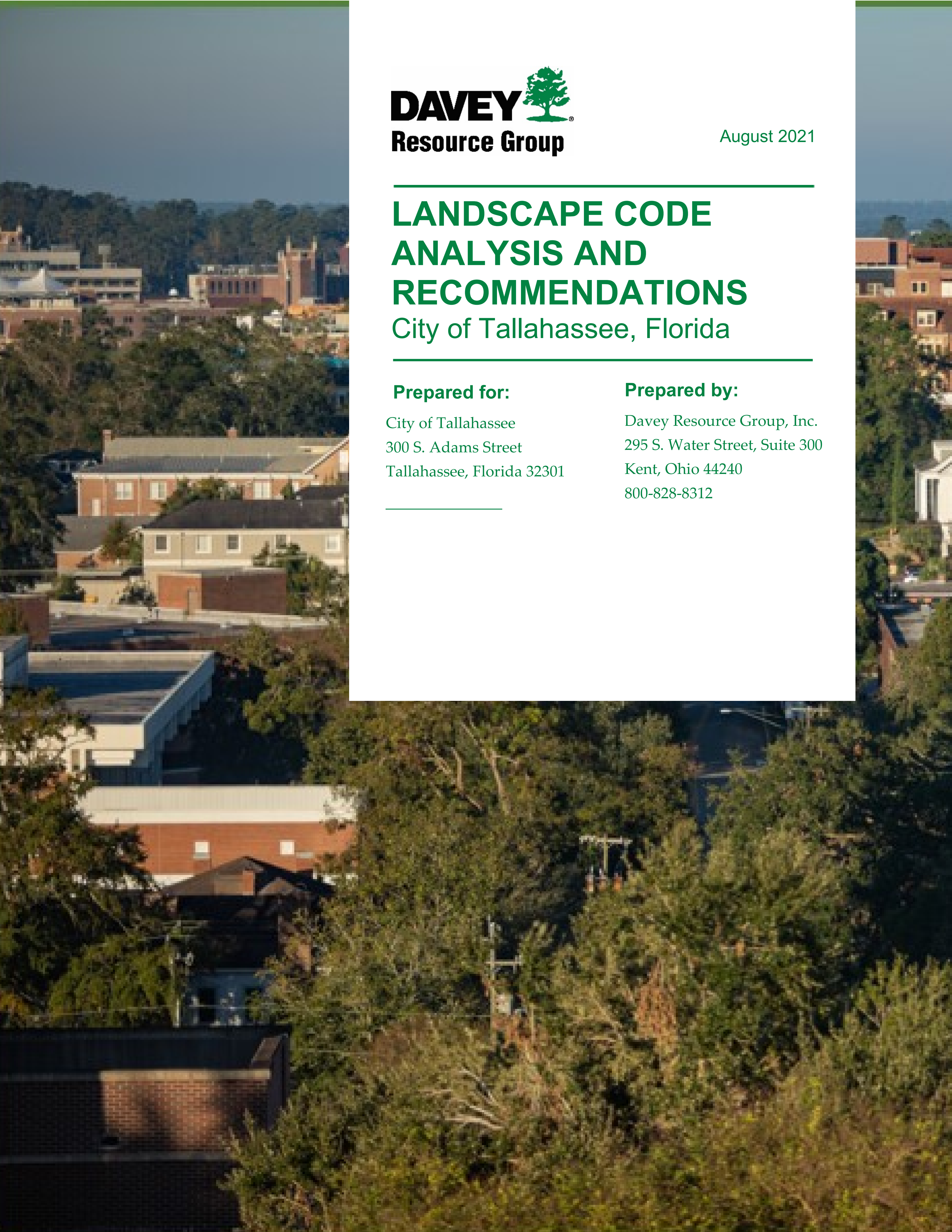

August 2021

LANDSCAPE CODE ANALYSIS AND RECOMMENDATIONS

City of Tallahassee, Florida

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Table of Contents

TABLES

FIGURES

APPENDICES

ACKNOWLEDGMENTS AND INTRODUCTION

This project is a continuation of the goals and vision to promote and enhance community well-being through public tree conservation and improved forestry management practices outlined in The City of Tallahassee's *Urban Forest Master Plan,* approved by the City Commission in December 2018. More specifically, this project offers expertise in preserving urban canopy through analysis of completed development projects so the environmental, economic, and social benefits it provides continue for generations.

Past urban forestry projects have demonstrated Tallahassee's dedicated commitment to sustaining the public tree resource with higher levels of tree care. Tallahassee maintains a staff of ISA Certified Arborists and performs proactive maintenance using goals set forth in the *Urban Forest Master Plan*. This project, then, is a continuation of the city's urban forestry program's commitment to maintaining a sustainable and resilient public tree resource.

Vision for Tallahassee's Urban Forest
Tallahassee values its extensive tree canopy and will strive to ensure that current and future actions result in improved quality canopy with no net loss of quantity. In response to current growth and future changes, the city and the community at-large will work together in partnership toward an urban tree canopy that will be a high-quality, sustainable, and safe asset providing benefits to all citizens.

- *Section 1: i-Tree Eco Findings* summarizes the analysis data.
- *Section 2: Wind Resistance & Species Observations* summarizes the impacts wind resistance and species composition has on the analysis.
- *Section 3: Recommendations* details recommendations that evolved out of the analysis.

Photograph 1. Major thoroughfares such as FAMU Way (shown here) provide ample opportunity for reforestation but can also pose significant challenges to wind resilience and tree health & establishment if these challenges are not proactively identified and steps taken to mitigate.

PROJECT SUMMARY

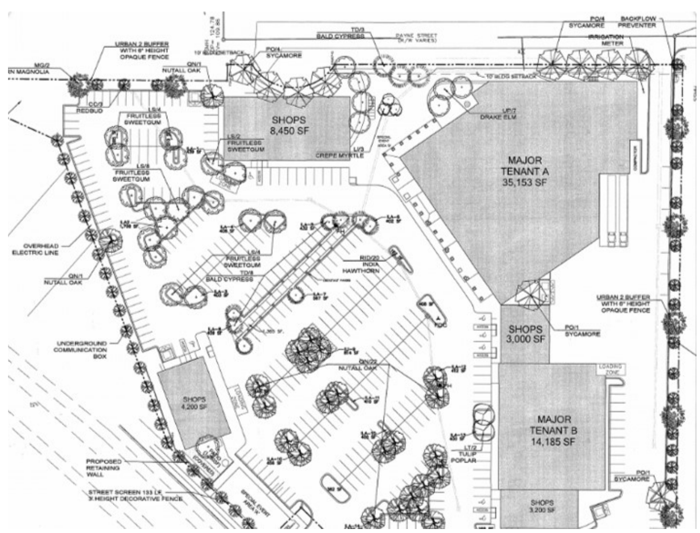
The City of Tallahassee's *Urban Forest Master Plan*, developed in cooperation with Davey Resource Group, Inc. "DRG", focuses on quantifying the benefits provided by the community's tree resources and addressing its needs by setting long-term goals. One recommendation that evolved out of that document was to evaluate the effectiveness of existing development regulations by conducting an analysis of completed development projects. To accomplish this goal, DRG worked with the Tallahassee staff to complete pre- and post-development assessments of the tree populations on nine (9) development sites in the Tallahassee area.

DRG staff analyzed the development sites data to better understand the structure, health, and composition of their respective tree resources. DRG also estimated the economic values of the various environmental benefits provided by analyzing inventory data with i-Tree Eco. i-Tree Eco's forecasting feature was used to project these same sites forty (40) years into the future to make comparisons to the initial pre- and post- development assessment data.

i-TREE ECO ANALYSIS

i-Tree Eco utilizes tree inventory data along with local air pollution and meteorological data to quantify the functional benefits of a community's tree resource. By framing trees and their benefits in a way that everyone can understand, dollars saved per year, i-Tree Eco helps a community to understand trees as both a natural resource and an economic investment. Knowledge of the composition, functions, and monetary value of trees helps to inform planning and management decisions, assists in understanding the impact of those decisions on human health and environmental quality, and aids communities in advocating for the necessary funding to manage their vested interest in the public tree resource appropriately.

For this project, i-Tree Eco was used to quantify environmental benefits based on pre- and post-construction tree data provide by the Tallahassee staff on the designated sites. Landscaping plans for each site were also provided as supplemental data. In some cases where discrepancies were noted between the tree data and landscape plan, the landscaping plan data was used to represent post-construction conditions. Pollution removal, carbon storage, and sequestration benefits were also quantified by projecting pre- and post-construction data sets out forty (40) years into the future. In addition to the aforementioned benefits, tree mortality was also noted in the forecasted data.



Photograph 2. Landscape plans, such as this, were provided by Tallahassee to verify post-construction tree data and location information critical to this analysis.

SECTION 1: i-TREE ECO FINDINGS

Trees occupy a vital role in the urban environment by providing of a wide array of economic, environmental, and social benefits far exceeding the investments in planting, maintaining, and removing them. Trees reduce air pollution, improve public health outcomes, reduce stormwater runoff, sequester and store carbon, reduce energy use, and increase property value. Using advanced analytics, such as i-Tree Eco, understanding the importance of trees to a community continues to expand by providing tools to estimate monetary values of the various benefits. For this project, ecosystem benefits were first quantified using tree data collected during pre- and post-construction site inspections. That same data was then used to forecast a smaller subset of ecosystem benefits forty (40) years into the future.

Initial pre- and post-construction ecosystem benefits are located in Appendix B while forecasted data is showcased in Section 2.

BENEFITS OF THE TREE RESOURCE FROM THE ANALYSIS

The i-Tree Eco analysis of the City of Tallahassee's nine development sites quantified the functional benefits of three critical ecosystem services that trees provide: air pollution removal, carbon sequestration, and avoided surface runoff. Benefits were quantified and assessed from both pre- and post-construction conditions.

Urban environments have unique challenges that make Tallahassee's tree resource an essential asset to the city. Compared to rural landscapes, urban landscapes are characterized by high emissions in a relatively small area. Avoiding stormwater runoff reduces the risk of flooding and combined sewer overflow, both of which impact people, property, and the environment. Carbon dioxide (CO_2) also impacts people, property, and the environment as the primary greenhouse gas driving climate change.

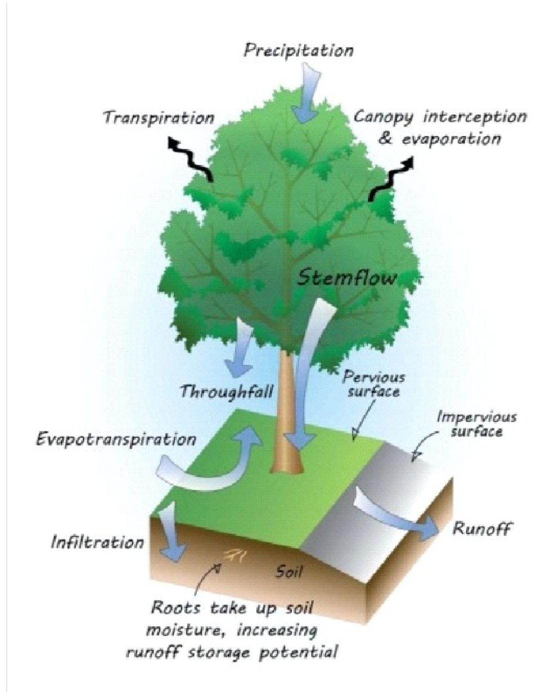
Sequestering and Storing Carbon

Trees are carbon sinks, which are the opposite of carbon sources. While carbon is emitted from cars and smokestacks, carbon is absorbed into trees during photosynthesis and stored in their tissue as they grow. The i-Tree Eco model estimates both the carbon sequestered each year and total carbon stored. Looking across the gradient of the nine (9) sites evaluated for Tallahassee, pre-construction sites have stored 2.4 tons of carbon valued at $418.00, annually, on the low end and on the high end 155.9 tons and valued at $266,000, annually. Comparatively, post-construction data from the aforementioned sites have stored 2.4 tons of carbon valued at $411.00, annually, on the low end and 13.1 tons valued at $2,240.00, annually, on the high end. **On average, post-construction sites resulted in a mean loss of ~48% in carbon sequestration and storage ecosystem benefits when compared to pre-construction data**. This accounts for all the carbon each tree has amassed throughout their lifetimes. Regarding individual tree species that are top performers, Water oak (*Quercus nigra*) and slash pine (*Pinus elliotii*) consistently stored the most carbon. Both species also consistently sequestered the most carbon across all nine (9) evaluation sites.

When looking at the same sites forecasted forty (40) years into the future, it was noted that both stored and sequestered carbon units and their respective values decreased over time when left in pre-construction conditions while post-construction data show consistent improvements across all nine (9) sites, yet never equal or exceed the original pre-construction data units and values. This can be simplified by stating that removing large diameter classes of mature trees during the development process has significant impacts on canopy loss and benefits and it takes a prolonged time to achieve similar levels again through replanting endeavors driven by code. This also reinforces the need to ensure appropriate planting space and ongoing maintenance is provided that allows trees to achieve maturity.

Controlling Stormwater

Trees intercept rainfall with their leaves and branches, helping lower stormwater management costs by avoiding runoff. Looking across the gradient of the nine (9) sites evaluated for Tallahassee, pre-construction sites have avoided 212 cubic feet of runoff on the low end and on the high end 15,300 cubic feet of runoff, annually. When looking at post-construction data from the aforementioned sites it indicated an avoidance of 411.3 cubic feet of runoff annually on the low end and 1,890 cubic feet annually on the high end. **On average, post-construction sites resulted in a mean loss of ~39% in stormwater ecosystem benefits when compared to pre-construction data.**



Of all species evaluated for stormwater benefits, water oak (Quercus nigra) and live oak (Q. virginiana) contributed the most annual stormwater benefits. On a per-tree basis, large trees with leafy canopies provided the most functional benefits. For example, live oak avoided twice as much runoff as eastern redbud did, despite only having about a third of its population size. This illustrates how large-statured trees with wide canopies provide significantly greater benefits.

Improving Air Quality

The tree resource of Tallahassee removes air pollutants, including sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O_3), and particulate matter (PM2.5). Looking across the gradient of the nine (9) sites evaluated for Tallahassee, the i-Tree Eco model estimated pre-construction sites have removed 4.5 pounds of pollutants valued at $5.36 annually on the low end and on the high end 318.9 pounds of pollutants valued at $401.00 annually. Comparatively, post-construction data from the same sites have stored 9.3 pounds of pollutants valued at $8.91 annually on the low end and 40.5 pounds of pollutants valued at $29.80 annually on the high end. **On average, post-construction sites resulted in a mean loss of ~47% in air quality ecosystem benefits when compared to pre-construction data.**

Key Takeaways

- Generally, ecosystem benefits were greatly reduced across all nine (9) development sites when comparing pre-construction data to post-construction data.
- Sites with marginal tree canopy in the pre-construction stage offered the most opportunity to gain ecosystem benefits by adding additional tree canopy whereas sites with moderate or substantial tree canopy in the pre-construction stage consistently showed the most losses in ecosystem benefits.
- Canopy replacement, no matter how aggressive or equitable, rarely reaches the levels of ecosystem benefits identified in the pre-construction stage, even when forecasted out forty (40) years into the future. This is the direct result of a couple key factors:
  - Removal of large, mature tree canopy during construction activities and replacing that canopy with much smaller stock. **Bigger, healthier trees provide more benefits, and they take substantial time to grow.**
  - Loss of additional tree canopy post-construction due to natural tree mortality, exposure, and/or lingering effects of construction activities. **Monitoring the health of preserved trees and ensuring the establishment of new stock will best provide for the opportunity and expediency needed to retain and add bigger, healthier trees. As trees grow, ecosystem benefits and their value will increase.**

Detailed synopsis of findings on all benefit analysis and forecasting can be found in Appendix B and Table one (1), respectively.

Photograph 3. The parking lot located at the Publix Development site. Note how replacement canopy is now located to adjacent hardscape, reinforcing the need to design appropriate root space.

Table 1. Summary of forecasted benefits (pre- and post-construction) provided by development site

Canterfield Assisted Living, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	274	138	49.64%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$401.00	$290.00	27.68%
Carbon Storage	155.9 tons	180.2 tons	13.49%
Carbon Sequestration	4.969 tons	3.62 tons	27.15%

Canterfield Assisted Living, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	389	249	35.99%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$45.30	$229.00	80.22%
Carbon Storage	13.13 tons	93.27 tons	85.93%
Carbon Sequestration	1.035 tons	3.59 tons	71.17%

Care Point, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	103	48	53.40%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$148.00	$108.00	27.03%
Carbon Storage	103.9 tons	96.05 tons	7.56%
Carbon Sequestration	2.463 tons	1.80 tons	26.92%

Care Point, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	97	51	47.43%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$106.00	$88.00	16.98%
Carbon Storage	74.01 tons	70.54	4.69%
Carbon Sequestration	1.722 tons	1.45	15.80%

Dunkin & RikSha Tacos, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	18	9	50.00%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$16.60	$14.00	15.66%
Carbon Storage	8.226 tons	9.94 tons	17.24%
Carbon Sequestration	0.332 tons	0.217 tons	34.64%

Dunkin & RikSha Tacos, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	46	28	39.13%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$6.20	$28.00	77.86%
Carbon Storage	2.721 tons	13.88 tons	80.40%
Carbon Sequestration	0.213 tons	0.491 tons	56.62%

K Station at Blairstone & Park, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	290	154	46.90%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$213.00	$268.00	20.52%
Carbon Storage	75.39 tons	138 tons	45.37%
Carbon Sequestration	2.797 tons	3.28 tons	14.73%

K Station at Blairstone & Park, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	272	163	40.07%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$97.40	$238.00	59.08%
Carbon Storage	39.62 tons	103.26 tons	61.63%
Carbon Sequestration	1.766 tons	3.14 tons	43.76%

Mellow Mushroom, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	22	9	59.09%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$44.20	$18.00	59.28%
Carbon Storage	37.79 tons	33.89 tons	10.32%
Carbon Sequestration	0.804 tons	0.519 tons	35.45%

Mellow Mushroom, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	53	30	43.40%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$29.80	$36.00	17.22%
Carbon Storage	24.11 tons	22.58 tons	6.35%
Carbon Sequestration	0.558 tons	0.544 tons	2.51%

Publix at Governor's Crossing, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	265	141	46.79%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$254.00	$274.00	7.30%
Carbon Storage	110.2 tons	181.1 tons	39.15%
Carbon Sequestration	4.186 tons	4.58 tons	8.60%

Publix at Governor's Crossing, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	249	147	40.96%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$34.30	$176.00	80.51%
Carbon Storage	10.41 tons	81.33 tons	87.20%
Carbon Sequestration	1.025 tons	3.18 tons	67.77%

Stadium Enclave, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	142	81	42.96%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$253.00	$172.00	32.02%
Carbon Storage	201.6 tons	200.4 tons	0.60%
Carbon Sequestration	4.306 tons	3.38 tons	21.50%

Stadium Enclave, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	418	258	38.28%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$39.90	$238.00	83.24%
Carbon Storage	21.78 tons	121.72 tons	82.11%
Carbon Sequestration	1.337 tons	4.56 tons	70.68%

The Standard Development, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	17	13	23.53%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$22.80	$18.00	21.05%
Carbon Storage	19.54 tons	31.19 tons	37.35%
Carbon Sequestration	0.421 tons	0.500 tons	15.80%

The Standard Development, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	170	103	39.41%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$7.28	$38.00	80.84%
Carbon Storage	1.097 tons	27.20 tons	95.97%
Carbon Sequestration	0.318 tons	1.168 tons	72.77%

Whole Foods, Pre-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	6	1	83.33%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$5.36	$1.00	81.34%
Carbon Storage	2.452 tons	1.17 tons	52.28%
Carbon Sequestration	0.093 tons	0.013 tons	86.02%

Whole Foods, Post-Construction			
Number of Trees	*Year 0*	*Year 40*	*Percent +/-*
	155	104	32.90%
Benefits	**Year 0**	**Year 40**	*Percent +/-*
Pollution Removal	$8.91	$83.00	89.27%
Carbon Storage	2.411 tons	34.98 tons	93.11%
Carbon Sequestration	0.302 tons	1.500 tons	79.87%

SECTION 2: WIND RESISTANCE & SPECIES OBSERVATIONS

SEVERE WEATHER EVENTS IN TALLAHASSEE

The severe weather events most commonly experienced in Florida include tornadoes and tropical storms/hurricanes. These types of severe weather events generally include high winds that can cause partial or whole tree failure, particularly in trees with preexisting defects. Full canopies on trees during the summer and fall months when tornadoes and hurricanes are most common can increase the dynamic loading experienced by trees and tree parts, increasing the chances of failure.

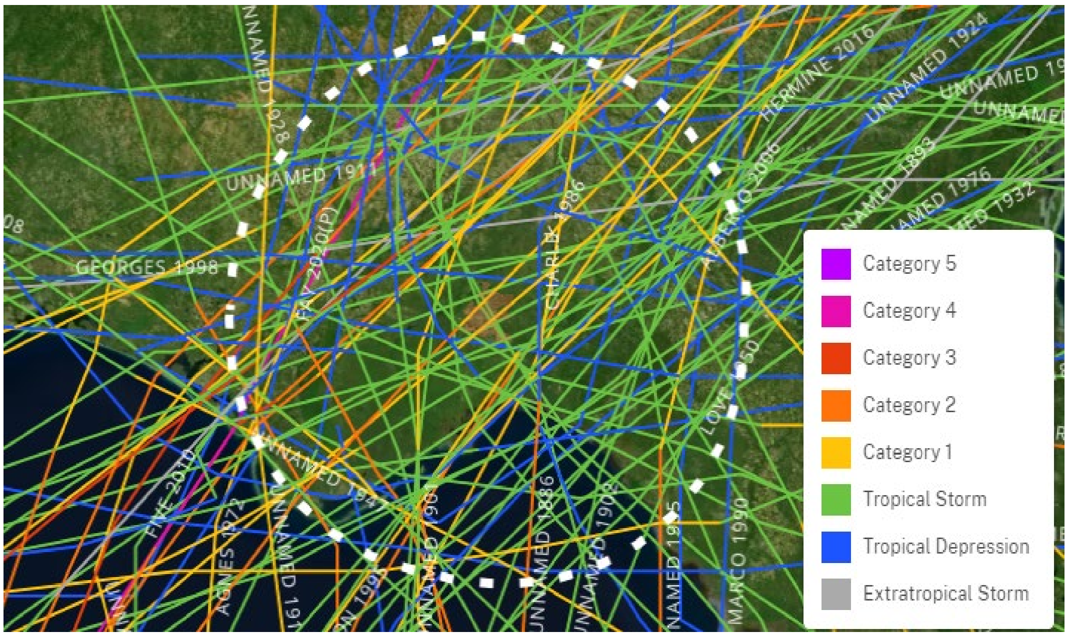


Figure 1. Tropical storm and hurricane tracks within 65 nautical miles of Tallahassee, FL since 1851 courtesy of the Historical Hurricane Track tool, NOAA.

Even relatively low wind speeds can cause tree damage in trees that are fully leafed out. Wind speeds from 45 to 57 miles per hour can cause small, healthy limbs to break as well as damaging larger dead or weakened branches. At 58 to 74 miles per hour, large, healthy branches will break, and shallowly rooted trees may be uprooted. Widespread tree damage with trees snapped or uprooted can occur at wind speeds from 75 to 89 miles per hour, and above 90 miles per hour even large and healthy trees may be snapped or uprooted. Full tree failure may occur at wind speeds as low as 30 miles per hour if the soil is heavily saturated, while much higher wind speeds may be required to cause damage when trees are not leafed out.

According to the National Oceanic and Atmospheric Administration's Historical Hurricane Tracking tool, a total of 4 tropical depressions, 26 tropical storms, and 68 hurricanes have made landfall within 65 nautical miles of Tallahassee since 1851 (Figure 1). The most severe hurricanes to impact the Tallahassee area were Hurricane Hermine in 2016, Hurricane Irma in 2017, and Hurricane Michael in 2018. The most recent tropical storm to impact the Tallahassee area was Omar in 2020. Tropical storms produce winds between 39 and 73 miles per hour, while the most severe hurricanes experienced by Florida have been category 5 hurricanes, which can produce sustained wind speeds over 157 miles per hour. Category 1 hurricanes, with wind speeds not exceeding 95 miles per hour, can uproot poorly rooted trees and snap large branches.

The National Weather Service's Storm Prediction Center reports that over the period of 1991-2010, an average of 66 tornadoes touched down in Florida annually, 14 of which touched down directly in Leon County. These tornadoes have ranged in magnitude from F0 to F3 on the Fujita Scale. F0 magnitude tornadoes have winds less than 73 miles per hour while F3 tornadoes can produce winds up to 206 miles per hour. Even winds below 73 miles per hour can uproot poorly rooted trees and break branches, particularly if a tree has a preexisting defect. On average, Florida experiences 66 tornadoes every year (Figure 2).

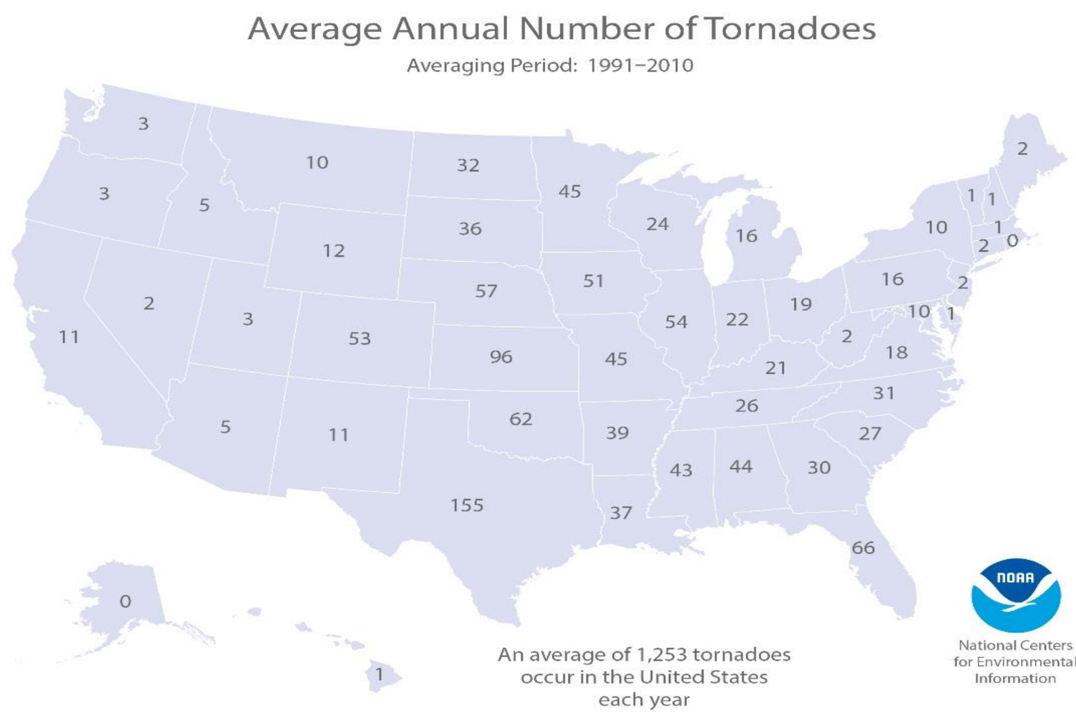


Figure 2. Average annual number of tornadoes by state, 1991–2010. Figure courtesy of Climate.gov and NOAA.

While any individual type of severe weather event may seem uncommon, when considered together, severe weather is not a rarity for Tallahassee. Many types of weather events can produce the high winds required to cause significant damage to Tallahassee's urban forest. Proactive maintenance is the best form of preparation a community can take for the potential damage brought by severe weather.

Global climate change has also sparked a sense of urgency for urban forestry professionals, as weather and climate are integrally tied to urban forest health. As a result of climatic changes, increases in the frequency and severity of storms are occurring throughout the Gulf Coast.

POPULATION CHARACTERISTICS RELATED TO STORM DAMAGE

With the recent development site data, the vulnerability of Tallahassee's urban forest to severe weather events can be assessed more accurately. Looking at the data from the nine (9) development sites, it is fair to state that retained trees can face challenges related to wind resilience in post-construction conditions due to their species composition, size classes and recent exposure--exceptions being when species composition has been bolstered with more wind-resilient species through replanting and/or if overall tree health improves. Certain species of trees are more prone to breaking and splitting in storms and high winds, for example, Callery pear *(Pyrus calleryana)* and red maple (*Acer rubrum)*. Trees that were previously located in the interior of a stand, as opposed to the edge, and trees under utility lines that have been severely pruned in the past are more prone to storm damage, as are trees in poor condition or with crown, trunk, or root defects. Trees under stress from insect and disease pressures are also more likely to fail in a storm. Simply stated, construction activities cause disturbance which in turn can increase the susceptibility of preserved trees to high wind events. Additionally, post-construction replacement trees are consistently of smaller size classes. This puts them at a disadvantage when compared to larger trees in terms of root mass and volume of wood, both of which lend to wind resilience.

Tree Condition and Defects

Generally, trees in poor condition and with more severe defects are more susceptible to storm damage than healthy trees. Trees with the defects of dead and dying parts, missing or decayed wood, and weakly attached branches and codominant stems are at increased risk of failure during storm-related events. Tree location as it relates to proximity to planned construction activities should also be considered. Trees grown in protected conditions can be particularly vulnerable if surrounding trees are removed and the stand dynamic is modified (e.g., interior trees become edge trees). Consider these factors when determining pre-construction canopy removals and prioritizing post-construction compliance inspections.

Ensuring future canopy removal decisions continue to consider tree condition and primary defects into the future can also help mitigate additional post-construction canopy loss. Trees with Poor or Fair condition ratings, an existing defect (especially dead and dying parts, weakly attached branches, or missing or decayed wood) are particularly susceptible. Trees that meet these criteria can be considered at an elevated risk of failure during storm events and should be considered for removal in the landscape approval process to decrease the chance that they will fail in the future.

In addition to health of a tree, age has shown to be a factor during storms. Mature trees tend to be larger in size with more severe consequences, not only from failure but also long-term consequences due to reduction is associated benefits from the increased volume of canopy loss. Any mature trees that have been around recent construction pose an increased risk due to potential for stress and damage to root zones.

Species Composition

Of the nine (9) sites evaluated in Tallahassee, approximately four (4) species account for almost half of the tree resource and half of the functional benefits provided. If any of these species were lost to invasive pests, disease, or other threats, its loss would have significant costs.

It is critical to promote species diversity with future plantings to minimize susceptibility to potential threats, and to plant large-statured broadleaf tree species wherever possible to maximize potential environmental and economic benefits. Species composition and diversity impacts urban forests in several ways:

- Certain species are more susceptible to breakage in storm events.
    - Species such water oak (*Quercus nigra*), although a great benefits provider, are particularly susceptible due to their weak structure, growth form, and shorter life span when compared to alternative species such as live oak (*Q. virginiana*) and swamp white oak (*Q. bicolor*).

- Greater diversity provides value to local wildlife habitat and aesthetics.
    - More specifically, species diversity provides for a greater abundance in diversity of forage and pollination mechanisms—this lends habit for a broad population of pollinators and other wildlife.

- Contiguous corridors of diverse forested areas provide better canopy structure and increased wind resistance.
    - Species diversity equates to better canopy structure which, in turn, provides better resistance to wind susceptibility by better distributing the force emitted by high winds throughout the canopy.

See Appendix A for a tree species list recommended by DRG for hardiness zone 8B.

Tree Species Prone to Storm Damage

Fast-growing, weak-wooded species have the highest potential to create large amounts of debris after storms. However, wood characteristics alone cannot accurately predict which trees or which species will be vulnerable to storm damage. Branching habit, crown shape, and preexisting defects all play a large role in determining the likelihood of storm damage. Since these characteristics tend to be shared within a species, certain tree species may be predisposed to failure under storm conditions. Water oak (*Quercus nigra*), for example, have proven to be more susceptible to storm damage than some other oak species due to their habit of developing poor structure and poor compartmentalization of decay. Research has shown that certain characteristics, including weak branch junctures, fine branching, dead and decaying branches, root damage, broad crowns, and horizontal branching habit, can increase a tree's susceptibility to wind and ice damage. These characteristics, much like crown shape and branching habit, are often shared within a species. For example, Callery pear (*Pyrus calleryana)* is prone to forming weak branch connections with included bark. Although a fast grower, tulip polar (*Liriodendron tulipifera)* is notoriously weak-wooded and, thus, equally susceptible. Both species are at high risk of damage during wind and ice events due to their inherent characteristics. Table 2 provides a list of tree species and their resistance to wind and ice damage.

This table was created from University of Florida, Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr173 and can also be found in the Tallahassee Urban Forest Master Plan.

Table 2. Wind susceptibility

Southeastern Coastal Plain Tree Species			
Highest Wind Resistance	Medium-High Wind Resistance	Medium-Low Wind Resistance	Lowest Wind Resistance
Dicots			
Carya floridana, Florida scrub hickory *Cornus florida*, dogwood *Ilex cassine*, dahoon holly *Ilex glabra*, inkberry *Ilex opaca*, American holly *Ilex vomitoria*, yaupon holly *Lagerstroemia indica*, crape myrtle *Magnolia grandiflora*, southern magnolia *Quercus geminata*, sand live oak *Quercus laevis*, turkey oak *Quercus myrtiflora*, myrtle oak *Quercus virginiana*, live oak *Podocarpus spp*, podocarpus *Vaccinium arboreum*, sparkleberry	*Acer saccharum*, Florida sugar maple *Acer palmatum*, Japanese maple *Betula nigra*, river birch *Carpinus caroliniana*, ironwood *Carya glabra*, pignut hickory *Carya tomentosa*, mockemut hickory *Cercis canadensis*, red bud *Chionanthus virginicus*, fringe tree *Diospyros virginiana*, common persimmon *Fraxinus americana*, white ash *Liquidambar styraciflua*, sweetgum *Magnolia virginiana*, sweetbay magnolia *Magnolia* x *soulangiana*, saucer magnolia *Nyssa aquatica*, water tupelo *Nyssa sylvatica*, black tupelo *Ostrya virginiana*, American hophombeam *Prunus angustifolia*, chickasaw plum *Quercus michauxii*, swamp chestnut *Quercus shumardii*, Shumard oak *Quercus stellata*, post oak *Ulmus alata*, winged elm	*Acer negundo*, boxelder *Acer rubrum*, red maple *Acer saccharinum*, silver maple *Celtis laevigata*, sugarberry *Celtis occidentalis*, hackberry *Cinnamomum camphora*, camphor (b) *Eriobotrya japonica*, loquat (c) *Eucalyptus cinerea*, silverdollar eucalyptus *Fraxinus pennsylvanica*, green ash *Morus rubra*, red mulberry *Myrica cerifera*, wax myrtle *Persea borbonia*, redbay *Platanus occidentalis*, sycamore *Prunus serotina*, black cherry *Quercus alba*, white oak *Quercus phellos*, willow oak *Salix* x *sepulcralis*, weeping willow *Ulmus americana*, American elm	*Carya illinoensis*, pecan *Liriodendron tulipifera*, tulip poplar *Prunus caroliniana*, Carolina laurelcherry *Pyrus calleryana*, Bradford pear *Quercus falcata*, southern red oak *Quercus laurifolia*, laurel oak *Quercus nigra*, water oak *Sapium sebiferum*, Chinese tallow (a) *Ulmus parvifolia*, Chinese elm
Conifers			
Taxodium distichum, baldcypress *Taxodium ascendens*, pondcypress		*Pinus elliottii*, slash pine *Pinus palustris*, longleaf pine *Pinus taeda*, loblolly pine	*Juniperus silicicola*, southern red cedar x *Cupressocyparis leylandii*, Leyland cypress *Pinus clausa*, sand pine *Pinus glabra*, spruce pine
Palms			
Butia capitata, pindo or jelly *Phoenix canariensis*, Canary Island date *Phoenix dactylifera*, date *Sabal palmetto*, cabbage, sabal			Washingtonia robusta, Washington fan
a Prohibited in Florida b Invasive, not recommended in Florida c Caution: manage to prevent escape in Florida (Fox et at. 2005)			
We present these lists with the caveat that no tree is perfectly wind-proof and that many other factors contribute to wind resistance including soil conditions, wind intensity, previous cultural practices, tree health, and age. These lists do not include all trees that could be wind resistant. They list those species encountered during our studies in large enough numbers to run statistical comparisons.			

Site Inspections

Inspections are essential to uncovering potential problems with trees. They should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care. Ideally, the arborist will be ISA Certified and hold the ISA Tree Risk Assessment Qualification credential.

It's worth noting that impacts to trees from construction-related activities associated with development sites such as soil compaction and root damage can take years to manifest in the trees being assessed. Ensuring that qualified staff with experienced in tree preservation and risk assessment can help proactively identify these issues before they become a liability and contribute to additional canopy loss and/or personal injury and property damage.

SECTION 3: RECOMMENDATIONS

At its core, the purpose of a city tree protection code is twofold - ensure public safety while advancing city goals. The "litmus test" question then becomes, "If the goals are to maintain canopy city wide and improve quality, does the current system work?" Analysis has highlighted some key points on how exactly to consider components of code revision, moving forward. It's important to note that further discussions with stakeholders, particularly the development industry, will lend to implementing the following recommendations and shouldn't be omitted from the evaluation process.

DRG recommends the following actions in considering landscape code revisions:

- Maximize Long-term Benefits Provided by the Urban Tree Canopy by Promoting Resilient, Longer-Lived Species and Overall Tree Population Health

Tree benefits are maximized by tree species that are healthier and longer lived, and the establishment period for trees can be arduous, especially on sites, post-construction. Analysis conveyed that post-construction development sites consistently fell short of the pre-construction benefits when forecasted forty years into the future. This is directly related to both projected mortality and the inability to broach pre-construction size classes within the forty (40)-year forecasted timeframe. Simply stated, removing large size classes of trees on the development process consistently results in large reductions of on-site canopy benefits and even aggressive reforestation/canopy replacement efforts take a long time (beyond 40 years) to return to pre-construction canopy benefit levels. By better assessing species suitability and location on development sites in the landscape plan review and the compliance inspection process, this will lend to the success of healthier, faster growing, long-lived trees that strive to mirror the benefits provided by the sites tree population, pre-construction.

i-Tree Eco analysis identified certain tree species as "top performers" for the spectrum of benefits. Species such as slash pine (*Pinus elliotii*), laurel oak (*Quercus laurifolia*), and water oak (*Quercus nigra*), on average, provide the most annual benefits to the community, but these species are also some of the more numerous, in terms of overall numbers, and shorter lived and more susceptible to high wind events and tree failure. Inversely, species such as live oak (*Quercus virginiana*) southern magnolia (*Magnolia grandiflora*) are longer lived, less susceptible to high wind events, and consistently charted as top benefits providers in the analysis. These species should be encouraged, where appropriate, and then monitored via proactive compliance inspections to ensure they are established and healthy into the future. The City of Tallahassee should cyclically review and update its current species list to reflect these recommendations and communicate these changes to the private development community.

- ### Strive to Preserve Larger, Longer-Lived Trees by Utilizing Canopy-Friendly Urban Construction Methods and Increase the Opportunity to Better Recoup Canopy Loss by Incentivizing Development on Urban Infill Sites

As stated before, larger trees and subsequently, larger surface areas of tree canopy results in greater benefits provided to the community. DRG recommends that Tallahassee staff strive to retain larger size classes of longer-lived tree species in the landscape plan review process through implementation and promotion of "canopy-friendly" construction activities such as vertical construction and sidewalk modifications. Vertical construction of infrastructure allows for a greater percentage of tree canopy to be retained in the pre-construction process and/or reforested in the post-construction process by reducing building footprints, thus increasing permeable surface and applicable tree canopy locations.

Additionally, urban infill sites provide for the greatest and least resistant way to recoup canopy benefits. **Urban infill** is the process of developing vacant or under-utilized parcels within existing developed areas. More specially, these locations already have existing infrastructure so canopy loss prior to new development is minimized and the opportunity for canopy replacement, and the subsequent benefits provided, are maximized. For example, when investigating a site such as Whole Foods (Table 1), DRG staff noted that this was the single example of where forecasted tree benefits exceeded that of the initial, pre-construction benefits. This site is a prime example of the success of urban infill sites in recouping canopy loss.

DRG recommends that Tallahassee consider modifying code language to incentivize development on urban infill sites and for incorporating "canopy-friendly" construction activities such as vertical construction and alternative sidewalk construction methods such as cutouts. Increased application of these methods and an increased frequency of development on urban infill sites will provide the most seamless pathway to both retaining and recouping urban tree canopy.

- ### Prioritizing a Proactive Compliance Inspection Program to Best Ensure the Long-Term Success of Canopy Replacement Efforts.

Trees at post construction sites are required to be kept in a healthy condition and/or replaced if needed for the life of the site. If canopy loss is identified, these findings are communicated to the property owner and proper action (canopy replacement) enforced by the appropriate city entity. DRG recommends that Tallahassee consider being more proactive with these compliance inspections, such as establishing more frequent inspection intervals, to ensure that communication of findings can be expedited to the private development community and enforcement can be implemented prior to additional canopy loss incurring, or not being captured, and the reforestation/canopy replacement cycle is lengthened.

One way that Tallahassee could consider implementing these proactive compliance inspections of development sites is via windshield survey (Level 1 or inspections performed from a vehicle) in line with *ANSI A300*, annually, and after all severe weather events, to identify canopy loss. This would capture the most egregious canopy loss without the need to have staff on-the-ground.

Efficacy of these inspections should continue to be evaluated as tree preservation and construction activities continue to evolve into the future.

CONCLUSION

Code language to protect trees during development exists now but has opportunity for improvement - additional staff, proactive compliance inspections, monitoring; replacement tree lists need to be cyclically reviewed and revised as climate change occurs and species suitability to hardiness zone 8B changes. Future code considerations and subsequent revisions will need to be cyclically reevaluated to best-aspire to the dual goals of no net loss (quantity of the UTC) and improving the condition (quality of the UTC) of urban tree canopy to best prepare for the complex dynamic of climate change and development pressures.

When properly maintained, the valuable benefits trees provide over their lifetime far exceed the time and money invested in planting, pruning, and inevitably removing them. Considering and successfully implementing the recommended changes to the City of Tallahassee's landscape code and inspection program should increase Tallahassee's ROI (return on investment) over time, or at least better maintain it in future years.

The program is ambitious and is a challenge to complete but becomes easier when communicated to private industry and supported by a robust, qualified staff. This *Landscape Analysis Report* could potentially help advocate for an increased urban forestry budget to fund the recommended staff improvements and prioritize code changes as local climate conditions continue to morph and development increases. Significant investment in communicating policy changes can help finesse these potentially complicated transitions.

As the urban forest grows, the benefits enjoyed by the City of Tallahassee and its residents will increase as well. Trees impacted by development are only a fraction of the total trees in Tallahassee, which is why it is important for the city to lead by example and continue to mirror policy for internal capital improvement projects related to tree preservation and reforestation. Tallahassee's urban forestry program is well on its way to creating a sustainable and resilient public tree resource, and can stay on track by updating goals, staffing, and policy, regularly checking progress, and setting more ambitious goals once they are reached.

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APPENDIX A
SUGGESTED TREE SPECIES FOR USDA HARDINESS ZONE 8B

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zone 8B on the USDA Plant Hardiness Zone Map.

DECIDUOUS TREES

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
*Aesculus flava**	yellow buckeye	
*Aesculus indica**	Indian horsechestnut	
Betula nigra	river birch	Heritage®
*Castanea mollissima**	Chinese chestnut	
Celtis laevigata	sugarberry	
Celtis occidentalis	common hackberry	
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Eucalyptus gunnii**	cider gum	
*Eucalyptus niphophila**	snow gum	
*Eucalyptus urnigera**	urn gum	
*Fraxinus tomentosa**	pumpkin ash	
Ginkgo biloba	ginkgo	(male trees only)
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Liquidambar styraciflua**	American sweetgum	Cherokee™
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'
*Magnolia acuminata**	cucumbertree magnolia	(numerous exist)
*Magnolia grandiflora**	southern magnolia	
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
*Platanus occidentalis**	American sycamore	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus falcata	southern red oak	
Quercus falcata pagodifolia	cherrybark oak	
Quercus hemisphaerica	Darlington oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus michauxii	swamp chestnut oak	

Large Trees: Greater than 45 Feet in Height at Maturity (continued)

Scientific Name	Common Name	Cultivar
Quercus nuttallii	Nuttall oak	
Quercus phellos	willow oak	
Quercus prinus	chestnut oak	
Quercus robur	English oak	Skyrocket™
Quercus shumardii	Shumard oak	
*Quercus stellata**	post oak	
*Quercus velutina**	black oak	
Quercus virginiana	live oak	
Taxodium ascendens	pondcypress	
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	Legend™
Ulmus alata	winged elm	
Ulmus crassifolia	cedar elm	
Ulmus parvifolia	lacebark elm	Allée®
Zelkova serrata	Japanese zelkova	'Village Green'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
*Cladrastis kentukea**	American yellowwood	'Rosea'
Emmenopterys henryi	Chinese emmenopterys	
*Idesia polycarpa**	Igiri tree	
Lagerstroemia fauriei	Japanese crapemyrtle	
Liquidambar acalycina	Chinese sweetgum	
Liquidambar formosana	Formosan sweetgum	
*Michelia doltsopa**	Chinese magnolia	
Nyssa ogeche	Ogeechee tupelo	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Pistacia chinensis	Chinese pistache	
*Pterocarya fraxinifolia**	Caucasian wingnut	
Quercus acutissima	sawtooth oak	
*Sapindus drummondii**	western soapberry	
*Zelkova sinica**	Chinese zelkova	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer barbatum	southern sugar maple	
Acer buergerianum	trident maple	Streetwise®
Acer campestre	hedge maple	Queen Elizabeth™
Acer leucoderme	chalkbark maple	
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(numerous exist)
Callistemon citrinus	lemon bottlebrush	
Callistemon viminalis	weeping bottlebrush	
*Carpinus caroliniana**	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
*Chionanthus virginicus**	white fringetree	
*Cornus florida**	flowering dogwood	(numerous exist)
*Cornus kousa**	kousa dogwood	(numerous exist)
*Cotinus coggygria**	common smoketree	'Flame'
*Diospyros kaki**	Japanese persimmon	(male trees only)
*Eriobotrya japonica**	loquat	
*Franklinia alatamaha**	Franklinia	
*Halesia tetraptera**	Carolina silverbell	'Arnold Pink'
Koelreuteria bipinnata	Bougainvillea goldenraintree	
Lagerstroemia indica	common crapemyrtle	'Biloxi','Choctaw' 'Miami','Muskogee' 'Natchez','Tuscarora' 'Tuskegee','Witchita'
*Magnolia stellata**	star magnolia	'Centennial'
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
*Magnolia × soulangiana**	saucer magnolia	'Alexandrina'
Malus spp.	flowering crabapple	(disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus campanulata	bell-flowered cherry	
Quercus acuta	Japanese evergreen oak	
Quercus georgiana	Georgia oak	
Quercus glauca	blue Japanese oak	
Quercus myrsinifolia	Chinese evergreen oak	
Sapium japonicum	tallow tree	
Sinojackia rehderiana	jacktree	
Staphylea trifolia	American bladdernut	
*Styrax japonicus**	Japanese snowbell	'Emerald Pagoda'
*Ziziphus jujuba**	Chinese date	

Note: * denotes species that are **not** recommended for use as street trees.

Coniferous and Evergreen Trees and Palms

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Cedrus atlantica	Atlas cedar	
*Cedrus deodara**	deodar cedar	
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
× *Cupressocyparis leylandii*	Leyland cypress	
Pinus echinata	shortleaf pine	
Pinus elliotii	slash pine	
Pinus glabra	spruce pine	
Pinus palustris	longleaf pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Sabal palmetto	sabal palm	
Washingtonia robusta	Mexican fan palm	

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	Atlantic whitecedar	(numerous exist)
Cunninghamia lanceolata	common Chinafir	
Cupressus sempervirens	Italian cypress	
Ilex opaca	American holly	
Juniperus virginiana	eastern redcedar	
Phoenix canariensis	Canary Island date palm	
Phoenix sylvestris	toddy palm	
Pinus thunbergii	Japanese black pine	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Butia capitata	pindo palm	
Ilex × attenuata	Foster's holly	
Trachycarpus fortunei	windmill palm	

Dirr's Hardy Trees and Shrubs (Dirr 2013) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1988) were consulted to compile this suggested species list. Cultivar selections are recommendations only and are based on DRG's experience. Tree availability will vary based on availability in the nursery trade.

APPENDIX B
I-TREE ECO DEVELOPMENT SITE BENEFITS TABLES

Summary of benefits (pre- and post-construction) provided by development site.

Canterfield Assisted Living, Pre-Construction		
Number of Trees	274	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	318.9 lbs	$ 401.00
Carbon Storage	155.9 tons	$ 266,000.00
Carbon Sequestration	4.969 tons	$ 847.00
Oxygen Production	13.25 tons	*x*
Avoided Runoff	15,300 ft³	$ 1,020.00
Structural Values	*x*	$ 443,000.00
Most Common Species: slash pine, water oak, laurel oak		

Canterfield Assisted Living, Post-Construction		
Number of Trees	389	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	40.56 lbs	$ 45.30
Carbon Storage	13.13 tons	$ 2,240.00
Carbon Sequestration	1.035 tons	$ 176.00
Oxygen Production	2.76 tons	*x*
Avoided Runoff	1,890 ft³	$ 126.00
Structural Values	*x*	$ 52,300.00
Most Common Species: southern magnolia, live oak, eastern redbud		

Care Point, Pre-Construction		
Number of Trees	103	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	124.9 lbs	$ 148.00
Carbon Storage	103.9 tons	$ 17,700.00
Carbon Sequestration	2.463 tons	$ 420.00
Oxygen Production	6.568 tons	*x*
Avoided Runoff	6,548 ft³	$ 438.00
Structural Values	*x*	$ 203,000.00
Most Common Species water oak, pecan, cabbage palmetto		

Care Point, Post-Construction		
Number of Trees	97	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	90.04 lbs	$ 106.00
Carbon Storage	74.01 tons	$ 12,600.00
Carbon Sequestration	1.722 tons	$ 294.00
Oxygen Production	4.592 tons	*x*
Avoided Runoff	4,667 ft³	$ 312.00
Structural Values	*x*	$ 147,000.00
Most Common Species: water oak, post oak, shumard oak		

Dunkin & RikSha Tacos, Pre-Construction		
Number of Trees	18	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	14.23 lbs	$ 16.60
Carbon Storage	8.226 tons	$ 1,400.00
Carbon Sequestration	0.332 tons	$ 56.70
Oxygen Production	0.886 tons	*x*
Avoided Runoff	768.2 ft³	$ 51.40
Structural Values	*x*	$ 17,700.00
Most Common Species: water oak, cabbage palmetto		

Dunkin & RikSha Tacos, Post-Construction		
Number of Trees	46	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	5.578 lbs	$ 6.20
Carbon Storage	2.721 tons	$ 464.00
Carbon Sequestration	0.213 tons	$ 36.30
Oxygen Production	0.568 tons	*x*
Avoided Runoff	290 ft³	$ 19.40
Structural Values	*x*	$ 7,990.00
Most Common Species: Chinese holly, bald cypress, live oak		

K Station at Blairstone & Park, Pre-Construction		
Number of Trees	290	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	168.1 lbs	$ 213.00
Carbon Storage	75.39 tons	$ 12,900.00
Carbon Sequestration	2.797 tons	$ 477.00
Oxygen Production	7.457 tons	*x*
Avoided Runoff	8,182 ft³	$ 547.00
Structural Values	*x*	$ 269,000.00
Most Common Species: laurel oak, sweetgum, slash pine		

K Station at Blairstone & Park, Post-Construction		
Number of Trees	272	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	74.88 lbs	$ 97.40
Carbon Storage	39.62 tons	$ 6,760.00
Carbon Sequestration	1.766 tons	$ 301.00
Oxygen Production	4.709 tons	*x*
Avoided Runoff	3,714 ft³	$ 248.00
Structural Values	*x*	$ 123,000.00
Most Common Species: southern magnolia, laurel oak, sweetgum		

Mellow Mushroom, Pre-Construction		
Number of Trees	22	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	40.36 lbs	$ 44.20
Carbon Storage	37.79 tons	$ 6,440.00
Carbon Sequestration	0.804 tons	$ 137.00
Oxygen Production	2.143 tons	*x*
Avoided Runoff	1,961 ft³	$ 131.00
Structural Values	*x*	$ 71,400.00

Most Common Species:
water oak, slash pine, southern magnolia

Mellow Mushroom, Post-Construction		
Number of Trees	53	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	27.58 lbs	$ 29.80
Carbon Storage	24.11 tons	$ 4,110.00
Carbon Sequestration	0.558 tons	$ 95.10
Oxygen Production	1.487 tons	*x*
Avoided Runoff	1,334 ft³	$ 89.20
Structural Values	*x*	$ 44,700.00

Most Common Species:
southern magnolia, eastern redbud, water oak

Publix at Governor's Crossing, Pre-Construction		
Number of Trees	265	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	208 lbs	$ 254.00
Carbon Storage	110.2 tons	$ 18,800.00
Carbon Sequestration	4.186 tons	$ 714.00
Oxygen Production	11.16 tons	*x*
Avoided Runoff	10,790 ft³	$ 721.00
Structural Values	*x*	$ 302,000.00

Most Common Species:
water oak, sweetgum, slash pine

Publix at Governor's Crossing, Post-Construction		
Number of Trees	249	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	31.21 lbs	$ 34.30
Carbon Storage	10.41 tons	$ 1,780.00
Carbon Sequestration	1.025 tons	$ 175.00
Oxygen Production	2.733 tons	*x*
Avoided Runoff	1,528 ft³	$ 102.00
Structural Values	*x*	$ 44,300.00

Most Common Species:
southern magnolia, live oak, shumard oak

Stadium Enclave, Pre-Construction		
Number of Trees	142	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	225.5 lbs	$ 253.00
Carbon Storage	201.6 tons	$ 34,400.00
Carbon Sequestration	4.306 tons	$ 734.00
Oxygen Production	11.48 tons	*x*
Avoided Runoff	11,420 ft³	$ 763.00
Structural Values	*x*	$ 398,000.00
Most Common Species: water oak, pecan, live oak		

Stadium Enclave, Post-Construction		
Number of Trees	418	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	38.32 lbs	$ 39.90
Carbon Storage	21.78 tons	$ 3,720.00
Carbon Sequestration	1.337 tons	$ 228.00
Oxygen Production	3.565 tons	*x*
Avoided Runoff	1,786 ft³	$ 119.00
Structural Values	*x*	$ 90,600.00
Most Common Species: live oak, eastern redbud, date palm		

The Standard Development, Pre-Construction		
Number of Trees	17	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	21.62 lbs	$ 22.80
Carbon Storage	19.54 tons	$ 3,330.00
Carbon Sequestration	0.421 tons	$ 71.80
Oxygen Production	1.122 tons	*x*
Avoided Runoff	1,106 ft³	$ 73.90
Structural Values	*x*	$ 46,700.00
Most Common Species: pecan, water oak		

The Standard Development, Post-Construction		
Number of Trees	170	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	8.66 lbs	$ 7.28
Carbon Storage	1.097 tons	$ 187.00
Carbon Sequestration	0.318 tons	$ 54.30
Oxygen Production	0.849 tons	*x*
Avoided Runoff	386.8 ft³	$ 25.90
Structural Values	*x*	$ 20,700.00
Most Common Species: princeton elm, Rhamnus spp, downy serviceberry		

Whole Foods, Pre-Construction		
Number of Trees	6	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	4.563 lbs	$ 5.36
Carbon Storage	2.452 tons	$ 418.00
Carbon Sequestration	0.093 tons	$ 15.90
Oxygen Production	0.249 tons	*x*
Avoided Runoff	212 ft³	$ 14.20
Structural Values	*x*	$ 6,690.00
Most Common Species: cabbage palmetto, red maple, live oak		

Whole Foods, Post-Construction		
Number of Trees	155	
Benefits	**Annual Units**	**Annual Benefit**
Pollution Removal	9.342 lbs	$ 8.91
Carbon Storage	2.411 tons	$ 411.00
Carbon Sequestration	0.302 tons	$ 51.40
Oxygen Production	0.805 tons	*x*
Avoided Runoff	411.3 ft³	$ 27.50
Structural Values	*x*	$ 11,800.00
Most Common Species: fringe tree, Texas red oak, eastern redbud		