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UF/IFAS PEER REVIEWED ENH1331

Florida's Urban Forest: A Valuation of Benefits[1]

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What is an urban forest?

An urban forest is a collection of trees and other woody vegetation found in and around human developments. An urban forest can be thought of as a gradient of trees extending from the street trees of densely packed urban cores, past the landscaped suburban plots, and all the way out to the remnant forests of exurban (or edges of urban) lands. It includes all the woody vegetation found in urban parks, industrial landscapes, residential properties, wetlands, riparian corridors, coastal ecosystems, greenways, and nature preserves, regardless of ownership (Figure 1).

Tree Canopy Coverage

Urban forest managers use a range of measurements to describe and value the urban forest and its benefits. One measurement that can be made over large areas of land with relative ease is the quantification of tree canopy coverage. Tree canopy cover is the percent of a given land area (e.g., city, national forest, etc.) covered by leaves and branches when viewed from above. Canopy coverage assessments are important tools that allow a community to estimate current canopy coverage, understand the extent of the urban forest, and track potential changes over time. Canopy coverage can be measured in the field with specialized equipment or by analysis of aerial and satellite imagery.

Figure 1. Urban forest gradient; from left to right and top to bottom: urban street trees, park trees, residential trees, and trees along a trail in a nature preserve.
Credits: Drew C. McLean, UF/IFAS

Florida has 29 metropolitan and micropolitan census-designated areas, representing 51 of the 67 counties and over 98% of the state's population (US Census Bureau 2019). These census-designated areas represent geographical regions with at least one densely populated urban area and related economic ties. Metropolitan areas must have one city or town with at least 50,000 people, while micropolitan

1. This document is ENH1331, one of a series of the Environmental Horticulture Department, UF/IFAS Extension. Original publication date November 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

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areas must have a city or town with a population between 10,000 and 50,000 people (US Census Bureau 2019).

To assess the urban forest throughout the state, we analyzed canopy coverage and its associated benefits in each of these census-designated areas. Tree canopy coverage was estimated using a point-based sampling approach. This method generates random points within a designated boundary on high-resolution aerial imagery. The random points are then assessed by a photo interpreter and classified as "Tree/Shrub" or "No-Tree." The classified points are tallied and divided by the total number of points to reach an overall canopy coverage percentage.

Tree canopy coverage ranged from 18.6% in the Okeechobee micropolitan area to 74.4% in the Crestview-Fort Walton-Destin metropolitan area (Table 1). In general, canopy coverage tended to decrease from north to south and west to east across the state (Figure 2).

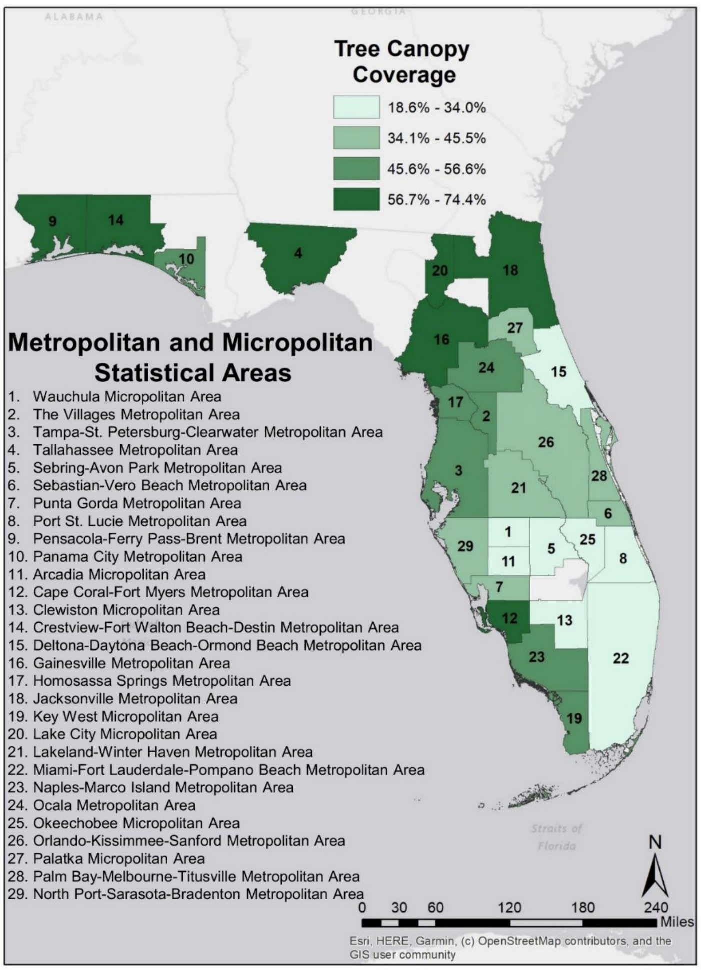

Figure 2. Locations of the 29 metropolitan and micropolitan areas in Florida. The different colors represent the percent of canopy coverage. Numbers correspond to the metropolitan and micropolitan area names in the legend on left side of the figure.

Urban Forest Benefits

Urban forest ecosystems provide a variety of economic and environmental benefits (Livesley et al. 2016), including shading homes to create energy savings, intercepting rain to reduce stormwater, improving air quality by filtering pollutants, and sequestering carbon to offset emissions associated with climate change. Many urban forest benefits are influenced by the combined surface area of all the leaves in a tree's canopy (Peper and McPherson 2003). Researchers use leaf area measurements to estimate the benefits provided by individual trees in an urban forest (Figure 3).

Figure 3. Sign displaying some of the estimated benefits produced from a tree in Pinellas County, FL.
Credits: Drew C. McLean, UF/IFAS

Researchers have developed ecosystem services models that use urban forest data to calculate the total economic value of all trees in a designated area, typically at the city or county level. Prior urban forest ecosystem service assessments for Gainesville and Tampa, Florida can be found at https://edis.ifas.ufl.edu/fr265 (Tampa) and https://edis.ifas.ufl.edu/fr414 (Gainesville). Evaluation of these benefits allows city managers and citizens to gauge the importance of the urban forest compared to other key infrastructure elements and to budget for the appropriate management of this natural resource.

Currently these models are able to estimate only some of the more tangible benefits of the urban forest, like the ones mentioned above. There are many other important benefits, such as wildlife habitat, recreational value, and human psychological effects. Researchers are working to apply economic values to these less tangible but important services. While all of these models are based on the best available science at the time, the data they produce are still just estimations.

For this study, the total acreage of each metropolitan and micropolitan area was calculated in a geographic information system (ArcGIS v10.5, ESRI). Acreage of tree canopy was estimated by multiplying the total area of each census-designated boundary by the canopy coverage percentage obtained during the aerial imagery interpretation process. We used the estimation of "canopy area" (Table 1) in each metropolitan and micropolitan area to calculate the value of benefits received from their corresponding urban forest. Benefit production rates (e.g., tons of air pollution removed per acre) and the monetary values for air pollution, avoided runoff, carbon sequestration, and carbon storage were based on data obtained from the i-Tree Canopy software v7.0 (https://canopy.itreetools.org/benefits/).

Air Pollution Removal

Toxic air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), ground level ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM_{10} and $PM_{2.5}$) can cause adverse effects to human health, disrupt ecosystem processes, and reduce visibility in cities (EPA 2019). Carbon monoxide, sulfur dioxide, and nitrogen dioxide gas are released into the atmosphere mainly through the burning of fossil fuels in power plants, industrial facilities, and automobiles. Ground-level ozone is created by chemical reactions between air pollutants and sunlight (EPA 2019). Particulate matter can be released directly from a source, such as unpaved roads, fields, and smokestacks, or created in the atmosphere through complex chemical reactions.

Air pollutants have been shown to affect cardiovascular and respiratory health, with long-term exposure potentially leading to the development of serious diseases (Stieb et al. 2009). In addition to the human health effects, air pollutants negatively affect the environment by contributing to pollution of coastal waters, smog production, and the formation of acid rain (Manisalidis et al. 2020).

Tree leaves primarily remove air pollutants by directly absorbing them or indirectly capturing them on their surfaces (Grote et al. 2016; Nowak et al. 2006). Altogether, the trees in Florida's 29 census-designated areas remove over 600,000 tons of combined air pollution each year, saving Florida residents an estimated $605 million in annual air-pollution-related health care costs (Figure 4; Table 2).

Estimated removal amounts for each air pollutant are listed by micropolitan and metropolitan area in Table 3.

Stormwater Runoff

Stormwater runoff is the rainwater that flows over the ground after a rain event. Impervious surfaces, such as roads, parking lots, and rooftops, do not allow water to infiltrate into the soil. Instead, these impervious surfaces swiftly direct large volumes of water into nearby stormwater drains that typically discharge into neighboring waterbodies. In urban areas with increased impervious surfaces, stormwater runoff can be a significant source of pollution to local waterbodies. As water flows over impervious surfaces, it can pick up many different pollutants (e.g., antifreeze, grease, pesticides, bacteria, etc.) that are present on these paved surfaces.

Trees help combat the negative effects of stormwater runoff by capturing rainfall on their leaves and bark, thereby reducing the amount of water hitting impervious surfaces. In addition, tree roots and old fallen leaves can promote soil conditions that allow more water to enter the soil during a rain event. Collectively, the urban forests in the 29 metropolitan and micropolitan areas intercept an estimated 50 billion gallons of water a year, resulting in savings of over $451 million in avoided annual stormwater treatment costs (Table 4). To put this volume of water in context, that is enough to fill approximately 75,000 Olympic-sized swimming pools each year (Figure 5).

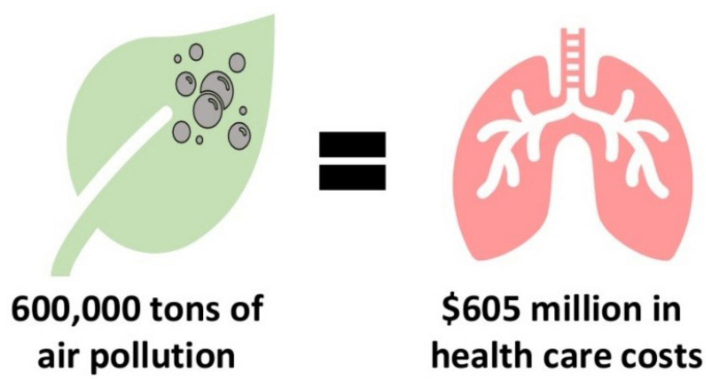

Figure 4. Tree leaves remove an estimated 600,000 tons of air pollutants each year, saving Floridians $605 million in air-pollution-related health care costs annually.

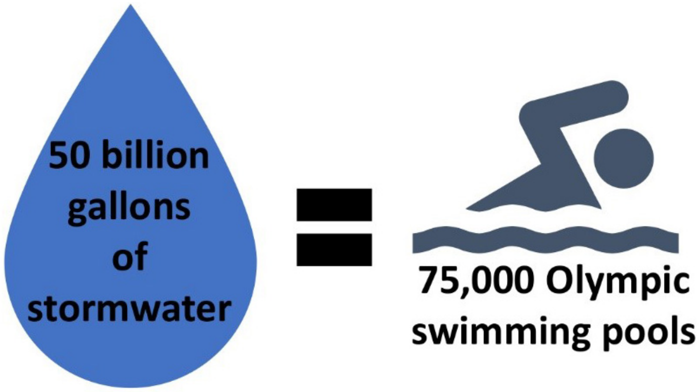

Figure 5. The amount of water Florida's urban forest reduce stormwater volumes by each year is enough to fill 75,000 Olympic swimming pools.

Carbon Sequestration and Storage

Carbon dioxide (CO_2) is a major greenhouse gas that plays a significant role in global climate change. Carbon dioxide is mainly released to the atmosphere through the burning of fossil fuels (EPA 2019). Trees can help combat climate change by taking in carbon dioxide from the atmosphere. During photosynthesis, trees take in atmospheric carbon dioxide and store it as carbon in their trunks, branches, and roots. A tree will continue to sequester and store carbon until it dies.

Carbon sequestration and storage rates are often presented as "carbon dioxide equivalents" as a way of measuring carbon footprints. Carbon dioxide equivalents report a single number to represent the amount of carbon dioxide that would create the same impact as all of the greenhouse gases combined (i.e., carbon dioxide, methane, nitrous oxide, and ozone). For example, because methane is a more powerful greenhouse gas, one ton of methane is equivalent to 25 tons of carbon dioxide (EPA 2019).

Equivalent calculators can be used to express these extremely large emission values in terms that are easier to digest and understand (Figure 6). Florida's urban forests sequester (e.g., capture through active growth) 65 million tons of carbon dioxide equivalent a year, which translates to an estimated $3 billion in annual benefits (Table 5). Florida's urban forests store (in their wood) a total of one billion tons of carbon dioxide equivalent, worth an estimated $76 billion in services (Table 6).

Carbon Pricing

Carbon pricing is a financial-based strategy that assigns monetary value to carbon emissions to help combat climate change. The price assigned to carbon can vary depending on the source and valuation method. In addition, carbon prices are influenced by regulatory, economic, and social factors and therefore may not always reflect current market prices. Even though carbon prices are not standardized and can fluctuate over time, they can be useful tools for portraying the economic value of carbon emissions. When assigning a value to carbon, it is important not only to list the price used in the valuation but also the amount of carbon the value relates to. This will allow for comparisons of carbon valuations across different markets using different carbon prices.

Valuable Natural Resource

Florida's urban forests are an extremely valuable natural resource that provides an estimated $4.1 billion in annual benefits for the state's citizens and visitors (Table 7). In addition, these urban forests will provide an estimated $76 billion in climate change benefits over their lifespan as trees continue to grow, storing more carbon in their tissues. It is important to remember that the benefit numbers and monetary values presented in this report are estimations obtained from scientific models. While these numbers may not be absolute, they are based on the best available science and are important for estimating the value of urban forests and the services they provide. In addition, this valuation of Florida's urban forest only includes some of the more tangible benefits, and we did not assess every county in the state. Many of the benefits presented in this report are influenced by the health and size of an individual tree's canopy. Preservation and management of the urban forest is critical to ensure that citizens receive the maximum benefits that urban trees can provide.

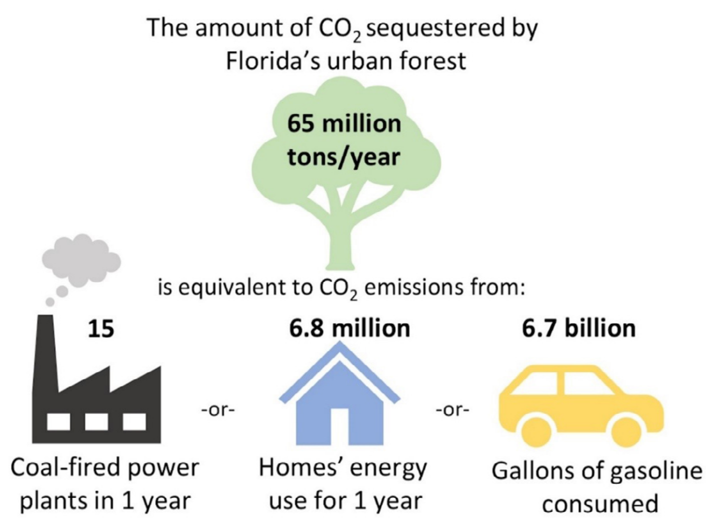

Figure 6. Carbon dioxide emission equivalent infographics. Credits: US EPA greenhouse gas equivalencies calculator

Acknowledgments

The authors would like to acknowledge the following people for their indispensable help conducting the canopy assessments: Brooke Anderson, Saige Middleton, and Hunter Thorn.

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Table 1. Population, percent tree canopy cover with 95% confidence interval, and estimated acres of tree canopy with associated standard error of the 29 metropolitan and micropolitan areas in Florida, sorted from highest to lowest canopy cover.

Overview of Canopy Cover				
Area	2019 Population[z]	Percent Canopy Cover with 95% Confidence Interval[y]	Canopy Area[x] (ac)	Canopy Area SE[w] (ac)
Crestview-Fort Walton Beach-Destin	284,809	74.4% ± 1.9%	946,304	12,771
Tallahassee	387,227	73.9% ± 1.9%	1,149,077	15,605
Jacksonville	1,559,514	67.8% ± 2.0%	1,367,161	22,678
Lake City	71,686	62.1% ± 2.1%	316,357	5,555
Gainesville	329,128	57.8% ± 2.2%	887,380	17,263
Pensacola-Ferrypass-Brent	502,629	57.2% ± 2.2%	616,384	12,012
Cape Coral-Fort Myers	770,577	56.7% ± 2.2%	279,271	5,770
Key West	74,228	56.6% ± 2.2%	350,308	7,406
Ocala	365,579	56.4% ± 2.2%	583,500	11,672
Homosassa Springs	149,657	55.3% ± 2.2%	212,249	4,380
The Villages	132,420	54.8% ± 2.2%	198,293	4,086
Naples-Marco Island	384,902	51.9% ± 2.2%	659,038	14,379
Panama City	174,705	51.5% ± 2.2%	252,326	5,542
Tampa-St. Petersburg-Clearwater	3,194,831	46.2% ± 2.2%	733,931	18,052
Orlando-Kissimmee-Sanford	2,608,147	45.5% ± 2.2%	1,046,163	26,673
Lakeland-Winter Haven	724,777	40.1% ± 2.1%	480,751	13,433
Sebastian-Vero Beach	159,923	40.0% ± 2.1%	121,779	3,418
Punta Gorda	188,910	38.6% ± 2.1%	168,267	4,841
Palm Bay-Melbourne-Titusville	601,942	37.3% ± 2.1%	236,040	6,968
North Port-Bradenton-Sarasota	836,995	35.9% ± 2.1%	296,465	8,950
Palatka	74,521	34.7% ± 2.1%	164,918	5,186
Deltona-Daytona Beach-Ormond Beach	668,365	34.0% ± 2.1%	349,023	11,093
Wauchula	26,937	33.5% ± 2.1%	133,914	4,244
Port St. Lucie	489,297	29.6% ± 2.0%	207,150	7,325
Arcadia	38,001	28.7% ± 2.0%	116,039	4,099
Clewiston	42,022	26.4% ± 1.9%	195,215	7,325
Miami-Fort Lauderdale-Pompano Beach	6,166,488	25.6% ± 1.9%	820,294	31,686
Sebring-Avon Park	106,221	25.2% ± 1.9%	166,551	6,481
Okeechobee	42,168	18.6% ± 1.7%	92,500	4,384

[z] 2019 population based on US Census Bureau estimations for 2019.
[x] Canopy cover estimations based on dot-based analysis of on 2019 leaf-on aerial imagery from National Agricultural Imagery Program (NAIP; USDA 2019).
[y] Canopy area is percent canopy cover multiplied by total acres of the metropolitan/micropolitan area.
[w] SE is an abbreviation for standard error, a measure of statistical accuracy for an estimated mean.

Table 2. Total estimated annual air pollution removal (in US tons) and total estimated air pollution removal values (in USD) with associated standard error (SE) calculations for the 29 metropolitan and micropolitan areas in Florida. Air pollution removal amounts and monetary values are based on county-level multipliers listed in the i-Tree canopy v7.0 software.

Total Air Pollution Removal (US tons)				
Metropolitan / Micropolitan Area	**Total Air Pollution Removal[z] (T)**	**Total Air Pollution Removal SE (T)**	**Annual Value**	**Annual Value SE**
Crestview-Fort Walton Beach-Destin	49,447	667	$19,876,367	$268,241
Tallahassee	48,107	653	$18,569,840	$252,193
Jacksonville	72,238	1,198	$67,597,085	$1,121,265
Lake City	16,837	296	$3,292,058	$57,811
Gainesville	42,082	819	$11,249,273	$218,836
Pensacola-Ferrypass-Brent	33,697	657	$35,387,009	$689,590
Cape Coral-Fort Myers	12,950	268	$21,513,273	$444,485
Key West	15,502	328	$2,198,593	$46,478
Ocala	28,501	570	$16,410,528	$328,269
Homosassa Springs	9,137	189	$13,143,399	$271,220
The Villages	8,437	174	$5,445,000	$112,199
Naples-Marco Island	31,777	693	$12,965,969	$282,902
Panama City	14,364	315	$11,079,671	$243,341
Tampa-St. Petersburg-Clearwater	35,392	870	$108,067,269	$2,657,995
Orlando-Kissimmee-Sanford	46,676	1,190	$66,711,108	$1,700,894
Lakeland-Winter Haven	22,330	624	$20,695,248	$578,240
Sebastian-Vero Beach	5,052	142	$5,800,433	$162,793
Punta Gorda	8,068	232	$8,014,045	$230,570
Palm Bay-Melbourne-Titusville	11,885	351	$13,505,954	$398,698
North Port-Bradenton-Sarasota	15,239	460	$24,949,673	$753,172
Palatka	9,482	298	$3,645,056	$114,617
Deltona-Daytona Beach-Ormond Beach	16,234	516	$18,988,661	$603,524
Wauchula	6,127	194	$743,110	$23,550
Port St. Lucie	9,642	341	$13,133,556	$464,407
Arcadia	5,645	199	$866,638	$30,611
Clewiston	8,422	316	$1,019,992	$38,274
Miami-Fort Lauderdale-Pompano Beach	36,871	1,424	$77,315,778	$2,986,515
Sebring-Avon Park	7,605	296	$2,695,689	$104,897
Okeechobee	3,797	180	$760,870	$36,061
Total	**631,544**	**14,461**	**$605,641,144**	**$15,221,645**

[z] Total air pollution is sum of carbon monoxide (CO), nitrogen dioxide (NO_2), ground level ozone (O_3), particulate matter between 10 and 2.5 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), and sulfur dioxide (SO_2).

Table 3. Annual estimated removal rates and associated standard errors (SE) in US tons of carbon monoxide (CO), nitrogen dioxide (NO_2), ground-level ozone (O_3), particulate matter between 10 and 2.5 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), and sulfur dioxide (SO_2) for the 29 metropolitan and micropolitan areas in Florida. Removal rates are based on county-level multipliers listed in the i-Tree canopy v7.0 software.

	Air Pollution Removal (US tons)											
Metropolitan / Micropolitan Area	**CO (T)**	**CO SE (T)**	**NO_2 (T)**	**NO_2 SE (T)**	**O_3 (T)**	**O_3 SE (T)**	**PM_{10} (T)**	**PM_{10} SE (T)**	**$PM_{2.5}$ (T)**	**$PM_{2.5}$ SE (T)**	**SO_2 (T)**	**SO_2 SE (T)**
Crestview-Fort Walton Beach-Destin	856	12	2,477	33	29,770	402	12,283	166	2,291	31	1,770	24
Tallahassee	675	9	4,065	55	29,053	395	11,682	159	2,068	28	564	8
Jacksonville	791	13	6,366	106	44,824	744	16,272	270	1,596	26	2,389	40
Lake City	229	4	1,455	26	10,174	179	4,632	81	151	3	196	3
Gainesville	608	12	3,458	67	27,633	538	8,900	173	774	15	709	14
Pensacola-Ferrypass-Brent	663	13	1,624	32	19,761	385	9,207	179	1,287	25	1,155	23
Cape Coral-Fort Myers	220	5	564	12	8,840	183	2,600	54	316	7	410	8
Key West	436	9	1,612	34	9,866	209	3,280	69	308	7	1	0.1
Ocala	646	13	1,486	30	18,166	363	6,773	135	806	16	624	12
Homosassa Springs	138	3	652	13	6,138	127	1,803	37	279	6	128	3
The Villages	220	5	506	10	5,895	121	1,480	30	293	6	43	1
Naples-Marco Island	839	18	1,968	43	21,427	468	6,692	146	849	19	2	0.1
Panama City	160	4	728	16	9,951	219	2,168	48	805	18	552	12
Tampa-St. Petersburg-Clearwater	483	12	2,243	55	23,882	587	6,926	170	975	24	883	22
Orlando-Kissimmee-Sanford	1,155	29	2,668	68	32,575	831	8,521	217	1,451	37	306	8
Lakeland-Winter Haven	306	9	1,219	34	15,387	430	4,232	118	698	19	488	14
Sebastian-Vero Beach	145	4	320	9	3,436	96	905	25	186	5	58	2
Punta Gorda	113	3	355	10	5,539	159	1,587	46	217	6	257	7
Palm Bay-Melbourne-Titusville	284	8	639	19	8,688	256	1,891	56	264	8	119	4
North Port-Bradenton-Sarasota	237	7	648	20	10,168	307	3,310	100	400	12	477	14
Palatka	141	4	830	26	6,237	196	1,791	56	259	8	224	7
Deltona-Daytona Beach-Ormond Beach	381	12	948	30	11,176	355	3,013	96	515	16	202	6
Wauchula	85	3	289	9	4,277	136	1,129	36	200	6	147	5
Port St. Lucie	269	10	439	16	6,875	243	1,619	57	255	9	185	7
Arcadia	74	3	251	9	3,845	136	1,139	40	158	6	180	6
Clewiston	225	8	539	20	5,545	208	1,752	66	360	14	0.5	0.1
Miami-Fort Lauderdale-Pompano Beach	981	38	2,168	84	23,376	903	8,614	333	1,363	53	369	14
Sebring-Avon Park	107	4	351	14	5,308	207	1,440	56	228	9	171	7
Okeechobee	111	5	226	11	2,413	114	901	43	104	5	42	2
Total	**11,576**	**278**	**41,096**	**910**	**410,226**	**9,495**	**136,541**	**3,063**	**19,455**	**443**	**12,650**	**272**

Table 4. Annual estimated avoided stormwater runoff volumes in gallons and estimated values of annual avoided runoff (in USD) with associated standard error (SE) calculations for the 29 metropolitan and micropolitan areas in Florida. Avoided runoff rates and monetary values are based on county-level multipliers listed in the i-Tree canopy v7.0 software.

Avoided Stormwater Runoff (gallons)				
Metropolitan / Micropolitan Area	**Avoided Runoff (gal)**	**Avoided Runoff SE (gal)**	**Annual Value**	**Annual Value SE**
Crestview-Fort Walton Beach-Destin	1,781,662,371	24,044,406	$15,878,139	$214,283
Tallahassee	1,562,790,401	21,223,893	$13,927,557	$189,147
Jacksonville	4,612,091,727	76,502,935	$41,102,869	$681,793
Lake City	76,558,303	1,344,426	$682,286	$11,981
Gainesville	618,468,676	12,031,305	$5,511,780	$107,223
Pensacola-Ferrypass-Brent	2,365,755,149	46,101,687	$21,083,563	$410,857
Cape Coral-Fort Myers	3,677,903,463	75,989,008	$32,777,402	$677,213
Key West	249,237,204	5,268,886	$2,221,197	$46,956
Ocala	1,290,632,073	25,817,272	$11,502,087	$230,083
Homosassa Springs	745,808,766	15,390,079	$6,646,633	$137,156
The Villages	351,263,494	7,238,107	$3,130,453	$64,506
Naples-Marco Island	1,387,538,412	30,274,477	$12,365,715	$269,806
Panama City	699,781,063	15,369,159	$6,236,435	$136,970
Tampa-St. Petersburg-Clearwater	6,283,890,090	154,556,937	$56,001,903	$1,377,408
Orlando-Kissimmee-Sanford	5,979,910,594	152,466,290	$53,292,844	$1,358,777
Lakeland-Winter Haven	1,656,706,879	46,289,537	$14,764,539	$412,531
Sebastian-Vero Beach	446,771,488	12,538,920	$3,981,619	$111,747
Punta Gorda	791,610,291	22,775,189	$7,054,815	$202,972
Palm Bay-Melbourne-Titusville	1,848,459,929	54,566,818	$16,473,438	$486,298
North Port-Bradenton-Sarasota	1,754,871,592	52,975,445	$15,639,381	$472,116
Palatka	205,138,758	6,450,474	$1,828,193	$57,486
Deltona-Daytona Beach-Ormond Beach	1,113,230,764	35,382,234	$9,921,090	$315,326
Wauchula	64,814,450	2,054,047	$577,625	$18,306
Port St. Lucie	975,534,147	34,495,185	$8,693,941	$307,420
Arcadia	80,874,822	2,856,611	$720,755	$25,458
Clewiston	105,822,330	3,970,849	$943,086	$35,388
Miami-Fort Lauderdale-Pompano Beach	9,655,586,366	372,971,087	$86,050,393	$3,323,911
Sebring-Avon Park	228,933,869	8,908,484	$2,040,254	$79,392
Okeechobee	53,723,799	2,546,181	$478,785	$22,692
Total	**50,665,371,271**	**1,322,399,929**	**$451,528,775**	**$11,785,202**

Table 5. Annual estimated carbon dioxide equivalent (CO_2e) sequestration amounts in US tons and annual estimated value of carbon dioxide equivalent (CO_2e) sequestration (in USD) with associated standard error (SE) calculations for the 29 metropolitan and micropolitan areas in Florida.

Carbon Sequestration (US tons)				
	Sequestered CO_2e[z] (T)	**Sequestered CO_2e[z] SE (T)**	**Annual Value[y]**	**Annual Value[x] SE**
Crestview-Fort Walton Beach-Destin	4,736,249	63,918	$220,282,941	$2,972,826
Tallahassee	5,751,129	78,105	$267,485,026	$3,632,652
Jacksonville	6,842,643	113,502	$318,251,323	$5,278,984
Lake City	1,583,365	27,805	$73,642,301	$1,293,218
Gainesville	4,441,339	86,399	$206,566,683	$4,018,420
Pensacola-Ferrypass-Brent	3,085,001	60,118	$143,483,402	$2,796,074
Cape Coral-Fort Myers	1,397,753	28,879	$65,009,503	$1,343,159
Key West	1,753,292	37,065	$81,545,612	$1,723,878
Ocala	2,920,418	58,419	$135,828,628	$2,717,060
Homosassa Springs	1,062,306	21,921	$49,407,846	$1,019,552
The Villages	992,455	20,450	$46,159,064	$951,150
Naples-Marco Island	3,298,485	71,969	$153,412,525	$3,347,283
Panama City	1,262,892	27,737	$58,737,117	$1,290,032
Tampa-St. Petersburg-Clearwater	3,673,326	90,348	$170,846,390	$4,202,094
Orlando-Kissimmee-Sanford	5,236,047	133,500	$243,528,533	$6,209,105
Lakeland-Winter Haven	2,406,159	67,230	$111,910,476	$3,126,856
Sebastian-Vero Beach	609,502	17,106	$28,347,927	$795,602
Punta Gorda	842,178	24,230	$39,169,698	$1,126,940
Palm Bay-Melbourne-Titusville	1,181,382	34,875	$54,946,063	$1,622,016
North Port-Bradenton-Sarasota	1,483,808	44,793	$69,011,894	$2,083,307
Palatka	825,417	25,955	$38,390,137	$1,207,156
Deltona-Daytona Beach-Ormond Beach	1,746,862	55,521	$81,246,534	$2,582,289
Wauchula	670,240	21,241	$31,172,878	$987,906
Port St. Lucie	1,036,784	36,661	$48,220,832	$1,705,103
Arcadia	580,777	20,514	$27,011,948	$954,100
Clewiston	977,053	36,663	$45,442,724	$1,705,181
Miami-Fort Lauderdale-Pompano Beach	4,105,573	158,588	$190,950,211	$7,375,928
Sebring-Avon Park	833,586	32,437	$38,770,086	$1,508,657
Okeechobee	462,961	21,942	$21,532,305	$1,020,500
Total	**65,798,981**	**1,517,889**	**$3,060,310,607**	**$70,597,028**

[z] CO_2e sequestration rate was 5.005 T/ac. Based on US-level rate listed in i-Tree canopy v7.0 software.
[y] CO_2e sequestration was valued at $46.51/T. Based on US-level value listed in i-Tree canopy v7.0 software.
[x] SE is an abbreviation for standard error, a measure of statistical accuracy for an estimated mean.

Table 6. Estimated carbon dioxide equivalent (CO_2e) storage amounts in US tons and estimated value of carbon dioxide equivalents (CO_2e) storage (in USD) with associated standard error (SE) calculations for the 29 metropolitan and micropolitan areas in Florida.

Carbon Storage (US tons)				
Metropolitan / Micropolitan Area	**CO_2e Storage[z] (T)**	**CO_2e Storage SE[y] (T)**	**CO_2e Storage Value[x]**	**CO_2e Storage Value SE[y]**
Crestview-Fort Walton Beach-Destin	118,947,511	1,605,255	$5,532,248,717	$138,266,145
Tallahassee	144,435,506	1,961,545	$6,717,695,366	$168,954,640
Jacksonville	171,848,090	2,850,525	$7,992,654,654	$245,525,566
Lake City	39,765,078	698,307	$1,849,473,796	$60,147,587
Gainesville	111,541,060	2,169,850	$5,187,774,704	$186,896,707
Pensacola-Ferrypass-Brent	77,477,600	1,509,813	$3,603,483,163	$130,045,410
Cape Coral-Fort Myers	35,103,574	725,273	$1,632,667,224	$62,470,306
Key West	44,032,677	930,853	$2,047,959,797	$80,177,568
Ocala	73,344,205	1,467,147	$3,411,238,966	$126,370,455
Homosassa Springs	26,679,053	550,534	$1,240,842,767	$47,419,355
The Villages	24,924,789	513,598	$1,159,251,914	$44,237,983
Naples-Marco Island	82,839,088	1,807,453	$3,852,845,981	$155,682,140
Panama City	31,716,636	696,586	$1,475,140,730	$59,999,395
Tampa-St. Petersburg-Clearwater	92,252,958	2,269,030	$4,290,685,057	$195,439,376
Orlando-Kissimmee-Sanford	131,499,573	3,352,768	$6,116,045,162	$288,785,468
Lakeland-Winter Haven	60,428,976	1,688,427	$2,810,551,659	$145,430,081
Sebastian-Vero Beach	15,307,201	429,606	$711,937,935	$37,003,459
Punta Gorda	21,150,699	608,521	$983,718,994	$52,413,978
Palm Bay-Melbourne-Titusville	29,669,558	875,850	$1,379,931,134	$75,439,971
North Port-Bradenton-Sarasota	37,264,769	1,124,936	$1,733,184,422	$96,894,596
Palatka	20,729,754	651,836	$964,140,861	$56,144,845
Deltona-Daytona Beach-Ormond Beach	43,871,182	1,394,374	$2,040,448,675	$120,102,274
Wauchula	16,832,607	533,445	$782,884,568	$45,947,498
Port St. Lucie	26,038,094	920,715	$1,211,031,741	$79,304,355
Arcadia	14,585,805	515,191	$678,385,784	$44,375,168
Clewiston	24,537,982	920,757	$1,141,261,557	$79,307,959
Miami-Fort Lauderdale-Pompano Beach	103,108,539	3,982,824	$4,795,578,148	$343,054,401
Sebring-Avon Park	20,934,918	814,639	$973,683,022	$70,167,636
Okeechobee	11,626,929	551,046	$540,768,464	$47,463,462
Total	**1,652,494,409**	**38,120,704**	**$76,857,514,962**	**$3,283,467,783**

[z] CO_2e storage rate was 125.697 T/ac. Based on US-level rate listed in i-Tree canopy v7.0 software.
[y] SE is an abbreviation for standard error, a measure of statistical accuracy for an estimated mean.
[x] CO_2e storage was valued at $46.51/T. Based on US-level value listed in i-Tree canopy v7.0 software.

Table 7. Estimated value of total annual benefits (air pollution removal, avoided stormwater runoff, and carbon dioxide equivalent [CO_2e] sequestration; in USD) and associated standard error (SE) calculations for the 29 metropolitan and micropolitan areas in Florida. Monetary values are based on county-level values listed in the i-Tree canopy v7.0 software.

	Total Annual Benefits							
Metropolitan / Micropolitan Area	Air Pollution	Air Pollution SE	Avoided Runoff	Avoided Runoff SE	CO_2e Sequestered[z]	CO_2e Sequestered SE[y]	Total Benefits[x]	Total Benefits SE[y]
Crestview-Fort Walton Beach-Destin	$19,876,367	$268,241	$15,878,139	$214,283	$220,282,941	$2,972,826	$256,037,447	$3,455,351
Tallahassee	$18,569,840	$252,193	$13,927,557	$189,147	$267,485,026	$3,632,652	$299,982,422	$4,073,991
Jacksonville	$67,597,085	$1,121,265	$41,102,869	$681,793	$318,251,323	$5,278,984	$426,951,277	$7,082,042
Lake City	$3,292,058	$57,811	$682,286	$11,981	$73,642,301	$1,293,218	$77,616,645	$1,363,011
Gainesville	$11,249,273	$218,836	$5,511,780	$107,223	$206,566,683	$4,018,420	$223,327,737	$4,344,479
Pensacola-Ferrypass-Brent	$35,387,009	$689,590	$21,083,563	$410,857	$143,483,402	$2,796,074	$199,953,974	$3,896,521
Cape Coral-Fort Myers	$21,513,273	$444,485	$32,777,402	$677,213	$65,009,503	$1,343,159	$119,300,178	$2,464,856
Key West	$2,198,593	$46,478	$2,221,197	$46,956	$81,545,612	$1,723,878	$85,965,402	$1,817,313
Ocala	$16,410,528	$328,269	$11,502,087	$230,083	$135,828,628	$2,717,060	$163,741,243	$3,275,412
Homosassa Springs	$13,143,399	$271,220	$6,646,633	$137,156	$49,407,846	$1,019,552	$69,197,878	$1,427,927
The Villages	$5,445,000	$112,199	$3,130,453	$64,506	$46,159,064	$951,150	$54,734,517	$1,127,855
Naples-Marco Island	$12,965,969	$282,902	$12,365,715	$269,806	$153,412,525	$3,347,283	$178,744,208	$3,899,991
Panama City	$11,079,671	$243,341	$6,236,435	$136,970	$58,737,117	$1,290,032	$76,053,222	$1,670,342
Tampa-St. Petersburg-Clearwater	$108,067,269	$2,657,995	$56,001,903	$1,377,408	$170,846,390	$4,202,094	$334,915,562	$8,237,497
Orlando-Kissimmee-Sanford	$66,711,108	$1,700,894	$53,292,844	$1,358,777	$243,528,533	$6,209,105	$363,532,485	$9,268,776
Lakeland-Winter Haven	$20,695,248	$578,240	$14,764,539	$412,531	$111,910,476	$3,126,856	$147,370,263	$4,117,627
Sebastian-Vero Beach	$5,800,433	$162,793	$3,981,619	$111,747	$28,347,927	$795,602	$38,129,978	$1,070,142
Punta Gorda	$8,014,045	$230,570	$7,054,815	$202,972	$39,169,698	$1,126,940	$54,238,558	$1,560,482
Palm Bay-Melbourne-Titusville	$13,505,954	$398,698	$16,473,438	$486,298	$54,946,063	$1,622,016	$84,925,455	$2,507,012
North Port-Bradenton-Sarasota	$24,949,673	$753,172	$15,639,381	$472,116	$69,011,894	$2,083,307	$109,600,947	$3,308,595
Palatka	$3,645,056	$114,617	$1,828,193	$57,486	$38,390,137	$1,207,156	$43,863,385	$1,379,260
Deltona-Daytona Beach-Ormond Beach	$18,988,661	$603,524	$9,921,090	$315,326	$81,246,534	$2,582,289	$110,156,285	$3,501,139
Wauchula	$743,110	$23,550	$577,625	$18,306	$31,172,878	$987,906	$32,493,613	$1,029,761
Port St. Lucie	$13,133,556	$464,407	$8,693,941	$307,420	$48,220,832	$1,705,103	$70,048,328	$2,476,930
Arcadia	$866,638	$30,611	$720,755	$25,458	$27,011,948	$954,100	$28,599,341	$1,010,168
Clewiston	$1,019,992	$38,274	$943,086	$35,388	$45,442,724	$1,705,181	$47,405,803	$1,778,843
Miami-Fort Lauderdale-Pompano Beach	$77,315,778	$2,986,515	$86,050,393	$3,323,911	$190,950,211	$7,375,928	$354,316,381	$13,686,353
Sebring-Avon Park	$2,695,689	$104,897	$2,040,254	$79,392	$38,770,086	$1,508,657	$43,506,029	$1,692,946

Metropolitan / Micropolitan Area	Total Annual Benefits							
	Air Pollution	Air Pollution SE	Avoided Runoff	Avoided Runoff SE	CO_2e Sequestered[z]	CO_2e Sequestered SE[y]	Total Benefits[x]	Total Benefits SE[y]
Okeechobee	$760,870	$36,061	$478,785	$22,692	$21,532,305	$1,020,500	$22,771,961	$1,079,252
Total	**$605,641,144**	**$15,221,645**	**$451,528,775**	**$11,785,202**	**$3,060,310,607**	**$70,597,028**	**$4,117,480,527**	**$97,603,875**

[z] CO_2e sequestration was valued at $46.51/T. Based on US-level value listed in i-Tree canopy v7.0 software.
[y] SE is an abbreviation for standard error, a measure of statistical accuracy for an estimated mean.
[x] Total Benefits = the sum of air pollution, avoided stormwater runoff, and CO_2 equivalent sequestration benefit values.