

Elizabeth River Watershed Urban Tree Canopy

I-TREE ACADEMY 2021
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PROJECT OVERVIEW

The Elizabeth River, located in Southeast Virginia, is known for its high levels of pollution. Its watershed is located in a highly urbanized area of the cities of Norfolk, Portsmouth, Chesapeake, and Virginia Beach. The river is home to some of the busiest ports in the Chesapeake Bay and the world (Figure 1). The Elizabeth River Project, a non-profit dedicated to improving the condition of the Elizabeth River, is currently preparing an updated Watershed Action Plan, which includes goals and steps for actions needed to restore the health of the river. Loss of urban tree canopy has been identified as a significant challenge. In order to understand this problem fully and create achievable goals for increasing the urban tree canopy, information about the current status of the tree canopy is needed.

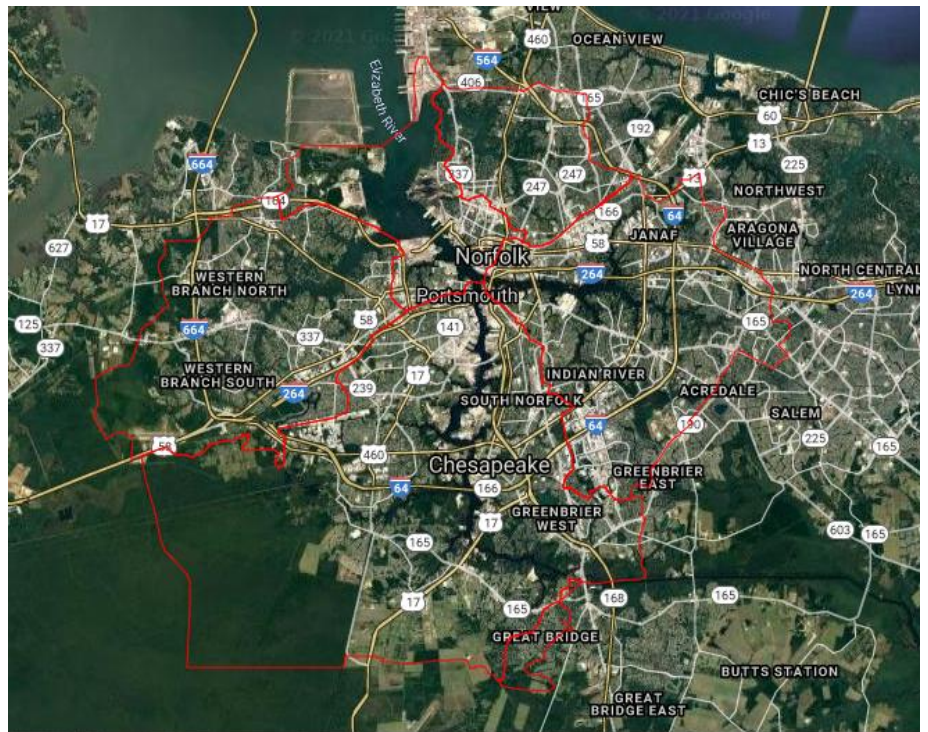


Figure 1: Elizabeth River Watershed. Boundaries were provided by the Elizabeth River Project

To assist the Elizabeth River Project as they prepare their Watershed Action Plan for 2021, an i-Tree Canopy Assessment for the 204 square mile Elizabeth River watershed was completed. To further assist the Elizabeth River Project in setting achievable planting goals to increase the Urban Tree Canopy, i-Tree Landscape Analysis was completed for the watersheds of each of the four branches of the river: Eastern Branch, Western Branch, Southern Branch, and Main Branch.

I-TREE CANOPY: TREE CANOPY ASSESSMENT

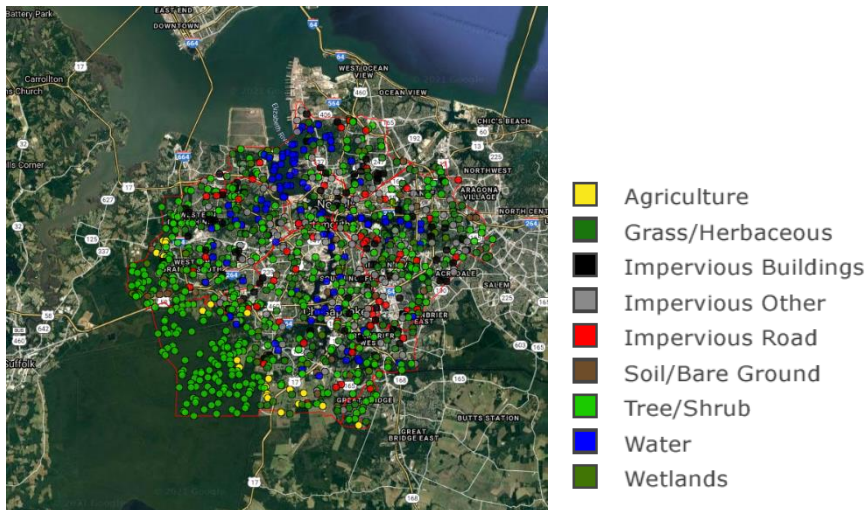


Figure 2: 1000 point land cover survey for the Elizabeth River Watershed

To assess the canopy coverage for the Elizabeth River Watershed, a 1000 point survey was done using i-Tree Canopy (Figure 2). The assessed area is 204 square miles, 21.22 square miles of which is water. The watershed’s tree canopy coverage was the most common land coverage type, and represents $37.70 \pm 1.53\%$ of the watershed (Figure 3). Much of the forested area is concentrated in the more rural, southern part of the watershed, while grass/herbaceous and impervious surfaces are concentrated in the more urban,

northern part of the watershed (Figures 2 and 3).

Tree Benefits

The trees in the Elizabeth River Watershed provide countless benefits to the environment and the people who live and work there. These benefits range from improving air and water quality to improving the physical and mental health of those who choose to live and work within the watershed. Estimates of some of these benefits were provided by i-Tree Canopy. This includes annual carbon sequestration of 64.35 kilotons (kilotons = 1,000 tons) of Carbon, or 235.96 kilotons of CO₂ equivalents. This benefit has an annual monetary value of \$10,975,609 (Table 1).

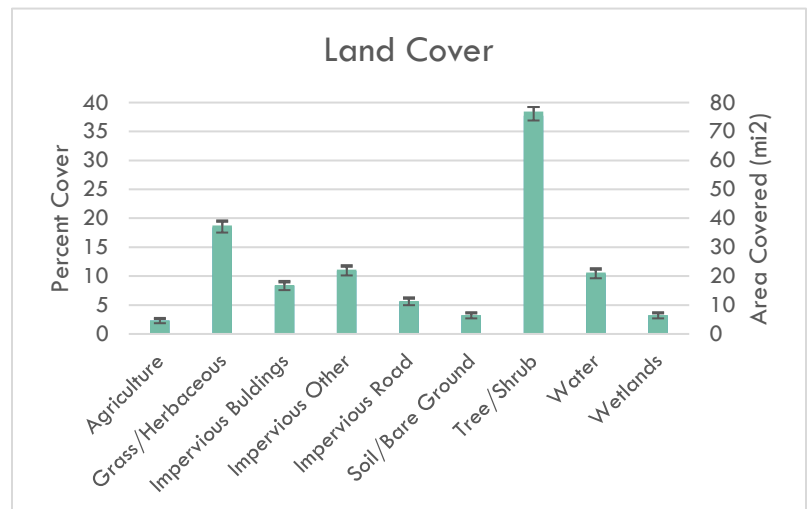


Figure 3: Percent cover and area for land cover classes within the Elizabeth River Watershed. Error bars represent standard error for percent cover.

Table 1: Tree Benefit Estimates: Carbon (from i-Tree Canopy Report)

Description	Carbon (kT)	±SE	CO ₂ Equiv. (kT)	±SE	Value (USD)	±SE
Sequestered annually in trees	64.35	±2.62	235.96	±9.59	\$10,975,609	±446,172
Stored in trees (Note: this benefit is not an annual rate)	1,687.88	±68.61	6,188.88	±251.59	\$287,868,439	±11,702,197

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 0.837 kT of Carbon, or 3.067 kT of CO₂, per mi²/yr and rounded. Amount stored is based on 21.940 kT of Carbon, or 80.446 kT of CO₂, per mi² and rounded. Value (USD) is based on \$170,550.73/kT of Carbon, or \$46,513.84/kT of CO₂ and rounded. (English units: kT = kilotons (1,000 tons), mi² = square miles)

The trees also provide significant air quality benefits by removing pollutants from the air. In total, it is estimated that the value of these air quality improvements has a monetary benefit of \$24,191,945 (Table 2).

Table 2: Tree Benefit Estimates: Air Pollution (from i-Tree Canopy Report)

Abbr.	Description	Amount (T)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	24.02	±0.98	\$32,033	±1,302
NO2	Nitrogen Dioxide removed annually	103.83	±4.22	\$61,319	±2,493
O3	Ozone removed annually	1,519.41	±61.77	\$6,446,866	±262,073
SO2	Sulfur Dioxide removed annually	117.93	±4.79	\$32,131	±1,306
PM2.5	Particulate Matter less than 2.5 microns removed annually	79.43	±3.23	\$15,883,723	±645,692
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	276.92	±11.26	\$1,735,874	±70,565
Total		2,121.55	±86.24	\$24,191,945	±983,432

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in T/mi²/yr @ \$/T/yr and rounded:

CO 0.312 @ \$1,333.50 | NO2 1.350 @ \$590.57 | O3 19.750 @ \$4,243.00 | SO2 1.533 @ \$272.44 | PM2.5 1.032 @ \$199,975.37 | PM10* 3.600 @ \$6,268.44 (English units: T = tons (2,000 pounds), mi² = square miles)

Finally, the trees provide significant hydrological benefits to the watershed through avoided run-off, evaporation, interception, transportation, potential evaporation, and potential evapotranspiration. These ecosystem services are particularly important for improving the water quality on the Elizabeth River (Table 3).

Table 3: Tree Benefit Estimates: Hydrological (from i-Tree Canopy Report)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	1,424.80	±57.92	\$12,731,995	±517,571
E	Evaporation	4,199.06	±170.70	N/A	N/A
I	Interception	4,199.06	±170.70	N/A	N/A
T	Transpiration	11,071.47	±450.07	N/A	N/A
PE	Potential Evaporation	34,584.39	±1,405.90	N/A	N/A
PET	Potential Evapotranspiration	28,905.59	±1,175.05	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in Mgal/mi²/yr @ \$/Mgal/yr and rounded:

AVRO 18.520 @ \$8,936.00 | E 54.582 @ N/A | I 54.582 @ N/A | T 143.913 @ N/A | PE 449.547 @ N/A | PET 375.731 @ N/A (English units: Mgal = millions of gallons, mi² = square miles)

I-TREE LANDSCAPE: PLANTING PRIORITIZATION BY BRANCH

To better understand the tree canopy within the Elizabeth River Watershed and determine priority planting areas, i-Tree Landscape was used to look more closely at the HUC-12 watershed's within the Elizabeth River. This includes the Main, Eastern, Southern, and Western Branches. Census tracts that were located within two branches are only represented in one branch's analysis. Additionally, those census tracts with less than approximately 50% of their area within the watershed were not included in the analysis. High resolution imagery was available for all watersheds and was used for analysis.

For each branch, two planting prioritizations were run to determine optimal areas to plant trees. The first, the poverty scenario, is a weighted index towards areas with relatively high proportion of population below the poverty line (40% weighting), low tree cover per capita (30% weighting), and high available planting space (30% weighting). The second, focuses on the urban heat island, and is an index weighted towards high

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proportion of population below the poverty line (33% weighting), low percent canopy (33% weighting), and high land surface temperature difference (34% weighting). These planting prioritization scenarios were chosen to address environmental justice, human health, and water quality concerns.

The Elizabeth River Watershed as a whole, is highly urbanized, particularly in the central and northern portions of the watershed. This is reflected in low urban tree canopy cover and high temperatures in these areas. Plantable space, however, is still available (Figures 4a-b).

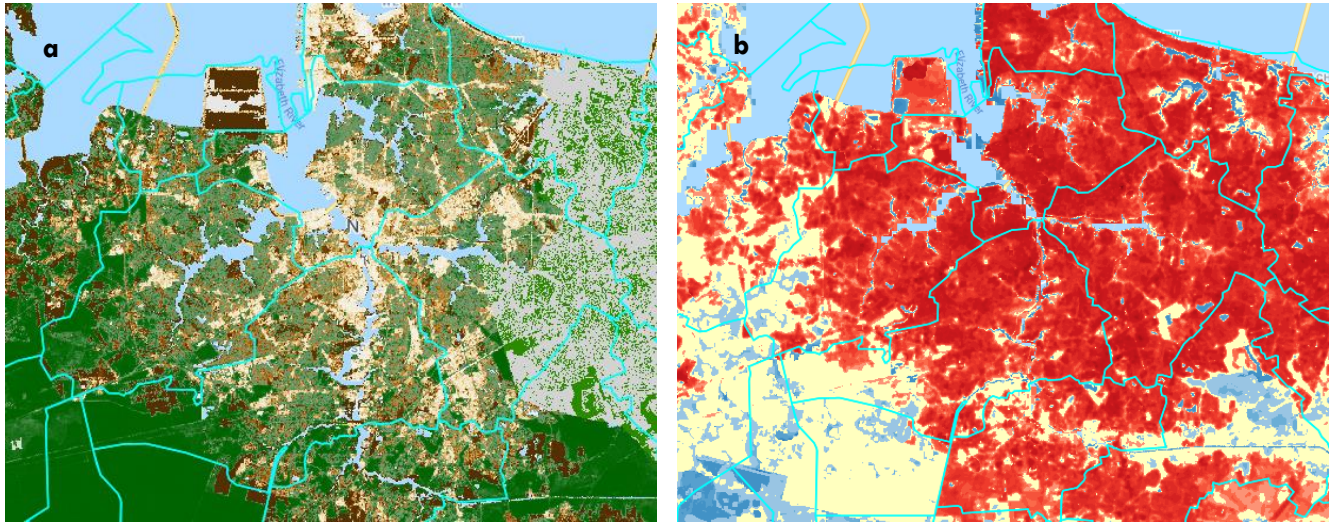


Figure 4: (a) Tree Canopy (green) and plantable space (brown), and (b) land surface temperature difference in the Elizabeth River Watershed

Main Branch

The Main Branch of the Elizabeth River's watershed is the smallest of each of the four branches. It includes the watershed for both the Main Branch and the Lafayette River. Tree cover represents 39.9% of the total land cover and impervious surfaces represent 39.7% of the total land cover. There are 2,950.5 acres classified as plantable space. This represents 20.4% of the total land cover within the Main Branch's watershed (Table 4). Individual census tracts ranged from 8.4% to 70% tree canopy cover.

The 5,775.1 acres of tree canopy store an estimated 89,958.1 tons of carbon, or 329,846.5 tons of CO₂ equivalents, for a value of \$15,342,424. Each year it is estimated that the trees sequester 2,832.3 tons of carbon, the equivalent of 10,385 tons of CO₂. This has a monetary value of \$483,047. The tree canopy also removes 495,598.1 pounds of air pollution per year (Table 5).

In addition to air quality benefits, the tree canopy also provides significant hydrological benefits. It is estimated that the canopy results in 158 million gallons of run-off avoided. This has a monetary value of \$1,411,818 and is particularly important for water quality of the Elizabeth River. Other benefits include transpiration and rainfall interception (Table 5).

The i-Tree Landscape poverty prioritization scenario suggests that planting should occur in the more urbanized areas of Norfolk and Portsmouth, particularly in the Lambert's Point, Lindenwood, Barvad Park, Hunter's Square, and Bruce's Park neighborhoods in Norfolk and the Park View neighborhood in Portsmouth (Figure 3a). The urban heat island scenario indicates that planting should be prioritized in nearly all census tracts

within the Main Branch Watershed. A core of highest priority planting areas runs from the Lambert's Point Area to Brambleton Ave. in the South and the Lafayette River in the East (Figure 3b).

Eastern Branch

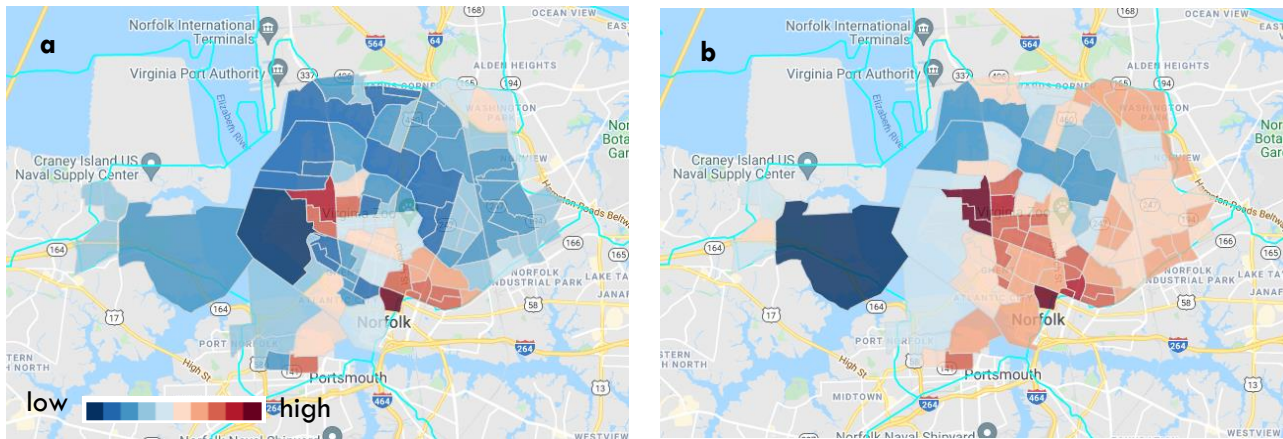


Figure 2: Main Branch Planting Prioritization by census tract. (A) Shows Poverty Scenario, and (B) shows Urban Heat Island scenario. Cooler colors indicate low priority, while warmer colors indicate high priority planting areas.

The Eastern Branch has tree canopy cover of 37.3% and impervious cover of 37.6%. There are 6,093.5 acres classified as plantable space. This represents 24.6% of the area (Table 4). Individual census tracts ranged from 12.3% to 73.3% tree canopy cover.

It is estimated that the 9,228.3 acres of tree canopy currently store 164,122.0 tons of carbon, the equivalent of 601,780.6 tons of CO₂. This has a monetary value of \$27,991,123. Annually, it is estimated that the canopy sequesters an estimated 5,942.5 tons of carbon, or 21,788.9 tons of CO₂ equivalents, for a value of \$1,013,489. The trees are also estimated to remove 847,499.1 pounds of air pollutants per year (Table 5).

In addition to air quality benefits, the tree canopy also provides significant hydrological benefits. It is estimated that the canopy results in 200.8 million gallons of run-off avoided per year. This has a monetary value of \$1,794,308, and it is particularly important for water quality on the Elizabeth River. Other benefits include transpiration and rainfall interception (Table 5).

Both the poverty and urban heat island planting scenario suggest that the greatest need for planting is in the southern part of the city of Norfolk, bordered by Church Street and interstate 464 to the west, the rail line that crosses the Elizabeth River between the Ford Plant and Granby Village in the east, and Liberty Street to the south and E. Princess Ann Road to the north (Figure 4a and b).

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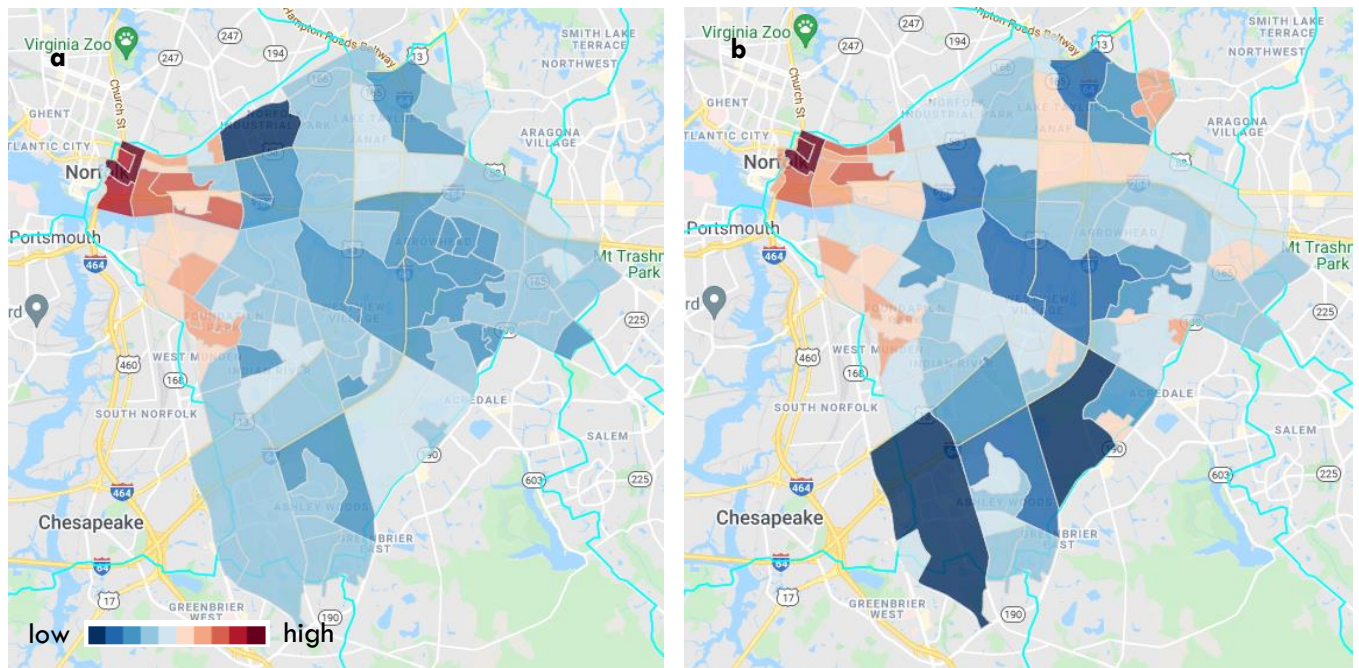


Figure 3: Eastern Branch Planting Prioritization by census tract. (A) Shows Poverty Scenario, and (B) shows Urban Heat Island scenario. Cooler colors indicate low priority, while warmer colors indicate high priority planting areas.

Southern Branch

Tree canopy cover within the census tracts of the Southern Branch of the Elizabeth River represent 46.0% of the land cover, and impervious surfaces represent 26.1% of the land cover. There are 7,339.9 acres classified as plantable space. This represents 27.0% of the total land area (Table 4). Individual census tracts ranged from 9.6% to 75.9% tree canopy cover.

This high tree canopy cover is driven predominantly by census tract 51550213011. This tract is 5,553.8 acres, and represents 19.09% of the total area within the watershed. It is located in the rural southwestern corner of the watershed, and has a tree canopy cover of over 75%. A portion of this tract is also within the Great Dismal Swamp National Wildlife Refuge. Removing this census tract from the analysis, results in the canopy coverage being below 30%.

The 12,528.3 acres of tree canopy within the watershed of the Southern Branch of the Elizabeth River currently stores an estimated 304,893.8 tons of carbon, which is equivalent to 1,117,944 tons of CO₂ equivalents. This has a value of \$51,999,864. Each year, it is estimated that the canopy sequesters 11,195.4 tons of carbon, or 41,049.9 tons of CO₂ equivalents. This has a value of \$1,909,388. The tree canopy also removes an estimated 1,099,207.0 pounds of air pollutants per year (Table 5).

In addition to air quality benefits, the tree canopy also provides significant hydrological benefits. It is estimated that the canopy results in 155.8 million gallons of run-off avoided per year. This has a monetary value of \$1,385,795, and it is particularly important for water quality on the Elizabeth River. Other benefits include transpiration and rainfall interception (Table 5).

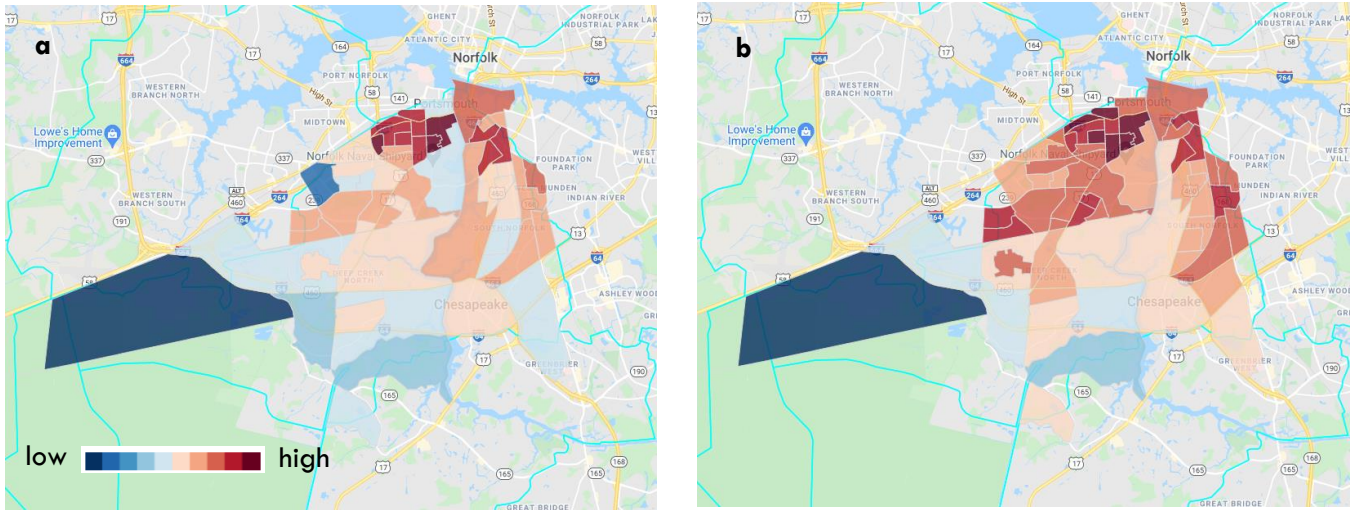


Figure 4: Southern Branch Planting Prioritization by census tract. (A) Shows Poverty Scenario, and (B) shows Urban Heat Island scenario. Cooler colors indicate low priority, while warmer colors indicate high priority planting areas.

Planting prioritization scenarios for both poverty and the urban heat island suggest that planting should be prioritized in the northern portion of the watershed. The highest priority area includes the city of Portsmouth and the South Norfolk area of Chesapeake (Figure 5a and b).

Western Branch

Within the census tracts of the Western Branch of the Elizabeth River's watershed, tree canopy cover represents 47.7% of the total land cover, and impervious surfaces represents 26.5% of the total land cover. There are 4,649.2 acres classified as plantable space. This represents 24.9% of the land cover within the analyzed area. Individual census tracts within the watershed range from 13.3% to 70.5% tree canopy cover.

The 8,915.6 acres of tree canopy within the analyzed area of Western Branch's watershed stores an estimated 208,055.4 tons of carbon, or 762,869.6 tons of CO₂ equivalents. This has a value of \$35,483,995. Each year, the canopy sequesters an estimated 6,851.4 tons of carbon, or 25,121.9 tons of CO₂ equivalents. This has a value of \$1,168,516. The tree canopy also removes an estimated 796,603.5 pounds of air pollutants per year (Table 4).

In addition to air quality benefits, the tree canopy also provides significant hydrological benefits. It is estimated that the canopy results in 149 million gallons of run-off avoided per year. This has a monetary value of \$1,331,160, and it is particularly important for water quality on the Elizabeth River. Other benefits include transpiration and rainfall interception (Table 5).

Compared to the other branches, the watershed of the Western Branch has fewer priority planting areas under both the poverty and the urban heat island scenarios. The highest priority areas under both scenarios are in the Midtown and Port Norfolk areas of Portsmouth (Figure 6a and b).

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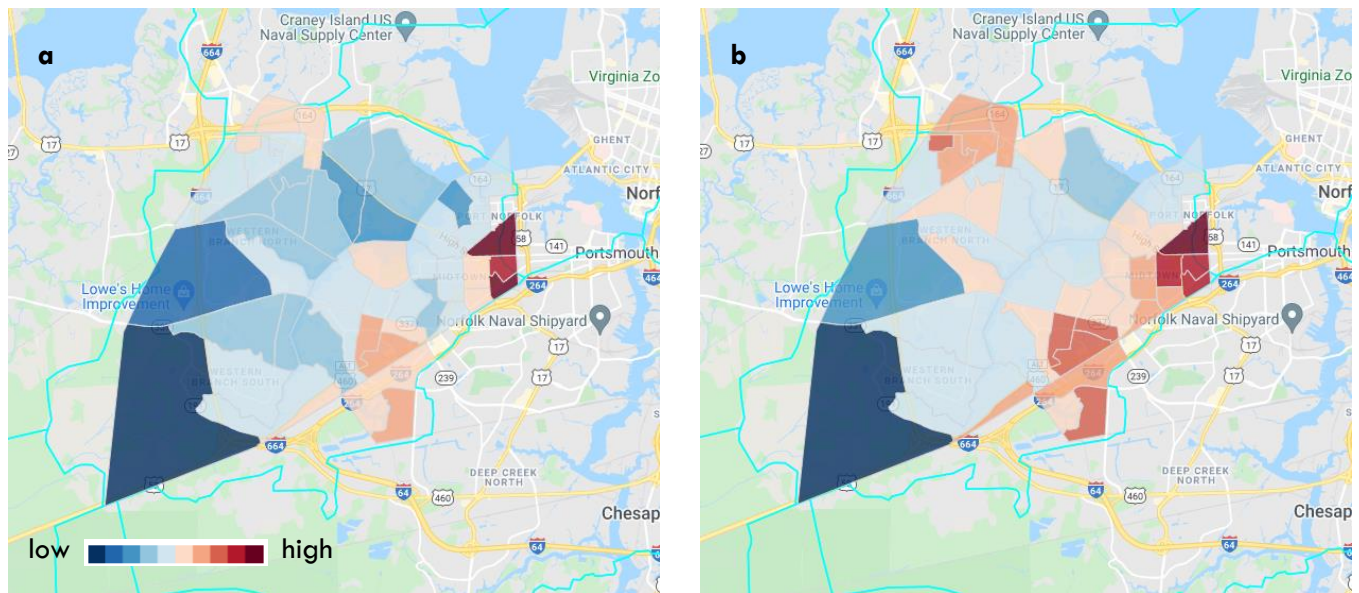


Figure 5: Western Branch Planting Prioritization by census tract. (A) Shows Poverty Scenario, and (B) shows Urban Heat Island scenario. Cooler colors indicate low priority, while warmer colors indicate high priority planting areas.

Table 4: Total Area, Percent Tree Canopy Cover, Impervious Surface, and Plantable Space within census tracts located in each branch of the Elizabeth River Watershed. Data is based on High Resolution Imagery, and analysis was done using i-Tree Landscape. Each census tract was only included in one watershed and only those that are located greater than approximately 50% within the watershed were used.

Branch	Total Area Included (acres)	Percent Tree Canopy	Percent Impervious Surface	Percent Plantable Space
Main Branch	18,650.0	39.90%	39.67%	20.39%
Eastern Branch	26,420.9	37.31%	37.56%	24.64%
Southern Branch	29,091.7	45.99%	26.09%	26.95%
Western Branch	20,406.3	47.70%	26.45%	24.87%

Table 5: Estimates of environmental services provided by the tree canopy within census tracts located in each branch of the Elizabeth River Watershed. Data is based on High Resolution Imagery, and analysis was done using i-Tree Landscape. Each census tract was only included in one watershed and only those that are located greater than approximately 50% within the watershed were used.

Branch	Carbon Sequestration (t/yr)	Carbon Storage (short ton)	Air pollution removed (lb/yr)	Transpiration (millions of gallons/yr)	Rainfall Interception (millions of gallons/yr)	Avoided Runoff (millions of gallons/yr)
Main	2,832.3	89,958.1	495,598.1	1,295.5	489.4	158.0
Eastern	5,942.5	164,122.0	847,499.1	1,707.2	859.0	200.8
Southern	11,195.4	304,893.8	1,099,207.0	2,258.6	1,098.9	155.1
Western	6,851.4	208,055.4	796,603.5	1,727.7	767.6	149.0

CONCLUSIONS

Both i-Tree Landscape and i-Tree Canopy suggest that the Urban Tree Canopy Cover within the Elizabeth River Watershed is within reach of the Elizabeth River Project's 2016 Goal of 40% canopy. Estimates range from 38% for the whole watershed to nearly 48% for census tracts analyzed within the Eastern Branch's watershed. However, the tree canopy cover varies greatly across the watershed appears to be concentrated at the outer edges of the Eastern, Southern, and Western Branch's Watersheds. The canopy at the outer edges of the watershed does provide countless benefits from sequestering carbon, removing air pollutants and preventing run-off, to others not discussed in this report, such as providing recreation opportunities. These benefits, however, are concentrated in areas with lower population densities. Increasing the urban tree canopy in the more urbanized areas that are suggested by the i-Tree Landscape planting scenarios would provide benefits to the most densely populated areas where residents may benefit from the ecological services they provide on a daily basis. Additionally, the benefits such as preventing run-off will have a greater impact on water quality of the Elizabeth River in the heavily urbanized areas.

REFERENCES

Elizabeth River Project, The. (2016). Star Power: Toward a Thriving Urban River, Twentieth Anniversary Watershed Action Plan for the Elizabeth River. https://elizabethriver.org/sites/default/files/ERP-watershed-action-plan_0.pdf

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