting Width[y]	Planting Distance	Planting Width	Planting Distance	Planting Width	Planting Distance	Planting Width
Acer rubrum	red maple	8 ft	16 ft	7 ft	14 ft	6 ft	12 ft	5 ft	10 ft
Betula nigra	river birch	6 ft	13 ft	6 ft	12 ft	5 ft	10 ft	5 ft	9 ft
Bursera simaruba	gumbo limbo	6 ft	12 ft	5 ft	11 ft	5 ft	10 ft	4 ft	9 ft
Carpinus caroliniana	American hornbeam	5 ft	10 ft	5 ft	9 ft	4 ft	9 ft	4 ft	8 ft
Carya glabra	pignut hickory	6 ft	13 ft	6 ft	12 ft	5 ft	10 ft	5 ft	9 ft
Celtis laevigata	sugarberry	10 ft	20 ft	8 ft	17 ft	7 ft	14 ft	5 ft	11 ft
Chrysophyllum oliviforme	devilwood	6 ft	11 ft	5 ft	10 ft	5 ft	10 ft	4 ft	9 ft
Coccoloba diversifolia	pigeon plum	5 ft	11 ft	5 ft	10 ft	5 ft	9 ft	4 ft	9 ft
Coccoloba uvifera	seagrape	7 ft	13 ft	6 ft	12 ft	5 ft	11 ft	5 ft	9 ft
Ficus citrifolia	shortleaf fig	8 ft	17 ft	7 ft	14 ft	6 ft	12 ft	5 ft	10 ft
Fraxinus pennsylvanica	green ash	6 ft	12 ft	6 ft	11 ft	5 ft	10 ft	5 ft	9 ft
Gordonia lasianthus	loblolly bay	8 ft	15 ft	7 ft	14 ft	6 ft	12 ft	5 ft	10 ft
Liquidambar styraciflua	sweetgum	7 ft	15 ft	7 ft	13 ft	6 ft	11 ft	5 ft	10 ft
Liriodendron tulipifera	tulip poplar	7 ft	15 ft	7 ft	13 ft	6 ft	11 ft	5 ft	10 ft
Lysiloma latisiliquum	wild tamarind	7 ft	14 ft	6 ft	13 ft	6 ft	11 ft	5 ft	10 ft
Magnolia grandiflora	southern magnolia	9 ft	18 ft	8 ft	15 ft	6 ft	13 ft	5 ft	10 ft
Magnolia virginiana	sweetbay magnolia	7 ft	14 ft	6 ft	13 ft	6 ft	11 ft	5 ft	10 ft
Nyssa biflora	swamp tupelo	8 ft	15 ft	7 ft	13 ft	6 ft	12 ft	5 ft	10 ft
Nyssa sylvatica	water tupelo	6 ft	11 ft	5 ft	11 ft	5 ft	10 ft	4 ft	9 ft
Piscidia piscipula	Jamaican dogwood	6 ft	13 ft	6 ft	12 ft	5 ft	10 ft	5 ft	9 ft
Platanus occidentalis	American sycamore	9 ft	19 ft	8 ft	16 ft	7 ft	13 ft	5 ft	11 ft
Prunus caroliniana	Carolina laurel cherry	5 ft	10 ft	5 ft	10 ft	5 ft	9 ft	4 ft	9 ft
Prunus serotina	black cherry	6 ft	13 ft	6 ft	12 ft	5 ft	10 ft	5 ft	9 ft
Quercus falcata	southern red oak	10 ft	19 ft	8 ft	16 ft	7 ft	14 ft	5 ft	11 ft
Quercus geminata	sand live oak	8 ft	16 ft	7 ft	14 ft	6 ft	12 ft	5 ft	10 ft
Quercus laurifolia	laurel oak	9 ft	19 ft	8 ft	16 ft	7 ft	13 ft	5 ft	11 ft
Quercus nigra	water oak	8 ft	16 ft	7 ft	14 ft	6 ft	12 ft	5 ft	10 ft
Quercus phellos	willow oak	5 ft	11 ft	5 ft	10 ft	5 ft	9 ft	4 ft	9 ft
Quercus shumardii	Shumard oak	7 ft	15 ft	7 ft	13 ft	6 ft	11 ft	5 ft	10 ft
Quercus texana[z]	Texas red oak	9 ft	17 ft	7 ft	15 ft	6 ft	13 ft	5 ft	10 ft
Quercus virginiana	southern live oak	13 ft	27 ft	11 ft	22 ft	9 ft	17 ft	6 ft	13 ft
Sassafras albidum	sassafras	6 ft	11 ft	5 ft	11 ft	5 ft	10 ft	4 ft	9 ft
Simarouba glauca	paradise-tree	6 ft	12 ft	5 ft	11 ft	5 ft	10 ft	4 ft	9 ft
Swietenia mahagoni	mahogany	7 ft	14 ft	6 ft	13 ft	6 ft	11 ft	5 ft	10 ft
Taxodium ascendens	pondcypress	10 ft	19 ft	8 ft	17 ft	7 ft	14 ft	5 ft	11 ft
Taxodium distichum	baldcypress	17 ft	33 ft	13 ft	27 ft	10 ft	21 ft	7 ft	14 ft
Tilia americana	American linden	5 ft	11 ft	5 ft	10 ft	5 ft	9 ft	4 ft	9 ft
Ulmus alata	winged elm	6 ft	12 ft	6 ft	11 ft	5 ft	10 ft	5 ft	9 ft

Botanical Name	Common Name	Max Genetic Potential[w]		75% of Max Genetic Potential		50% of Max Genetic Potential		25% of Max Genetic Potential	
		Planting Distance[x]	Planting Width[y]	Planting Distance	Planting Width	Planting Distance	Planting Width	Planting Distance	Planting Width
Ulmus americana	American elm	8 ft	16 ft	7 ft	14 ft	6 ft	12 ft	5 ft	10 ft

[w] "Max Genetic Potential" refers to the maximum diameter at breast height found in Florida's big tree register. It is challenging to predict how large a tree will grow in urban settings. To avoid conflict and future costs, we suggest giving the tree the maximum recommended planting space.
[x] "Planting Distance" tells you how far to plant a tree from a single road, driveway, sidewalk, or other ground-level infrastructure.
[y] "Planting Width" gives the necessary width of a planting strip such as the space between a road and sidewalk or the width of a median.
[z] Diameter for *Quercus texana* was obtained from the Texas Big Tree Registry because Florida data was not available.

Table 3. Planting space recommendations based on habitat categories and example diameters. These give rough estimates of planting space recommendations for medium and large trees that are not featured in Tables 1 and 2.

	10-inch Expected DBH[x]		20-inch Expected DBH		30-inch Expected DBH		40-inch Expected DBH	
Typical Habitat[w]	Planting Distance[y]	Planting Strip Width[z]	Planting Distance	Planting Strip Width	Planting Distance	Planting Strip Width	Planting Distance	Planting Strip Width
Upland	5 ft	9 ft	5 ft	10 ft	6 ft	11 ft	6 ft	12 ft
Variable	5 ft	9 ft	5 ft	11 ft	6 ft	12 ft	7 ft	13 ft
Wetland	5 ft	9 ft	5 ft	11 ft	6 ft	12 ft	7 ft	14 ft

[w] Typical habitat categories are based on the "wetland indicator status" provided by the USDA PLANTS Database.
[x] Expected diameters can be obtained from big tree registers and urban tree inventories.
[y] "Planting Distance" tells you how far to plant a tree from a single road, driveway, sidewalk, or other ground-level infrastructure.
[z] "Planting Width" gives the necessary width of a planting strip such as the space between a road and sidewalk or the width of a median.