Using i-Tree to analyze the benefits of tree plantings in urban Honolulu

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The following report summarizes the i-Tree tools that were used to quantify the existing tree canopy in downtown Honolulu, the importance of planting trees in the area, and the benefits of the trees to be planted.

Like most downtown areas in cities, buildings, roads, and grey infrastructure generally take precedent over trees. The City and County of Honolulu (City) Division of Urban Forestry (DUF) is dedicated to caring for our City trees and growing our tree canopy, as demonstrated in this project to plant more trees in downtown Honolulu.

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i-Tree Canopy

Methods:

To find the estimated tree canopy cover, i-Tree Canopy was used along a drawn boundary in downtown Honolulu. The boundaries were from the mauka edge of westbound Nimitz Highway to the mauka edge of Berentania Street and the ewa edge of River Street to the Diamond Head edge of Fort Street Mall. The following analysis included a sample total of 350 randomly placed points in the above stated plot (Image 1.)

The points were classified into seven possible land cover classes: grass/ herbaceous, impervious buildings, impervious other, impervious road, soil/ bare ground, tree/ shrub, and water.

Note: The "impervious other" land cover class consisted of parking lots, sidewalks, and pedestrian walking mall.

Results:

The results shown in Table 1 and Graph 1 show an estimated tree canopy of 8.86% and total impervious cover (impervious buildings, impervious other, impervious road) of 87.9% in downtown Honolulu or approximately 5.17 acres of tree canopy and 51.32 acres of total impervious surfaces.

In urban spaces trees are especially valuable infrastructure that provide benefits to the surrounding community. With only 8.86% existing tree canopy cover in the defined area, it sequesters 13.39 tons of carbon annually (valued at $2,284), removes a total of 484 pounds of air pollutants, and avoids 103,650 ounces of avoided runoff among other benefits (See Table 2-4.)

Discussion:

This project using i-Tree Canopy strengthens the fact that the majority of the land cover in the defined area in downtown Honolulu is impervious surfaces with only a small amount of tree/shrub cover. We will then use i-Tree Landscape to determine the priority of planting in the area and i-Tree Design to calculate the benefits of new tree plantings.

Image 1. Land cover assessment using random sampling points in downtown Honolulu using i-Tree Canopy

Table 1. Downtown Honolulu land cover points by cover class with total percentages and area by acreage.

Abbr.	Cover Class	Points	% Cover ± SE	Area (ac) ± SE
H	Grass/Herbaceous	10	2.86 ± 0.89	1.67 ± 0.52
IB	Impervious Buildings	191	54.57 ± 2.66	31.84 ± 1.55
IO	Impervious Other	44	12.57 ± 1.77	7.34 ± 1.03
IR	Impervious Road	73	20.86 ± 2.17	12.17 ± 1.27
S	Soil/Bare Ground	0	0.00 ± 0.00	0.00 ± 0.00
T	Tree/Shrub	31	8.86 ± 1.52	5.17 ± 0.89
W	Water	1	0.29 ± 0.29	0.17 ± 0.17
Total		**350**	**100.00**	**58.35**

Graph 1. Existing downtown Honolulu land canopy coverage by percentage and acreage

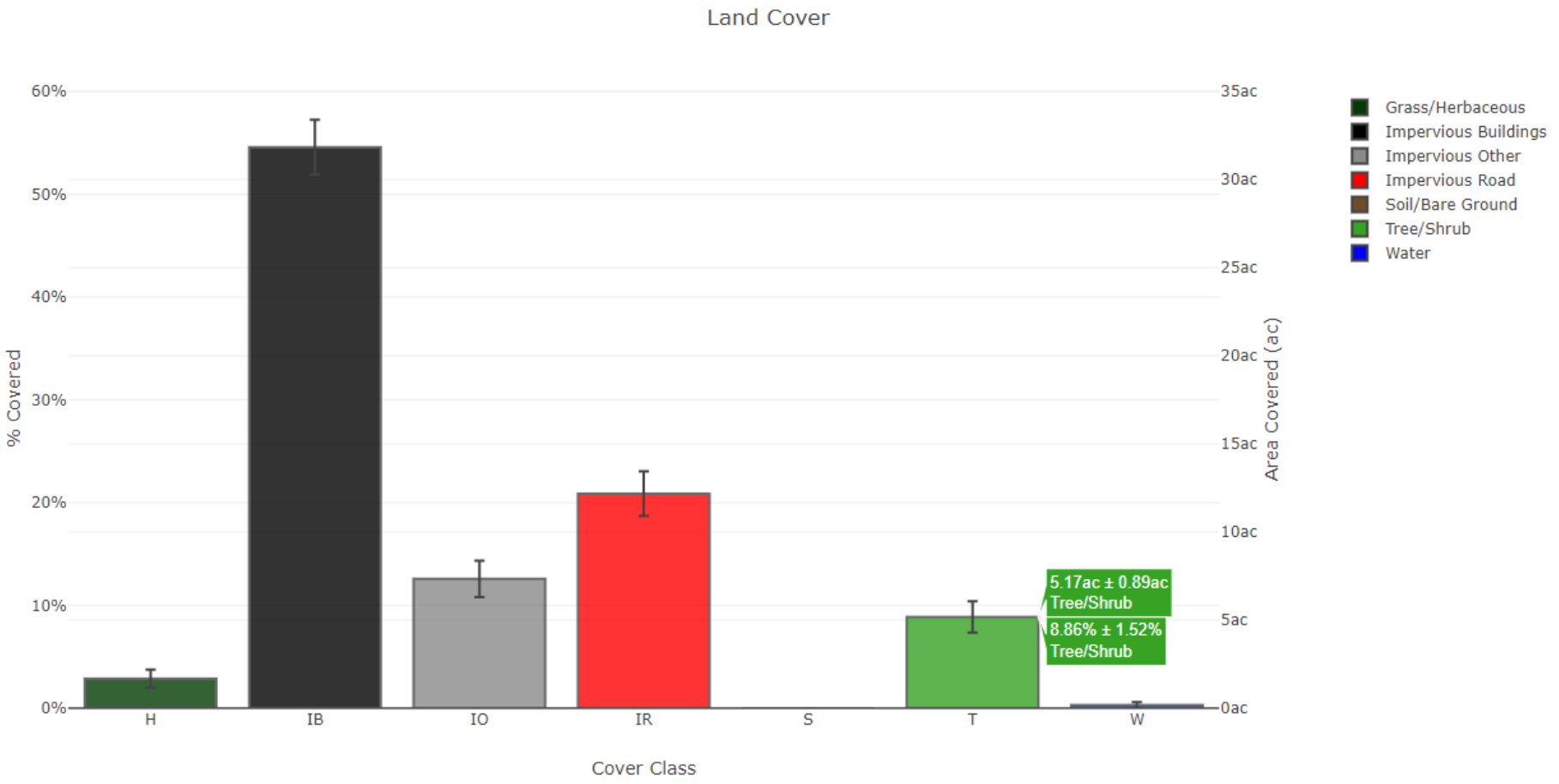


Table 2. Existing downtown Honolulu tree canopy carbon benefits

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (T)	±SE	CO_2 Equiv. (T)	±SE	Value (USD)	±SE
Sequestered annually in trees	13.39	±2.30	49.11	±8.42	$2,284	±392
Stored in trees (Note: this benefit is not an annual rate)	177.16	±30.38	649.59	±111.38	$30,215	±5,181

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 2.592 T of Carbon, or 9.503 T of CO_2, per ac/yr and rounded. Amount stored is based on 34.281 T of Carbon, or 125.697 T of CO_2, per ac and rounded. Value (USD) is based on $170.55/T of Carbon, or $46.51/T of CO_2 and rounded. (English units: T = tons (2,000 pounds), ac = acres)

Table 3. Existing downtown Honolulu tree canopy air pollution benefits

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	14.36	±2.46	$10	±2
NO2	Nitrogen Dioxide removed annually	22.59	±3.87	$1	±0
O3	Ozone removed annually	286.22	±49.08	$47	±8
SO2	Sulfur Dioxide removed annually	88.94	±15.25	$0	±0
PM2.5	Particulate Matter less than 2.5 microns removed annually	10.12	±1.74	$46	±8
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	61.77	±10.59	$200	±34
Total		**484.00**	**±82.99**	**$303**	**±52**

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 lb/ac/yr @ $/lb/yr and rounded:
CO 2.778 @ $0.69 | NO2 4.371 @ $0.02 | O3 55.385 @ $0.16 | SO2 17.210 @ $0.00 | PM2.5 1.958 @ $4.50 | PM10* 11.952 @ $3.24 (English units: lb = pounds, ac = acres)

Table 4. Existing downtown Honolulu tree canopy hydrological benefits

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (oz)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	102,650.77	±17,601.22	$7	±1
E	Evaporation	12,386,021.82	±2,123,793.63	N/A	N/A
I	Interception	12,407,224.79	±2,127,429.24	N/A	N/A
T	Transpiration	32.58	±5.59	N/A	N/A
PE	Potential Evaporation	99,991,399.65	±17,145,222.28	N/A	N/A
PET	Potential Evapotranspiration	89,492,438.85	±15,344,997.29	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 oz/ac/yr @ $/oz/yr and rounded:
AVRO 19,863.170 @ $0.00 | E 2,396,724.907 @ N/A | I 2,400,827.732 @ N/A | T 6.305 @ N/A | PE 19,348,575.476 @ N/A | PET 17,317,001.397 @ N/A (English units: oz = ounces, ac = acres)

i-Tree Landscape

Methods:

Using i-Tree Landscape, U.S. census blocks in downtown Honolulu were selected for analysis. The included:

- 150030053001
- 150030052002
- 150030052001
- 150030040002
- 150030040001
- 150030042002
- 150030051001
- 150030051002
- 150030041002
- 150030039001
- 150030042001
- 150030041001
- 150030041003
- 150030053002

This is meant to give a more comprehensive view of the **general area** (**blue**), but the **study area** census blocks that are highlighted **red** are outlined in the i-Tree Canopy analysis below in Image 2: 150030053001, 150030052002, 150030042002, and 150030051001.

Through i-Tree Landscape, we can create scenarios with Census data and land cover data to prioritize tree planting locations. Common scenarios for the following were run:

- Population: an index weighted towards areas of relatively high population density, low tree cover per capita, and high available planting space.
- Minorities: an index weighted towards areas of relatively high minority population density, low tree cover per capita, and high available planting space.
- Poverty: an index weighted towards areas of relatively high proportion of population below the poverty line, low tree cover per capita, and high available planting space.

Results:

Three scenarios (Images 3-5) show tree planting prioritization scenarios where dark green is minimum prioritization and the dark pink is maximum prioritization. The minority prioritization scenario shows that there is a range of mid-level tree planting prioritization in the study area and higher prioritization in several of the areas mauka (Image 3.) The minority percentage in the general area ranged from 40% to 98% (Table 5.) In the population prioritization scenario, the study area has low to mid-level tree planting prioritization (Image 4.) In the poverty prioritization scenario, the study area shows low and mid to high-level tree planting prioritization (Image 5.)

Discussion:

The minority and population scenarios may have a lower planting prioritization compared to the Census blocks mauka because there is a higher population in these areas (Table 5.) In an unofficial brief comparison, there are more businesses and commercial buildings in the study area compared to apartments and housing in the general wider area which is why it could attribute to the lower prioritization.

The poverty prioritization scenario shows high prioritization for the most ewa census blocks in the study area. Interestingly enough, the study area includes the highest median income and the second lowest median income in the general area (Table 6.)

It would be interesting in a future analysis to see at a larger scale how the study area compares to different areas on O‘ahu.

Image 2. i-Tree Landscape range in downtown Honolulu with highlighted study area

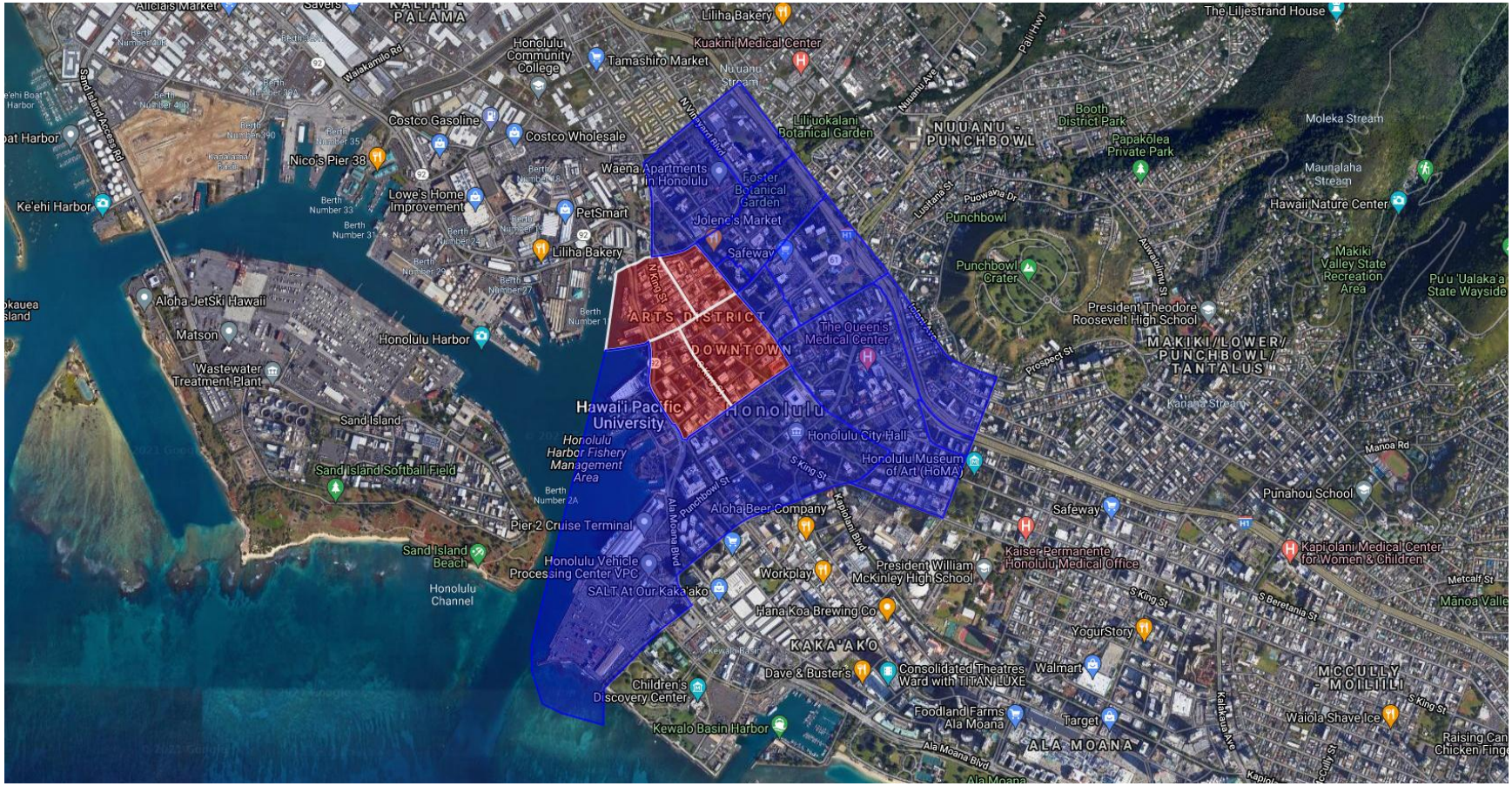


Image 3. i-Tree Landscape planting and minority prioritization in downtown Honolulu

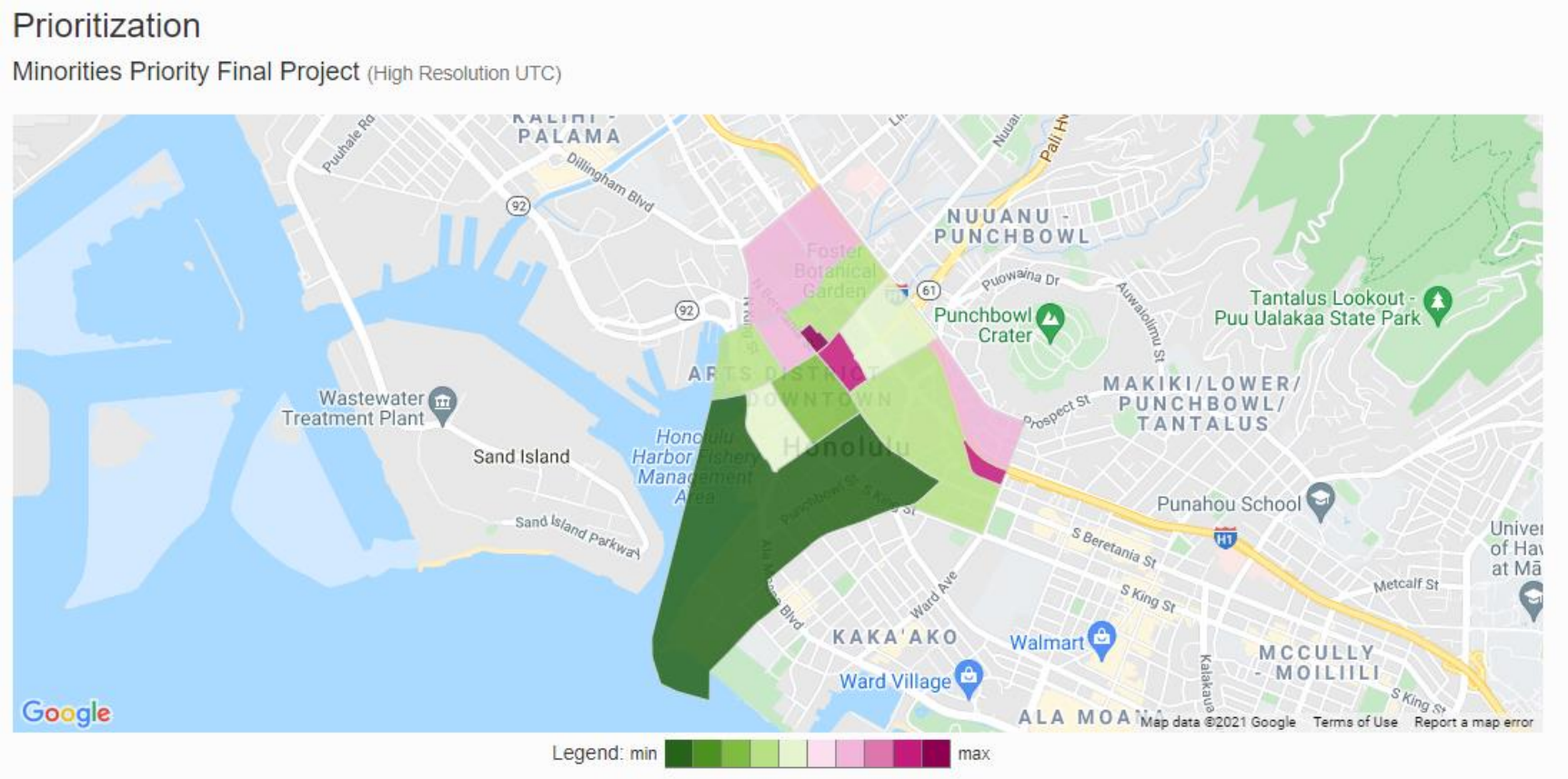


Image 4. i-Tree Landscape planting and population prioritization in downtown Honolulu

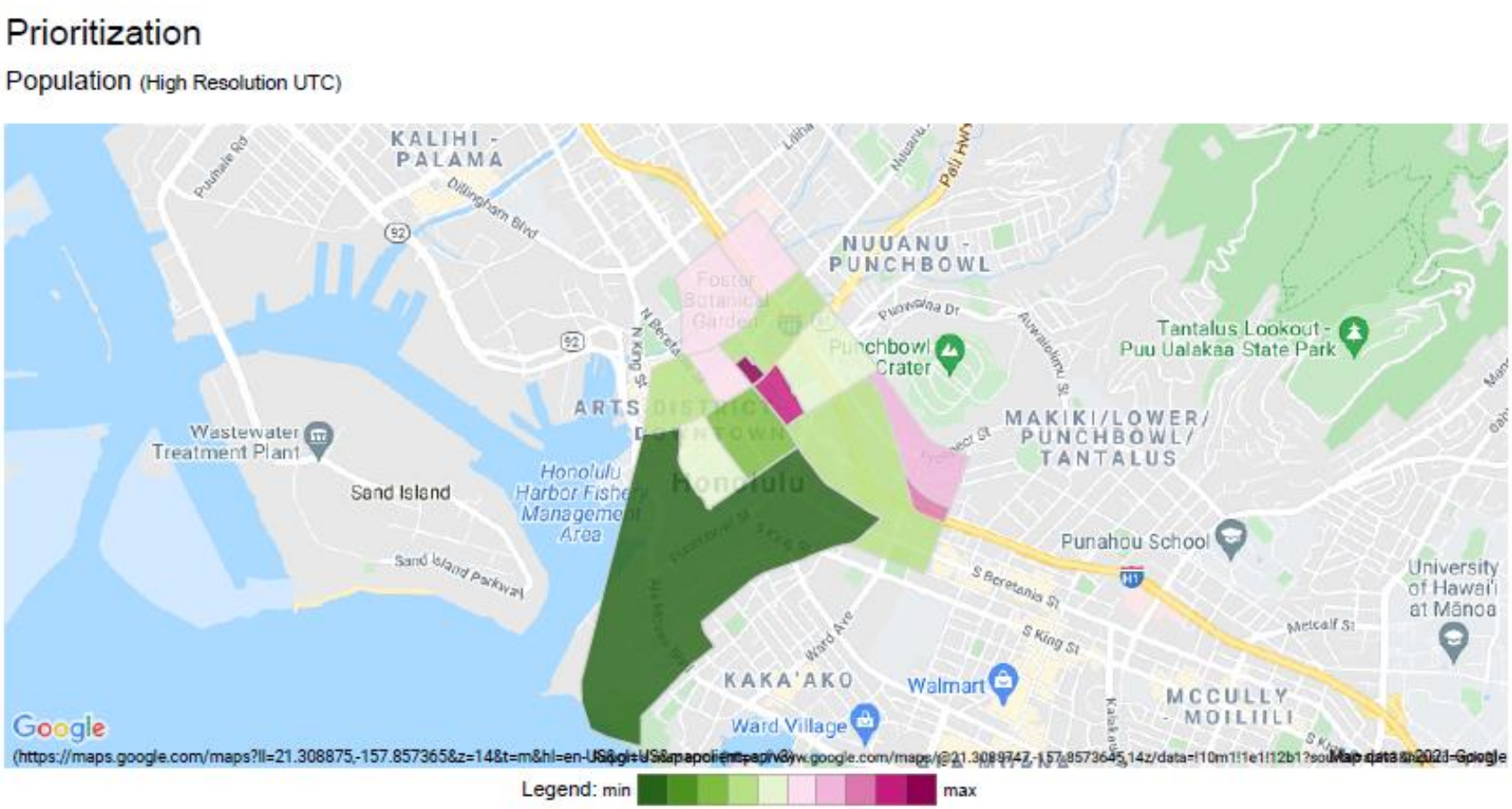


Image 5. i-Tree Landscape planting and poverty prioritization in downtown Honolulu

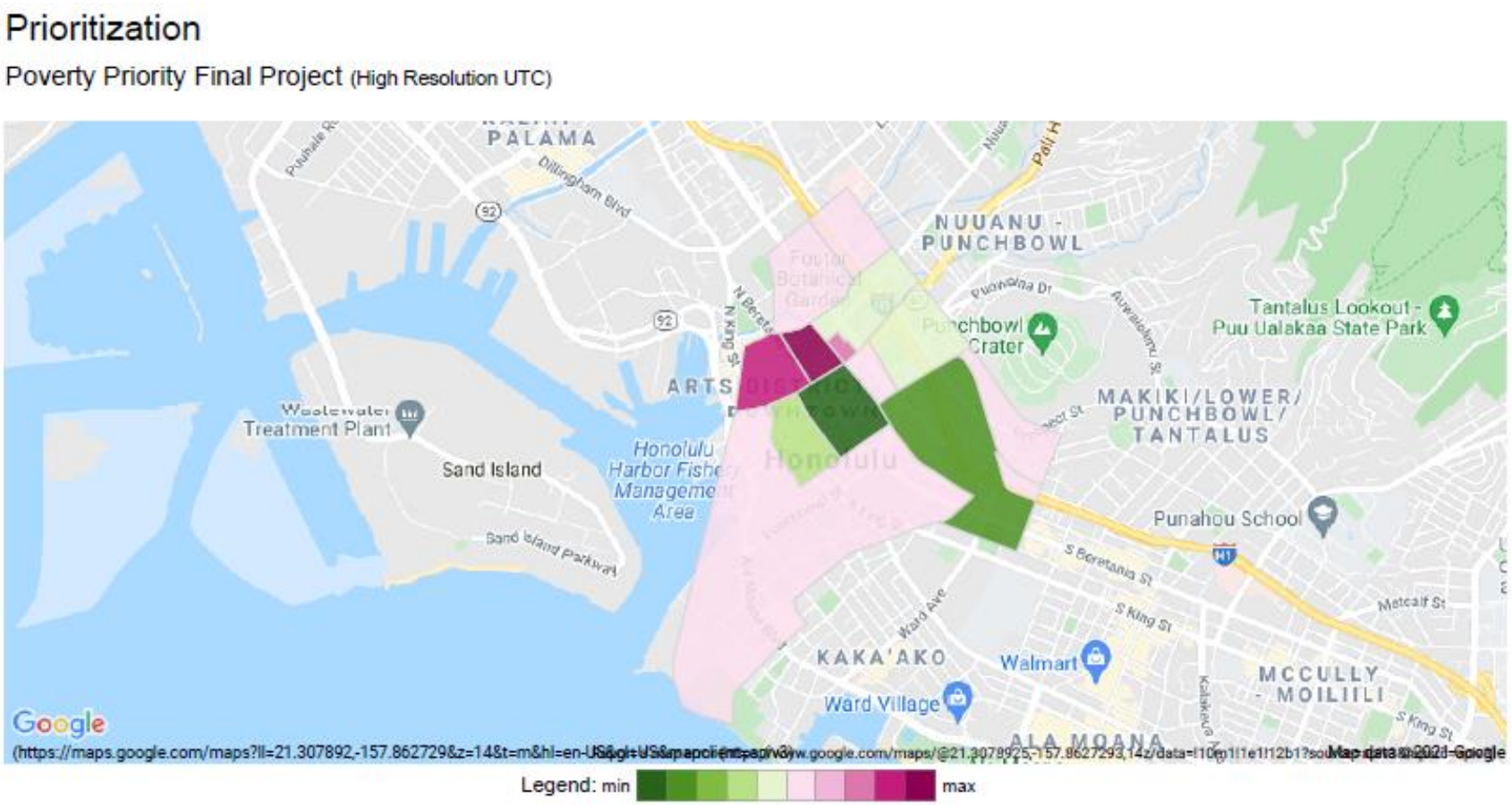


Table 5. i-Tree Landscape planting and minority prioritization table in downtown Honolulu

Data Tools | Area | Land Cover HiRes | Land Cover 2011 | Census Data | Forest Risk | Health Risk | Future Climate

Population | Income Overview | Home Overview | Household Type | Home Tenure | Educational Attainment

Remove	Dataset	Type	Name	ID	Swap	Highlight	Population	Minority %
✖	N/A	Block Group	N/A	150030039001	⇄	☐	655.0	82.14
✖	N/A	Block Group	N/A	150030041003	⇄	☐	674.0	82.05
✖	N/A	Block Group	N/A	150030040001	⇄	☑	768.0	69.79
✖	N/A	Block Group	N/A	150030040002	⇄	☑	784.0	42.60
✖	N/A	Block Group	N/A	150030052001	⇄	☑	1,078.0	89.61
✖	N/A	Block Group	N/A	150030042001	⇄	☐	1,081.0	69.47
✖	N/A	Block Group	N/A	150030053002	⇄	☐	1,212.0	95.13
✖	N/A	Block Group	N/A	150030051002	⇄	☐	1,463.0	68.90
✖	N/A	Block Group	N/A	150030051001	⇄	☐	1,627.0	98.65
✖	N/A	Block Group	N/A	150030041001	⇄	☐	1,661.0	76.76
✖	N/A	Block Group	N/A	150030041002	⇄	☐	2,169.0	84.42
✖	N/A	Block Group	N/A	150030052002	⇄	☑	2,215.0	91.15
✖	N/A	Block Group	N/A	150030042002	⇄	☐	2,351.0	77.07
✖	N/A	Block Group	N/A	150030053001	⇄	☐	2,424.0	98.31
^	**Selection Total:**					☐	20,162.0	86.63

Table 6. i-Tree Landscape poverty prioritization table in downtown Honolulu

Data Tools | Area | Land Cover HiRes | Land Cover 2011 | Census Data | Forest Risk | Health Risk | Future Climate

Population | Income Overview | Home Overview | Household Type | Home Tenure | Educational Attainment

Remove	Dataset	Type	Name	ID	Swap	Highlight	Median Income $	Per Capita Income $	Poverty %
✖	N/A	Block Group	N/A	150030052001	⇄	☑	27,618.0	19,622.0	31.5
✖	N/A	Block Group	N/A	150030040002	⇄	☑	83,077.0	48,653.0	13.3
✖	N/A	Block Group	N/A	150030052002	⇄	☑	15,742.0	13,052.0	31.5
✖	N/A	Block Group	N/A	150030040001	⇄	☑	45,909.0	38,685.0	13.3
✖	N/A	Block Group	N/A	150030051001	⇄	☐	15,357.0	12,289.0	24.0
✖	N/A	Block Group	N/A	150030051002	⇄	☐	70,813.0	55,676.0	24.0
✖	N/A	Block Group	N/A	150030042002	⇄	☐	60,541.0	37,935.0	13.5
✖	N/A	Block Group	N/A	150030042001	⇄	☐	48,902.0	37,716.0	13.5
✖	N/A	Block Group	N/A	150030039001	⇄	☐	29,167.0	23,335.0	33.6
✖	N/A	Block Group	N/A	150030041002	⇄	☐	43,926.0	24,148.0	9.0
✖	N/A	Block Group	N/A	150030053001	⇄	☐	45,000.0	18,419.0	14.1
✖	N/A	Block Group	N/A	150030053002	⇄	☐	30,625.0	19,168.0	14.1
✖	N/A	Block Group	N/A	150030041001	⇄	☐	45,411.0	26,088.0	9.0
✖	N/A	Block Group	N/A	150030041003	⇄	☐	36,285.0	32,642.0	9.0
^	**Selection Total:**					☐	N/A	N/A	N/A

i-Tree MyTree

Methods:

i-Tree MyTree was used to measure the benefits of the predicted newly planted trees. Instead of calculating out each individual tree, each anticipated tree species to be planted was analyzed with the generalized inputs below:

Tree Field	**Input**
Location	101-129 S Hotel St, Honolulu, HI 96813, USA
Type of Tree	New Planting
Tree Species (Scientific)	*
Tree Condition	Excellent
Trunk Size (in.)(Diameter)	4
Sun Exposure	Full
Is the tree within 60 ft of a building?	Yes
How old is the building?	Built before 1950
How far is it from the building?	0-19 ft
Estimate the compass direction	North (0°)

*Species as listed: Geometry Tree (Bucida buceras), Tulipwood (Harpullia pendula), White Tecoma (Tabebuia berteroi) – Species was not available, benefits were based off Tabebuia spp., and Silver Trumpet (Tabebuia aurea)

The fields inputted into MyTree provided the total tree benefits for one tree of each specified species (Figure 6.) Each species was then multiplied by the estimated number of trees to get the total amount of benefits for the project.

Results:

The total monetary benefits of 15 geometry trees (Bucida buceras) is $59.85 of carbon dioxide sequestered, $1.50 storm water runoff avoided, $3.60 of air pollution removed, $244.80 of energy usage savings per year, and $16.80 of avoided energy emissions.

The total monetary benefits of 12 tulipwood trees (Harpullia pendula) is $31.92 of carbon dioxide sequestered, $1.20 storm water runoff avoided, $5.16 of air pollution removed, $228.48 of energy usage savings per year, and $15.84 of avoided energy emissions.

The total monetary benefits of 25 white tecoma trees (represented as Tabebuia spp.) is $31.50 of carbon dioxide sequestered, $2.50 storm water runoff avoided, $6.00 of air pollution removed, $67.00 of energy usage savings per year, and $16.50 of avoided energy emissions.

The total monetary benefits of 5 silver trumpet trees (Tabebuia aurea) is $7.40 of carbon dioxide sequestered, $0.50 storm water runoff avoided, $1.25 of air pollution removed, $72.40 of energy usage savings per year, and $5.35 of avoided energy emissions.

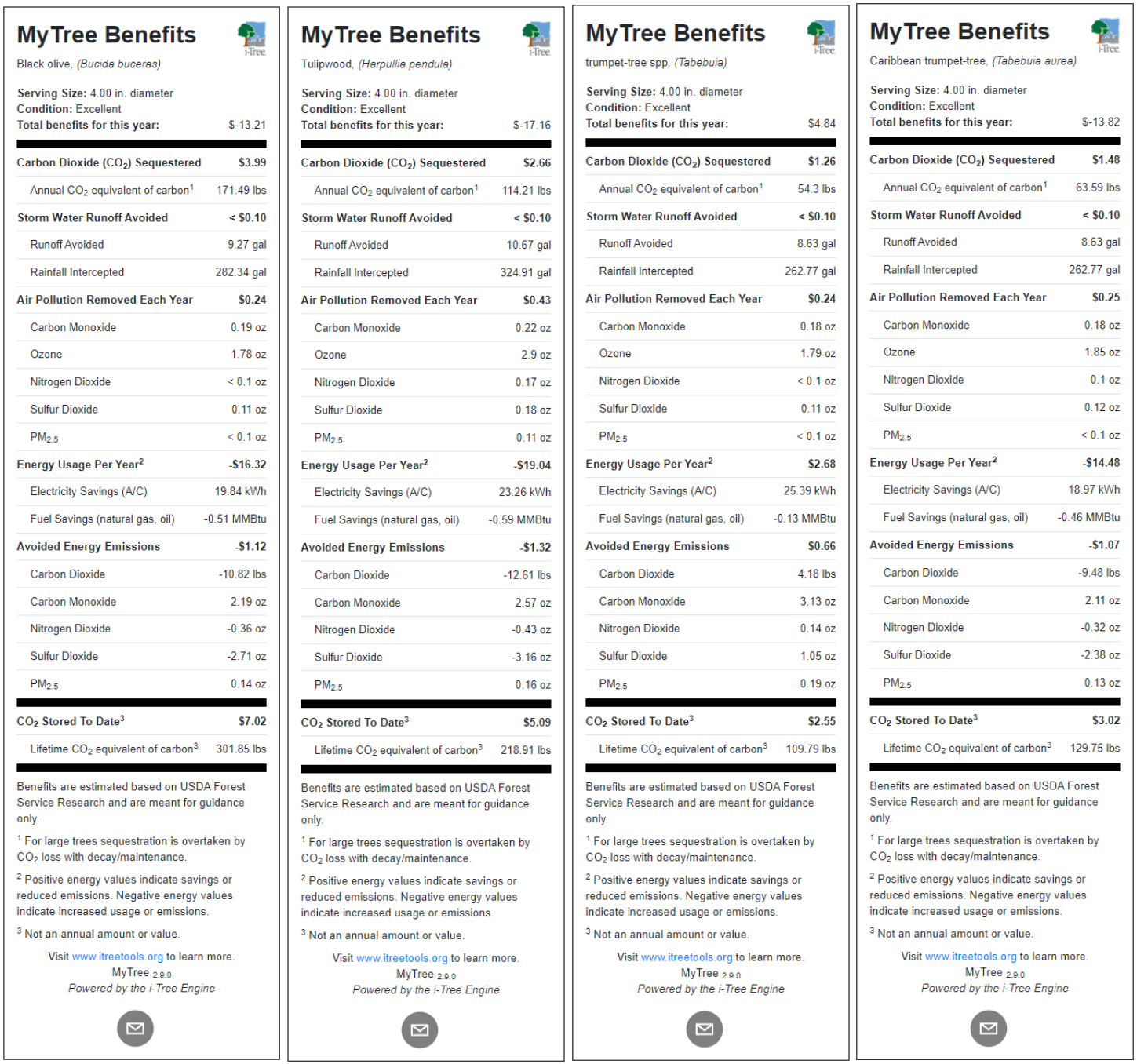
Total, there are 57 trees that have a comprehensive monetary value at $130.67 of carbon dioxide sequestered, $10.20 storm water runoff avoided, $16.01 of air pollution removed, $612.68 of energy usage savings per year, and $54.49 of avoided energy emissions.

Discussion:

The trees that are going to be planted in downtown Honolulu have a notable benefit to the surrounding area and community, providing environmental and economic benefits that can be quantified in iTree MyTree. This project will add trees to the urban forest and grow the tree canopy cover.

In the future, monetary estimates such as this can be used for project justification and in the budgeting process.

Image 6. i-Tree MyTree benefits for four tree species in downtown Honolulu



MyTree Benefits

Black olive, *(Bucida buceras)*

Serving Size: 4.00 in. diameter
Condition: Excellent
Total benefits for this year: $-13.21

Carbon Dioxide (CO_2) Sequestered	**$3.99**
Annual CO_2 equivalent of carbon[1]	171.49 lbs
Storm Water Runoff Avoided	**< $0.10**
Runoff Avoided	9.27 gal
Rainfall Intercepted	282.34 gal
Air Pollution Removed Each Year	**$0.24**
Carbon Monoxide	0.19 oz
Ozone	1.78 oz
Nitrogen Dioxide	< 0.1 oz
Sulfur Dioxide	0.11 oz
$PM_{2.5}$	< 0.1 oz
Energy Usage Per Year[2]	**-$16.32**
Electricity Savings (A/C)	19.84 kWh
Fuel Savings (natural gas, oil)	-0.51 MMBtu
Avoided Energy Emissions	**-$1.12**
Carbon Dioxide	-10.82 lbs
Carbon Monoxide	2.19 oz
Nitrogen Dioxide	-0.36 oz
Sulfur Dioxide	-2.71 oz
$PM_{2.5}$	0.14 oz
CO_2 Stored To Date[3]	**$7.02**
Lifetime CO_2 equivalent of carbon[3]	301.85 lbs

Benefits are estimated based on USDA Forest Service Research and are meant for guidance only.

[1] For large trees sequestration is overtaken by CO_2 loss with decay/maintenance.

[2] Positive energy values indicate savings or reduced emissions. Negative energy values indicate increased usage or emissions.

[3] Not an annual amount or value.

Visit www.itreetools.org to learn more.
MyTree 2.9.0
Powered by the i-Tree Engine

MyTree Benefits

Tulipwood, *(Harpullia pendula)*

Serving Size: 4.00 in. diameter
Condition: Excellent
Total benefits for this year: $-17.16

Carbon Dioxide (CO_2) Sequestered	**$2.66**
Annual CO_2 equivalent of carbon[1]	114.21 lbs
Storm Water Runoff Avoided	**< $0.10**
Runoff Avoided	10.67 gal
Rainfall Intercepted	324.91 gal
Air Pollution Removed Each Year	**$0.43**
Carbon Monoxide	0.22 oz
Ozone	2.9 oz
Nitrogen Dioxide	0.17 oz
Sulfur Dioxide	0.18 oz
$PM_{2.5}$	0.11 oz
Energy Usage Per Year[2]	**-$19.04**
Electricity Savings (A/C)	23.26 kWh
Fuel Savings (natural gas, oil)	-0.59 MMBtu
Avoided Energy Emissions	**-$1.32**
Carbon Dioxide	-12.61 lbs
Carbon Monoxide	2.57 oz
Nitrogen Dioxide	-0.43 oz
Sulfur Dioxide	-3.16 oz
$PM_{2.5}$	0.16 oz
CO_2 Stored To Date[3]	**$5.09**
Lifetime CO_2 equivalent of carbon[3]	218.91 lbs

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MyTree Benefits

trumpet-tree spp, *(Tabebuia)*

Serving Size: 4.00 in. diameter
Condition: Excellent
Total benefits for this year: $4.84

Carbon Dioxide (CO_2) Sequestered	**$1.26**
Annual CO_2 equivalent of carbon[1]	54.3 lbs
Storm Water Runoff Avoided	**< $0.10**
Runoff Avoided	8.63 gal
Rainfall Intercepted	262.77 gal
Air Pollution Removed Each Year	**$0.24**
Carbon Monoxide	0.18 oz
Ozone	1.79 oz
Nitrogen Dioxide	< 0.1 oz
Sulfur Dioxide	0.11 oz
$PM_{2.5}$	< 0.1 oz
Energy Usage Per Year[2]	**$2.68**
Electricity Savings (A/C)	25.39 kWh
Fuel Savings (natural gas, oil)	-0.13 MMBtu
Avoided Energy Emissions	**$0.66**
Carbon Dioxide	4.18 lbs
Carbon Monoxide	3.13 oz
Nitrogen Dioxide	0.14 oz
Sulfur Dioxide	1.05 oz
$PM_{2.5}$	0.19 oz
CO_2 Stored To Date[3]	**$2.55**
Lifetime CO_2 equivalent of carbon[3]	109.79 lbs

Benefits are estimated based on USDA Forest Service Research and are meant for guidance only.

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[3] Not an annual amount or value.

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MyTree Benefits

Caribbean trumpet-tree, *(Tabebuia aurea)*

Serving Size: 4.00 in. diameter
Condition: Excellent
Total benefits for this year: $-13.82

Carbon Dioxide (CO_2) Sequestered	**$1.48**
Annual CO_2 equivalent of carbon[1]	63.59 lbs
Storm Water Runoff Avoided	**< $0.10**
Runoff Avoided	8.63 gal
Rainfall Intercepted	262.77 gal
Air Pollution Removed Each Year	**$0.25**
Carbon Monoxide	0.18 oz
Ozone	1.85 oz
Nitrogen Dioxide	0.1 oz
Sulfur Dioxide	0.12 oz
$PM_{2.5}$	< 0.1 oz
Energy Usage Per Year[2]	**-$14.48**
Electricity Savings (A/C)	18.97 kWh
Fuel Savings (natural gas, oil)	-0.46 MMBtu
Avoided Energy Emissions	**-$1.07**
Carbon Dioxide	-9.48 lbs
Carbon Monoxide	2.11 oz
Nitrogen Dioxide	-0.32 oz
Sulfur Dioxide	-2.38 oz
$PM_{2.5}$	0.13 oz
CO_2 Stored To Date[3]	**$3.02**
Lifetime CO_2 equivalent of carbon[3]	129.75 lbs

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