2021 i-Tree Academy Course

Wye Research Center (Queenstown, MD)

i-Tree Planting Benefit Strategies and Educational Tools

PART 1 Results

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i-Tree

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OBJECTIVE

The objective of this project is to assess current tree coverage and inventory as well as to propose tree-based environmental and energy improvements to the Wye Research and Education Center Central area (WREC-C) by using i-Tree tools. Resulting data will also be utilized to create educational material towards showcasing tree benefits. These could be used in current and/or future forest-related programs.

PROJECT DESCRIPTION

The Wye Research and Education Center (WREC) is situated on 1,000 acres on Maryland's Eastern Shore in the town of Queenstown, MD. The Center researches several aspects of the Chesapeake Bay agriculture and product diversity. The University of Maryland Extension (UME) forestry program utilizes the main grounds (central area or 'WREC-C' for the purpose of this project) for tree ID and, also for educational forest health programs. This area is located along the Wye River and has a sizable collection of deciduous and evergreen tree species. These mostly encompass Ailanthus *Ailanthus altissima*, Bald Cypresses *Taxodium distichum*, Black Walnuts *Juglans nigra*, Locust *Robinia sp.,* Norway Maple *Acer platanoides,* Norway Spruce *Picea abies,* Pines *Pine sp*., River Birches *Betula nigra*, Sawtooth Oaks *Quercus acutissima*, White cedars *Thuja occidentalis* and Zelkovas *Zelkova sp.* Most trees at WREC-C were planted approximately 30 years ago and are clustered next or adjacent to 7 main buildings. There are significant poor drainage areas and careful consideration towards stabilizing the riverbank.

To date, no assessment of tree coverage or tree inventory has been performed. Discussion with the area's forest administrator and site manager indicated 2 overall concerns:

1 – Decay and damage: Some trees have experienced significant decay over the years. Maintenance personnel have complained of spending a significant amount of time picking up branches prior to mowing. Also, the site has lost a number of trees due to nearby construction and culvert pipe damage. Trees that are closest to the buildings

are causing foundation damage which needs to be quickly addressed. Removal of these trees may have a negative impact on heating and cooling bills resulting in discussions towards their replacements and additions.

2 - Lack of diversity and presence of non-native, invasive species: Although the current trees represent a wide range of species, they are planted as species clusters. Also, some trees species are non-native to the Chesapeake area, and a few are listed as invasive species in the Mid-Atlantic are such as Ailanthus *Ailanthus altissima*, Norway Maple *Acer platanoides*, Norway Spruce *Picea abies* Sawtooth Oak *Quercus acutissima and* Zelkovas *Zelkova sp.*. Source: [Plants - Mid-Atlantic Invaders Tool (invasive.org)]

There is an opportunity to better assess these concerns and make recommendations for improving the environment and energy savings by using i-Tree. i-Tree is a peer-reviewed collection of urban and rural forestry analysis and benefits assessment tools. It was designed and developed by the US Forest Service to quantify and value ecosystem services provided by trees including pollution removal, carbon sequestration, avoided carbon emissions, avoided stormwater runoff, and more. Several i-Tree tools used for a number of assessments in this project, each one was selected to address a specific project question.

Once assessments are finalized, i-Tree tags will be created to highlight benefits of individual tree specimens for educational purposes, thus fulfilling one of WREC's objectives.

COMMUNITY, PARTNERS, RESOURCES NEEDED

Name of Community, Geographic Area and/or Tree Resource Involved: Wye Research and Education Center (124 Wye Narrows Drive, Queenstown, MD 21658)

Project team: Agnes H. Kedmenecz (Forest Stewardship Educator, WREC, Queenstown MD, akedmen@umd.edu), David Muhleman (Manager, WREC, Queenstown MD, dmuhlema@umd.edu), Alexis R. Crouch (Environmental Science Major, Senior Year student, Rutgers University, New Brunswick, NJ, kittyarc@comcast.net), Mikaela Boyle (Senior Agent Associate – Master Gardener Coordinator & Urban Horticulture, Talbot Country MD, mboley@umd.edu)

Resources Needed: Headcount to help assess tree inventory (see note above on Environmental Science college student).

i-Tree tools used in the Project:

PART 1 i-Tree Canopy, i-Tree Planting Calculator, i-Tree Design

PART 2 i-Tree Eco

EDUCATIONAL MATERIAL i-Tree My-tree

END PRODUCTS

- PART 1
  - TREE COVERAGE ASSESSMENT
  - NATIVE TREES BENEFIT ASSESSMENT IN AREA AWAY FROM BUILDINGS
  - ENERGY SAVINGS ESTIMATE RESULTING FROM PLANTING NEAR BUILDING STRUCTURES
- PART 2
  - TREE INVENTORY ANALYSIS (FUNCTIONAL, STRUCTURE AND COMPOSITION, MODELING)
- I-TREE TAGS (PROTOTYPES)
- FINAL REPORT

Project time will be used as part of the grant match (Volunteer match, MD state)

TIMELINE

STEPS	DESCRIPTION	I-TREE RESOURCE	TIMING
PART 1			
1	TREE COVERAGE ASSESSMENT	i-Tree Canopy	May 2021
2	NATIVE TREES BENEFITS ASSESSMENT IN AREA AWAY FROM BUILDINGS. Comparative estimate of long-term environmental benefits of select native species[1]	i -Tree Planting Calculator	May 2021
3	ENERGY SAVINGS ESTIMATE RESULTING FROM TREE REPLACEMENT NEAR BUILDING AREA -- Drawing of building footprint and placement of native trees from step 2 to assess effects on building energy use	i-Tree Design	May 2021
PART 2			
4	WREC-C tree inventory* + analyses (functional, structure and composition, modeling (various)	i-Tree Eco	July 2021
WRAP-UP			
5	Tree tags highlighting tree benefits will be created for select trees after all data is generated in alignment with Project Team.	i-Tree my tree	July 2021
6	Final Report		August 2021

*Assessment to be performed in July due to Project Team availability.

[1] Chesapeake Bay area and keystone species will be comparatively assessed. A keystone species is a species which has a disproportionately large beneficial effect on its natural environment relative to its abundance. This is a concept introduced in 1969 by the zoologist Robert T. Paine and recently popularized by the entomologist Professor Doug Tallamy towards native tree benefits. WREC also showed a particular interest in planting species that are better adapted to climate change. Maintenance personnel will also weigh in on easier to care species once selection is scientifically established.

PART 1 RESULTS

1. TREE COVERAGE ASSESSMENT

1.1 IDENTIFYING WREC-C BOUNDARIES AND SUB-SITES FEATURES

WREC-C Canopy area and benefits were calculated using i-Tree Canopy. This was an important assessment to demonstrate the current environmental value and health benefits delivered by the current canopy. The WREC-C boundaries used in the i-Tree Canopy assessment were obtained from a map provided by the site manager. (*Figure* 1).

Figure 1 – Wye Research Center Central (WREC-C) aerial boundaries Source: David Muhleman (left) and i-Tree canopy tracing of same boundaries (right).

WREC-C has 3 distinct areas that serve different purposes *(Figure 2).* The combination of these three sites totals 29 acres. Each area also has distinct landscape features.

1) **'The Grove'**, or area adjacent to 7 main buildings. Clusters of same tree species have been planted across this site. In addition to the buildings, most roads and parking lots are located here. The trees on this site are approximately 30 years old. The site manager pointed out structural damage to the buildings due to root overgrowth. Some tree species also have experienced decay.

2) **'The Buffer'**, the strip along-side the Wye River. This area is part of the Critical Zone; therefore approvals must be obtained before replacing trees. 'The Buffer' area is composed of 3 different zones – a Black Walnut-densely planted area in the North, a meadow/early succession area along the main building and an open, grassy zone facing the Wye River. There is an ongoing project for removing Ailanthus *Ailanthus altissima* which is planted next to the riverbank.

3) **'The Park'**, or park-like area between Cheston Ln and Houghton Lab Ln. This is the largest of the 3 sites. This area accommodates outdoor community events. Similar to 'The Grove', trees are planted as clusters and are approximately 30 years old. These clusters are sparsely positioned. This area has 2 small lakes.

Figure 2 - Google Map aerial view of WREC-C 3 assessment sites: 1 –'The Grove', 2 – 'The Buffer', 3 – 'The Park'

1.2 WREC-C TREE COVERAGE ASSESSMENT AND BENEFITS

I-Tree Canopy was used to assess tree coverage and associated environmental and health benefits provided by the current total tree/shrub planted area. The rural setting was used in the analysis. Six cover classes (T – Trees/Shrubs, H – Grass/Herbaceous, IB – Impervious Buildings, IR – Impervious Roads, IO – Impervious Others (parking lot) and W – Water (lakes) were identified, and 601 locations (points) were surveyed *(Table 1 and Figure 3).*

The tree coverage analysis showed that 35.8% of the total area is covered by trees or shrubs, while 53.7% is covered by low vegetation. Buildings, roads and parking lots comprise about 8% of the total area while the 2 lakes account for 2%.

Table 1 – WREC-C Cover Class analysis (% and area in acres)

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Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (ac) ± SE
H	Grass/Herbaceous	Low vegetation	323	53.74 ± 2.03	16.01 ± 0.61
IB	Impervious Buildings	Office buildings, Trailers, Covered garages	24	3.99 ± 0.80	1.19 ± 0.24
IO	Impervious Other	Parking Lots	2	0.33 ± 0.24	0.10 ± 0.07
IR	Impervious Road	Paved and non-paved roads	24	3.99 ± 0.80	1.19 ± 0.24
T	Tree/Shrub	Tree/Shrub	215	35.77 ± 1.96	10.65 ± 0.58
W	Water	Lakes	13	2.16 ± 0.59	0.64 ± 0.18
Total			**601**	**100.00**	**29.78**

Figure 3 – WREC-C color-coded survey points.

The current total WREC-C canopy delivers substantial environmental and health-associated benefits *(Table 2).* Below are a few highlights.

1 CARBON MANAGEMENT: Trees are a cost-effective means for carbon removal and storage. The WREC-C trees and shrubs store over 365 Tons of Carbon. It is also estimated that over 14 Tons are sequestered annually for a CO2 equivalent of 53.3 Tons.

1 AIR POLLUTION: Although not a very relevant parameter to our rural assessment area, the current total WREC-C canopy removes over 531 pounds of ozone from the atmosphere annually. Ozone is a common air pollutant, and it is one of the six criteria pollutants regulated by the EPA. It can affect human health. Breathing in ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. Particulate matter (PM) contains microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems. Particles less than 10 micrometers in diameter can get deep into the lungs and some may even get into the bloodstream. It is estimated that 200 pounds of less than 10 microns PM are removed annually the WREC-C canopy.

2 HYDROLOGICAL BENEFITS: Transpiration resulting from current canopy is estimated as 566 gallons annually. Transpiration accounts for the movement of water within a plant and the subsequent exit of water as vapor through stomata in its leaves in vascular plants. It has the benefit to cool the local environment.

Table 2 – WREC-C Environmental and health benefit parameters assessed by i-Tree Canopy

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (T)	±SE	CO_2 Equiv. (T)	±SE	Value (USD)	±SE
Sequestered annually in trees	14.54	±0.79	53.32	±2.91	$2,480	±136
Stored in trees (Note: this benefit is not an annual rate)	365.21	±19.96	1,339.12	±73.19	$62,287	±3,404

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 1.365 T of Carbon, or 5.005 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)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	9.51	±0.52	$0	±0
NO2	Nitrogen Dioxide removed annually	51.84	±2.83	$0	±0
O3	Ozone removed annually	521.99	±28.53	$12	±1
SO2	Sulfur Dioxide removed annually	33.02	±1.80	$0	±0
PM2.5	Particulate Matter less than 2.5 microns removed annually	25.32	±1.38	$25	±1
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	175.86	±9.61	$10	±1
Total		**817.54**	**±44.68**	**$48**	**±3**

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 0.893 @ $0.01 | NO2 4.866 @ $0.00 | O3 48.997 @ $0.02 | SO2 3.100 @ $0.00 | PM2.5 2.376 @ $0.98 | PM10* 16.507 @ $0.06 (English units: lb = pounds, ac = acres)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (gal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	2.32	±0.13	$0	±0
E	Evaporation	396.07	±21.65	N/A	N/A
I	Interception	398.21	±21.76	N/A	N/A
T	Transpiration	566.93	±30.99	N/A	N/A
PE	Potential Evaporation	3,088.61	±168.81	N/A	N/A
PET	Potential Evapotranspiration	2,515.72	±137.50	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 gal/ac/yr @ $/gal/yr and rounded:
AVRO 0.218 @ $0.01 | E 37.177 @ N/A | I 37.379 @ N/A | T 53.215 @ N/A | PE 289.915 @ N/A | PET 236.140 @ N/A (English units: gal = gallons, ac = acres)

1.3 POTENTIAL NEW TREE PLANTING AREA.

Among the 3 sites that constitute the WREC-C, the most likely for new tree/shrub plantings is 'The Park'. 'The Grove' is relatively crowded with buildings, trees, and parking lots and 'The Buffer' already has dense canopy in some areas. Also, feed-back from the Project team indicates that the office building users enjoy the unobstructed views to the river offered by its grassy zone. 'The Park' is also the largest of the 3, representing about 21 acres of the total WREC-C area.

The canopy of 'The Park' area was further analyzed with i-Tree Canopy so we could more clearly identify the % of potential new planting tree/shrub area.

Only 3 cover classes were used as the objective was to estimate current planted areas vs. areas with potential for new planting: T – Trees/Shrubs, NeT – Non-Tree with Potential of New Tree planting and NT – Non-Tree with no potential of tree planting (Lakes, Buildings, Roads). Six hundred points were surveyed *(Table 3 and Figure 4).*

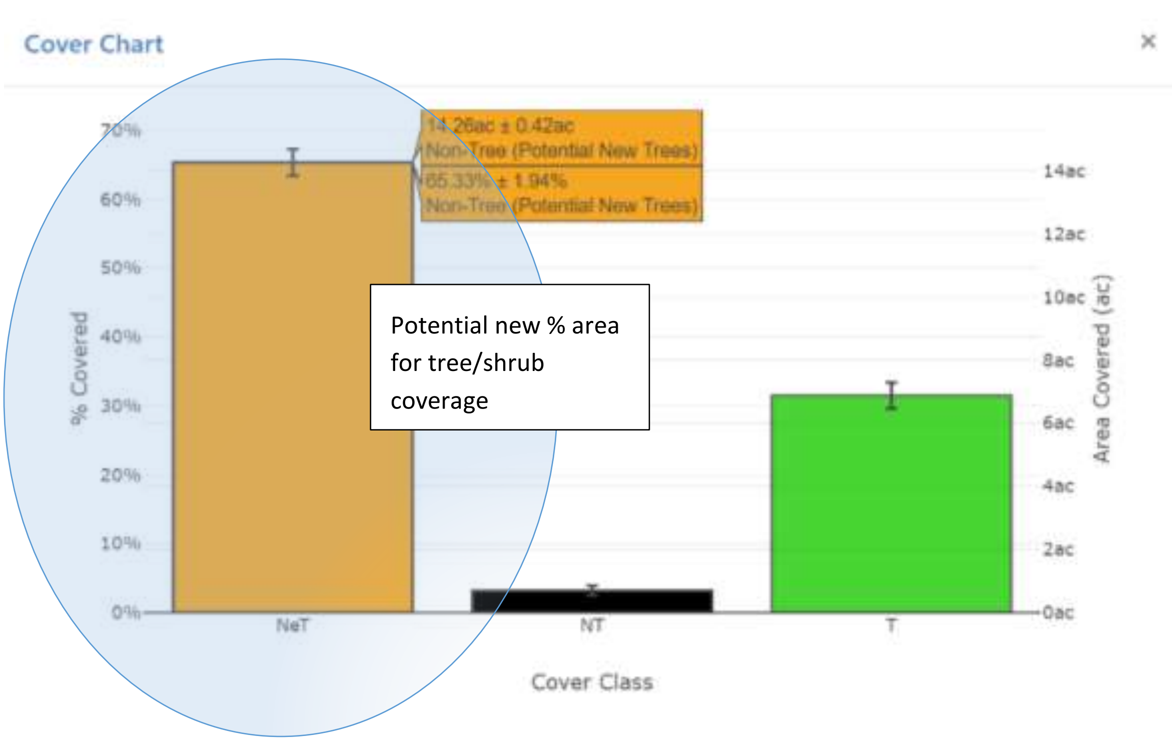
The existing Park canopy represents 31.5% of its total area *(Table 3).* Lakes, Buildings and Roads are non-plantable areas represent about 3%. Trees/shrubs could potentially cover an additional 65.3% or the equivalent of 14.2 of the total 21 acres *(Table 3 and Figure 5).*

Table 3 – 'The Park' Cover Class analysis (% and area in acres)

Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (ac) ± SE
NeT	Non-Tree (Potential New Trees)	All other surfaces	392	65.33 ± 1.94	14.26 ± 0.42
NT	Non-Tree (Trees cannot be planted in the area)	Lakes, Buildings, Roads	19	3.17 ± 0.71	0.69 ± 0.16
T	Tree	Tree, Shrub	189	31.50 ± 1.90	6.88 ± 0.41
Total			**600**	**100.00**	**21.83**

Figure 4– 'The Park' color-coded survey points

Figure 5– 'The Park' Cover Class analysis in graphic form (% and area in acres) highlighting the potential new % area for tree/shrub coverage.



2 - NATIVE TREES BENEFIT ASSESSMENT IN AREA AWAY FROM BUILDINGS

Step 2 of this project aimed at selecting new and replacement trees species using the i-Tree Planting Calculator. The I-Tree Planting Calculator shares data on sought-after long-term environmental tree benefits such as Greenhouse Gas (GHG) sequestered and avoided (owing to reductions in energy use), energy conservation, air pollutants captured and avoided, stormwater filtered and tree total biomass. Since 'The Park' was identified as the best location for new tree planting, energy conservation measures were not considered as this area has no significant building structures.

The Project team wishes to plant new trees that are native to the Chesapeake Bay area and that support the highest biodiversity based on the number of Lepidoptera species supported. Therefore, a preliminary tree selection was performed combining these 2 criteria (Table 4). Adaptation to climate change was identified as a third criterion. Plants that are reported to better adapt to climate change in the Mid-Atlantic were selected based on fluctuating and increasingly warming temperatures and also wetter soil conditions. Since limited resources are found about this topic, the third criterion was used as information only and to aid on future prioritization.

Sources for the 3 criteria are identified below.

1. Native to the Chesapeake Bay area. Source: Slattery B, Reshetiloff K, Zwicker SM. Native Plants for Wildlife Habitat and Conservation Landscaping. Chesapeake Bay Watershed. US Fish & Wildlife Service. 2005.

2. Keystone species. These are defined by Doug Tallamy (*Professor U. of Delaware)* as woody plants that support the highest number of Lepidoptera. Source: Doug Tallamy, 2007. Bringing Nature Home.

Woody Plants		
Plant Genus	**Common Name**	**# of Lepidoptera* species supported**
Quercus	oak	557
Prunus	black cherry	456
Salix	willow	455
Betula	birch	413
Populus	poplar	368
Malus	crabapple	311
Acer	maple	297
Vaccinium	blueberry	288
Alnus	alder	255
Carya	hickory	235
Ulmus	elm	215
Pinus	pine	203
Crataegus	hawthorn	168
Picea	spruce	156
Tilia	basswood	150
Fraxinus	ash	150
Rosa	rose	139
Corylus	filbert	131
Juglans	walnut	130
Fagus	beech	127
Castanea	chestnut	127

Recommended reading:
Tallamy, D. 2007. *Bringing Nature Home*. Timber Press.

3. Climate change-adaptable species (for prioritization only). Source: Climate change adaptable plants. Source: DCNR selecting tree for Pennsylvania's changing climate, 2019. Source: Article (pa.gov).

A total of 33 species were selected for the lifetime analysis based on the first 2 criteria plus availability within the i-Tree Planting Calculator *(Table 4).* Chesapeake native species were identified, and Keystone species where then cross-checked against it (Yes/No). Although not referred as Keystone species, 3 Pinus native species were also included for evergreens addition into the mix. Finally, the list was run against available species in the i-Tree Planting Calculator.

Table 4 – Listing of tree species criteria (Chesapeake natives and Keystone species) and availability in i-Tree Planting Calculator

Chesapeake Bay Watershed native trees. *Scientific Name*/Common Name	**Are these Keystone species? (Yes/No)**	**Are these trees listed in i-Tree Planting Calculator? (Yes/No)**
Acer negundo Box elder	**Yes**	Yes
Acer rubrum Swamp maple	**Yes**	Yes
Acer saccharinum Silver maple	**Yes**	Yes
Acer saccharum Sugar maple	**Yes**	Yes
Acer spicatum Mountain maple*	**Yes**	No
Betula alleghaniensis Yellow birch	**Yes**	No
Betula lenta Sweet birch	**Yes**	Yes
Betula nigra Black birch	**Yes**	Yes
*Carya alba Muckernut hickory**	**Yes**	No
Carya cordiformis Swamp hickory	**Yes**	No
Carya glabra Smoothbark hickory	**Yes**	Yes
*Carya ovata Shagbark hickory**	**Yes**	Yes*
Castanea pumila Allegany chinkapin/chestnut	**Yes**	No

Chesapeake Bay Watershed native trees. *Scientific Name*/Common Name	**Are these Keystone species?(Yes/No)**	**Are these trees listed in i-Tree planting calculator? (Yes/No)**
Crataegus crus-galli Cockspur hawthorn	**Yes**	No
Crataegus viridis Green hawthorn	**Yes**	No
Fagus grandifolia American beech	**Yes**	Yes
Fraxinus americana White ash	**Yes**	Yes
Fraxinus pensylvanica Swamp ash	**Yes**	Yes
Juglans nigra Black walnut	**Yes**	Yes
Malus coronaria American crabapple	**Yes**	No
Pinus echinata Shortleaf pine*	No	Yes*
Pinus rigida Pitch pine	No	No
Pinus serotina Marsh pine	No	No
Pinus strobus White pine	No	No
Pinus taeda North Carolina pine	No	Yes
Pinus virginiana Virginia pine	No	Yes
Populus deltoides Carolina poplar*	**Yes**	Yes*
Populus heterophilla Downy poplar	**Yes**	No
Prunus americana American wild plum	**Yes**	No
Prunus pensylvanica Fire cherry	**Yes**	No
Prunus serotina Black chokeberry	**Yes**	Yes
Prunus virginiana Chokeberry	**Yes**	No
Quercus alba White oak	**Yes**	Yes
Quercus bicolor Swamp oak	**Yes**	Yes
Quercus coccinea Scarlet oak	**Yes**	Yes
Quercus falcata Spanish oak	**Yes**	Yes
Quercus ilicifolia Scrub oak	**Yes**	No
Quercus marylandica	**Yes**	Yes
Quercus montana Cow oak	**Yes**	No
Quercus muehlenbergii Chestnut oak	**Yes**	Yes
Quercus nigra Water oak	**Yes**	Yes
Quercus palustris Spanish oak	**Yes**	Yes
Quercus phellos Pin oak*	**Yes**	Yes*
Quercus primus Chestnut oak	**Yes**	No
Quercus rubra Northern Red oak	**Yes**	Yes
Quercus stellata Iron oak	**Yes**	Yes
Quercus vellutina Black oak*	**Yes**	Yes*
Salix nigra Swamp willow	**Yes**	Yes
Salix sericea Silky willow	**Yes**	No
Tilia americana American basswood	**Yes**	Yes
Ulmus americana White elm	**Yes**	Yes
Ulmus rubra Red elm, slippery elm*	**Yes**	Yes*
**** Climate change adaptable species (for prioritization only).***		

The final listing (N=33 species, Table 5) was entered in the i-Tree Planting Calculator for comparative assessment of long-term environmental tree benefits. Since 'The Park' does not have structural buildings, the *>60 feet* setting was used. Excellent tree condition, planted in full sun and 1.0-inch diameter at breast height (DBH) were used across all selections.

Acer saccharinum, Populus deltoids, Prunus serotina, Quercus nigra and Quercus phellos showed better CO_2 benefits vs. other species. *Prunus serotina* was also a top contender on rainfall interception and avoided runoff benefits. Other species with good benefits towards these parameters were *Juglans Nigra, Salix nigra and Ulmus americana and rubra*. *Jugrans nigra and Pinus virginiana* excelled towards pollutant removal benefits across the health parameters. Four out of the 5 species identified as better adapted to climate changes showed top benefits vs. others *(Populus deltoids, Quercus phellos, Ulmus rubra, Pinus echinata).* Table 5 presents the comparative results.

Table 5 lists the pre-selected 33 species and resulting benefits. Three to five best performers are highlighted (in red) within each parameter.

Tree Group Characteristics	CO2 Sequestered (pounds)	CO2 Sequestered ($)	Tree Biomass (short ton)	Rainfall Interception (gallons)	Avoided Runoff (gallons)	Avoided Runoff ($)	O3 Removed (pounds)	NO2 Removed (pounds)	SO2 Removed (pounds)	PM2.5 Removed (pounds)
Acer negundo	5,489.80	$127.68	1.4	13,268.00	106.6	$0.95	26.6	3	1.1	0.5
Acer rubrum	5,629.70	$130.93	1.4	7,238.40	58.1	$0.52	18.6	2.2	0.7	0.5
Acer saccharinum	7,456.10	$173.41	1.9	6,567.70	52.8	$0.47	17.8	2.1	0.7	0.5
Acer saccharum	2,552.60	$59.37	0.6	5,006.60	40.2	$0.36	12	1.4	0.5	0.3
Betula lenta	4,142.70	$96.35	1.1	9,908.20	79.6	$0.71	20.9	2.4	0.8	0.4
Betula nigra	5,065.00	$117.80	1.3	12,943.70	104	$0.93	26.9	3	1.1	0.6
Carya glabra	1,629.00	$37.89	0.4	6,067.30	48.7	$0.44	12.7	1.4	0.5	0.3
Carya ovata	1,449.00	$33.70	0.4	6,084.50	48.9	$0.44	10.9	1.2	0.5	0.2
Fagus grandifolia	2,608.40	$60.66	0.7	8,912.00	71.6	$0.64	20.5	2.4	0.8	0.5
Fraxinus americana	4,855.30	$112.92	1.2	9,462.40	76	$0.68	21.5	2.5	0.9	0.5
Fraxinus pennsylvanica	4,831.60	$112.37	1.2	12,519.70	100.6	$0.90	27.6	3.2	1.1	0.6
Juglans nigra	5,414.60	$125.93	1.3	15,097.40	121.3	$1.08	30.9	3.5	1.3	0.6
Pinus echinata	3,688.70	$85.79	0.9	10,295.30	82.7	$0.74	28.1	4.4	1.4	0.7
Pinus taeda	5,397.60	$125.53	1.4	6,674.40	53.6	$0.48	21.2	3.4	1.1	0.6
Pinus virginiana	3,634.60	$84.53	0.9	12,561.40	100.9	$0.90	34.2	5.4	1.8	0.8
Populus deltoides	8,587.50	$199.72	2.1	11,467.60	92.1	$0.82	26.9	3.1	1.1	0.6
Prunus serotina	9,015.90	$209.68	2.3	14,808.30	118.9	$1.06	26.9	3	1.1	0.5
Quercus alba	2,204.20	$51.26	0.5	6,390.60	51.3	$0.46	13.9	1.6	0.6	0.3
Quercus bicolor	6,648.50	$154.62	1.7	13,037.80	104.7	$0.94	28.6	3.3	1.2	0.6
Quercus coccinea	6,015.60	$139.91	1.5	11,349.30	91.2	$0.81	25.8	3	1	0.6
Quercus falcata	4,269.50	$99.30	1.1	8,777.20	70.5	$0.63	19.5	2.2	0.8	0.4
Quercus marilandica	592.6	$13.78	0.2	3,118.90	25.1	$0.22	5.5	0.6	0.2	0.1
Quercus muehlenbergii	4,648.40	$108.11	1.2	9,260.90	74.4	$0.66	20.2	2.3	0.8	0.4
Quercus nigra	7,663.40	$178.23	1.9	12,322.60	99	$0.88	27	3.1	1.1	0.6
Quercus palustris	5,272.40	$122.62	1.3	13,525.00	108.6	$0.97	29.5	3.4	1.2	0.6
Quercus phellos	7,692.20	$178.90	1.9	12,174.70	97.8	$0.87	28.1	3.3	1.1	0.7
Quercus rubra	4,645.60	$108.04	1.2	10,092.00	81.1	$0.72	22.1	2.5	0.9	0.5
Quercus stellata	2,118.80	$49.28	0.5	8,821.10	70.8	$0.63	16.3	1.8	0.7	0.3
Quercus velutina	6,143.70	$142.88	1.5	8,811.70	70.8	$0.63	19.1	2.2	0.8	0.4
Salix nigra	7,054.00	$164.06	1.8	14,054.00	112.9	$1.01	27.4	3.1	1.1	0.5
Tilia americana	2,867.90	$66.70	0.7	8,310.60	66.7	$0.60	19.1	2.2	0.8	0.4
Ulmus americana	6,813.90	$158.47	1.7	14,483.20	116.3	$1.04	27.5	3	1.1	0.5
Ulmus rubra	7,110.20	$165.36	1.8	14,487.30	116.4	$1.04	28.8	3.2	1.2	0.6

Red font represents highest values within each column

NOTE:

This data was produced from the i-Tree Planting Calculator version 2.1.2 for Queenstown; MD.

Location: Queenstown; MD 21658

Electricity Emissions Factor: 1231.9637021999997

Fuel Emissions Factor: 197.31348999999997

Lifetime: 40

Tree Mortality: 10

Run Date: 5-30-2021

3 ENERGY SAVINGS ESTIMATE RESULTING FROM TREE REPLACEMENT NEAR BUILDING AREA

There is a question from the Project Team as to whether we could implement a tree planting strategy that provides better energy savings to buildings in "The Grove" site. Trees in that particular area are decaying and causing structural damage from roots. Here as well, the Project team wishes to use replacement trees that are native to the Chesapeake Bay area and that are also Keystone species and adaptable to climate change.

Heating/cooling can improve with tree replacement. Strategically placed trees can increase building energy efficiency. Trees modify the local environment and conserve building energy use in three principal ways depending on species and season:

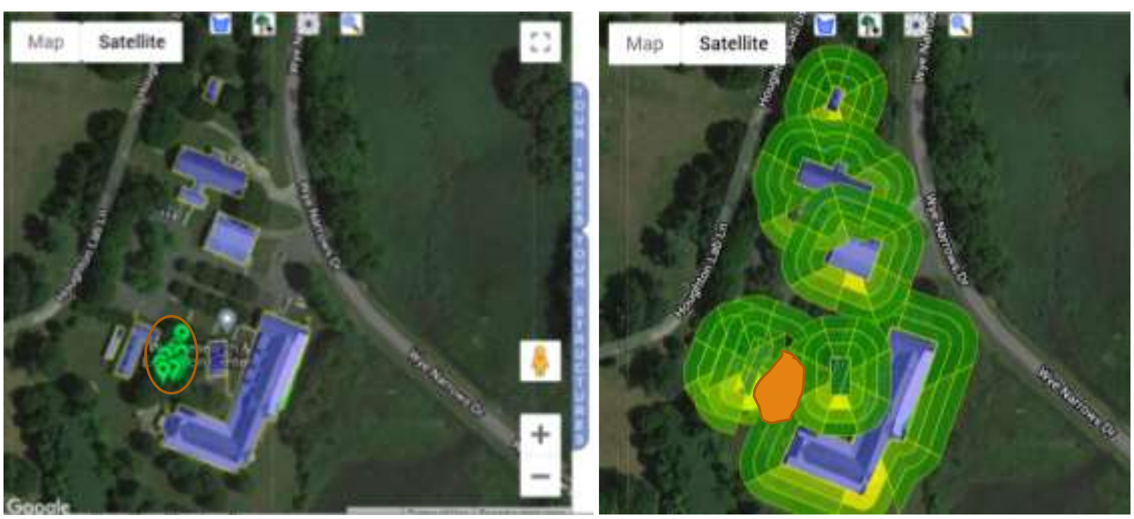
- Shading reduces the amount of heat absorbed and stored by buildings.
- Evapotranspiration of moisture by foliage reduces air temperatures.
- Trees slow down winds thereby reducing the amount of heat lost from buildings.

I-Tree Design was selected as the tool to estimate the energy savings achieved by the replacement. With inputs of location, species, tree size, and condition, users can understand tree benefits related to GHG mitigation, air quality improvements, and stormwater interception. With the additional step of drawing a building footprint – and virtually "planting" or placing a tree – tree effects on building energy use can be evaluated. Multiple trees and buildings can be added to compare benefits or to provide a full accounting of a property's trees.

The total building footprint for 'The Grove' area was created so the effects on building energy use could be evaluated for current and future assessments *(Figure 6).* The area between the 3 central administrative buildings was used for the present simulation. (*Figure 6, area highlighted in Orange*). Currently the location is the set of 11 decaying *Robinia sp (Locust)* trees.

It is proposed that the *Robinia* trees are replaced by the biodiverse selection of native trees identified in Item 2 (Page 12) for the analysis. In summary: *Acer saccharinum (Silver Maple), Populus deltoids (Eastern Cottonwood), Prunus serotina Black Cherry), Quercus nigra (Water Oak), Quercus phellos(Willow Oak), Juglans Nigra (Black Walnut), Salix nigra (Black Willow), Ulmus americana (American Elm), Ulmus rubra (Slippery Elm), Pinus virginiana (Virginia Pine), Pinus echinata (Shortleaf Pine)*.

Figure 6 – I-Tree Design overview of 'The Grove' area highlighting current Robinia sp. tree cluster (Orange)



Initially, a baseline was created to understand savings associated with current tree portfolio. Since the *Robinia* trees are 30 years old, the projected total benefit was set for a 30 lifespan. It was assumed that all trees were 1 inch in diameter when planted, were exposed to full sun light and that the tree conditions were good. Pins were positioned on or about what was thought to be the current tree trunk position. *(Figure 7).* A 30-year model crown growth simulation on the *Robinia* scenario confirmed that the trees approximately filled the current canopy space *(Figure 8).* A comparison was made assuming that tree conditions were poor which is the present scenario *(Figure 9).*

Figure 7 – I-Tree Design overview of area between buildings + Robinia sp pins. Assumes trees in good condition.

Figure 8 - I-Tree Design overview of area between buildings + Robinia sp model growth simulation (30 years).

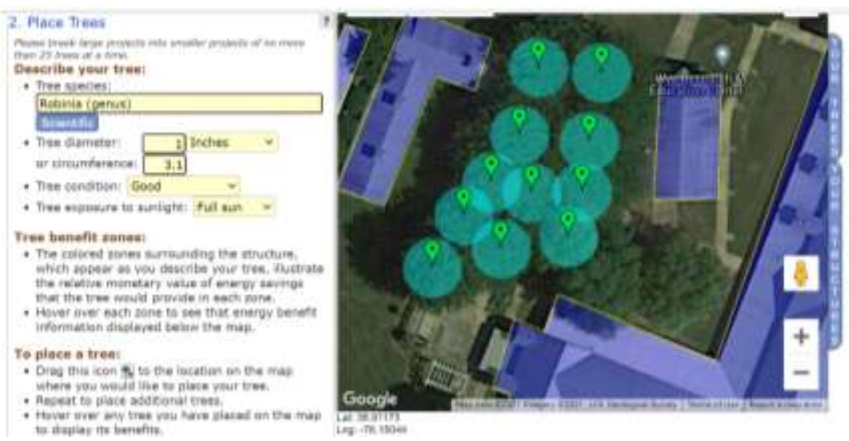


Figure 9 – I-Tree Design overview of area between buildings + Robinia sp pins. Assumes trees in poor condition.

The *Robinia's* area 30 years forecast considering trees with good condition is shown below. Combined summer and winter energy savings for the 11 current trees was calculated as **$8,147**. The total combined benefit of this scenario including CO2 reduction, air pollution removal and stormwater interception and avoided runoff was estimated as **$10.806.**

Total Projected Benefits (2021-2051) - Over the next 30 years, based on forecasted tree growth, i-Tree Design projects total benefits worth $10,806:

- $4 of storm runoff savings by avoiding 443 gallons of stormwater runoff (intercepting 55,208 gallons of rainfall)
- $14 of air quality improvement savings by absorbing and intercepting pollutants such as ozone, sulfur dioxide, nitrogen dioxide, and particulate matter; reducing energy production needs; and lowering air temperature
- $2,640 of savings by reducing 113,516 lbs. of atmospheric carbon dioxide through CO_2 sequestration and decreased energy production needs and emissions
- $4,301 of summer energy savings by direct shading and air cooling effect through evapotranspiration
- $3,846 of winter energy savings by slowing down winds and reducing home heat loss

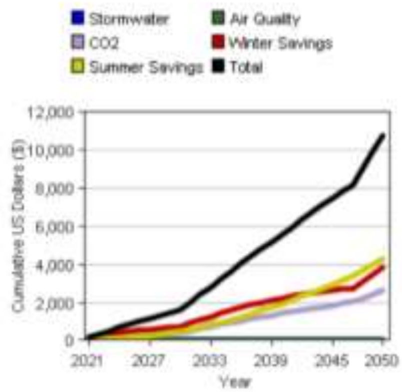


Figure 1. Tree benefit forecast for 30 years

The 30 years forecast considering trees in poor condition (more realistic to what is currently observed) is significantly reduced to **$5,362** and **$7,150** for energy savings and total benefits, respectively.

Total Projected Benefits (2021-2051) - Over the next 30 years, based on forecasted tree growth, i-Tree Design projects total benefits worth $7,150:

- $2 of storm runoff savings by avoiding 218 gallons of stormwater runoff (intercepting 27,156 gallons of rainfall)
- $9 of air quality improvement savings by absorbing and intercepting pollutants such as ozone, sulfur dioxide, nitrogen dioxide, and particulate matter; reducing energy production needs; and lowering air temperature
- $1,777 of savings by reducing 76,423 lbs. of atmospheric carbon dioxide through CO_2 sequestration and decreased energy production needs and emissions
- $2,367 of summer energy savings by direct shading and air cooling effect through evapotranspiration
- $2,995 of winter energy savings by slowing down winds and reducing home heat loss

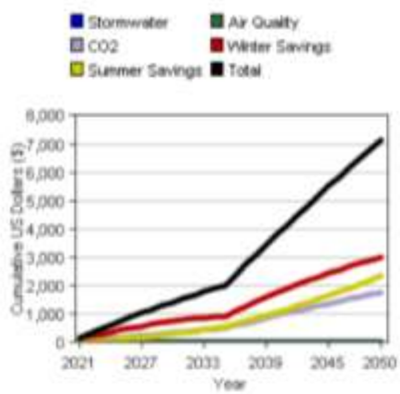


Figure 1. Tree benefit forecast for 30 years

A similar simulation was performed with our previously identified biodiverse native trees selection i.e. *Acer saccharinum (Silver Maple), Populus deltoids (Eastern Cottonwood), Prunus serotina Black Cherry), Quercus nigra (Water Oak), Quercus phellos(Willow Oak), Juglans Nigra (Black Walnut), Salix nigra (Black Willow), Ulmus americana (American Elm), Ulmus rubra (Slippery Elm), Pinus virginiana (Virginia Pine), Pinus echinata (Shortleaf Pine)*. One specimen of each of the 11 native trees was randomly pinned to the map. The projected total benefit was also set for a 30 lifespan and assumptions were identical to the *Robinia* scenario (i.e. all trees were 1 inch in diameter when planted, were exposed to full sun light and that the tree conditions were good). Pins were positioned on similar positions as the *Robinia* example. *(Figure 10).*

Figure 10 – I-Tree Design overview of area between buildings + Biodiverse Tree pins. Assumes trees in good condition.

The Biodiverse tree 30 years forecast considering trees with good condition was higher than the current *Robinia*. Combined summer and winter energy savings for the 11 diverse trees was calculated as **$13,151**. The total combined benefit of this scenario including CO2 reduction, air pollution removal and stormwater interception and avoided runoff was estimated as **$17,980.**

Total Projected Benefits (2021-2051) - Over the next 30 years, based on forecasted tree growth, i-Tree Design projects total benefits worth $17,980:

- $5 of storm runoff savings by avoiding 562 gallons of stormwater runoff (intercepting 69,910 gallons of rainfall)
- $25 of air quality improvement savings by absorbing and intercepting pollutants such as ozone, sulfur dioxide, nitrogen dioxide, and particulate matter; reducing energy production needs; and lowering air temperature
- $4,798 of savings by reducing 206,300 lbs. of atmospheric carbon dioxide through CO_2 sequestration and decreased energy production needs and emissions
- $5,572 of summer energy savings by direct shading and air cooling effect through evapotranspiration
- $7,579 of winter energy savings by slowing down winds and reducing home heat loss

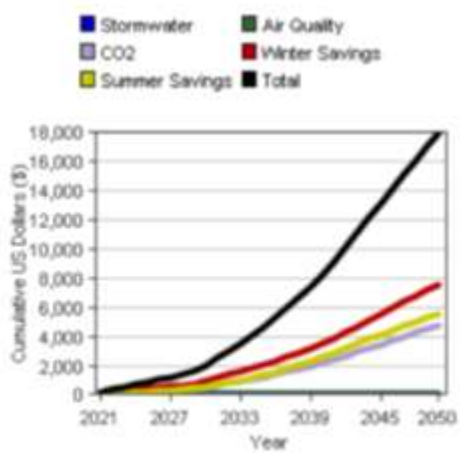


Figure 1. Tree benefit forecast for 30 years

A deep dive into the reason for higher benefits from the Biodiverse scenario can be explained by the tree quality. While each *Robinia* tree averaged about $1,080 in savings over 30 years, 7 out of the 11 Biodiverse trees shower a higher savings potential (Table 6 and 7, respectively). This data is important for decision making on optimizing energy savings once decayed *Robinia* trees are replaced. Multiple native trees specimens with highest saving benefits vs. *Robinia (i.e. Acer* *saccharinum, Juglans nigra, Salix nigra, Ulmus americana, Ulmus rubra, Pinus virginiana, Pinus echinata)* might be favored for this location. Additional factors such as soil condition, root system and tree maintenance will also be considered in the future tree replacement.

Mapping of additional areas next to buildings is complete and can be used for additional simulations.

Table 6 – Individual Tree Benefits as per I-Tree Design - *Robinia sp*

Individual Tree Benefits							
Tree	DBH (in)	Condition	Location to Structure	Benefits			
				Current Year (2021)	Future Year (2051)	Projected Total (2021-2051)	Total to Date
1. Robinia spp	1	Good	5: East (50 ft) 6: Northwest (26 ft)	$16.69	$90.54	$1,172	$0
2. Robinia spp	1	Good	5: East (23 ft) 6: Northwest (53 ft)	$16.48	$87.87	$1,104	$0
3. Robinia spp	1	Good	5: East (27 ft) 6: West (60 ft)	$8.20	$41.24	$506	$0
4. Robinia spp	1	Good	5: Southeast (40 ft) 7: West (56 ft)	$16.48	$75.16	$993	$0
5. Robinia spp	1	Good	5: South (34 ft) 7: West (42 ft)	$15.76	$61.75	$608	$0
6. Robinia spp	1	Good	5: Southeast (34 ft) 7: West (50 ft)	$16.19	$66.94	$890	$0
7. Robinia spp	1	Good	5: Southeast (51 ft) 7: West (45 ft)	$24.71	$124.21	$1,649	$0
8. Robinia spp	1	Good	5: Southeast (54 ft) 7: West (31 ft)	$16.33	$81.73	$1,046	$0
9. Robinia spp	1	Good	6: Southwest (41 ft) 7: West (25 ft)	$15.96	$74.55	$898	$0
10. Robinia spp	1	Good	5: East (55 ft) 6: West (29 ft)	$16.46	$93.67	$1,191	$0
11. Robinia spp	1	Good	6: Southwest (31 ft) 7: Northwest (46 ft)	$15.65	$67.01	$750	$0
Total				**$178.93**	**$864.65**	**$10,806**	**$0**

Table 7 – Individual Tree benefits as per I-Tree Design – Biodiverse Trees

Individual Tree Benefits							
Tree	DBH (in)	Condition	Location to Structure	Benefits			
				Current Year (2021)	Future Year (2051)	Projected Total (2021-2051)	Total to Date
1. Silver maple	1	Good	5: East (26 ft) 6: Northwest (50 ft)	$16.34	$76.40	$1,308	$0
2. Eastern cottonwood	1	Good	5: East (19 ft) 6: West (62 ft)	$8.04	$42.54	$831	$0
3. Black cherry	1	Good	5: Southeast (32 ft) 7: West (64 ft)	$7.97	$39.83	$687	$0
4. Water oak	1	Good	5: South (30 ft) 7: West (52 ft)	$13.19	$48.34	$976	$0
5. Willow oak	1	Good	5: South (39 ft) 7: West (36 ft)	$15.47	$57.97	$889	$0
6. Black walnut	1	Good	5: East (48 ft) 6: Northwest (28 ft)	$16.61	$68.57	$1,444	$0
7. Black willow	1	Good	5: East (50 ft) 6: West (32 ft)	$16.03	$97.90	$1,386	$0
8. American elm	1	Good	6: West (33 ft) 7: Northwest (55 ft)	$24.43	$97.98	$1,909	$0
9. Slippery elm	1	Good	6: Southwest (38 ft) 7: West (28 ft)	$14.65	$78.93	$1,201	$0
10. Virginia pine	1	Good	5: Southeast (56 ft) 7: West (32 ft)	$17.75	$124.90	$2,576	$0
11. Shortleaf pine	1	Good	5: Southeast (48 ft) 7: West (48 ft)	$26.51	$189.71	$4,772	$0
Total				**$176.98**	**$923.09**	**$17,980**	**$0**

PART 2 – PLANNING, I-TREE TAGES AND FINAL REPORT

WREC-C tree inventory including DBH and tree condition assessment will be performed in the July timeframe to accommodate to Project Team's schedule. In depth functional, structure and composition analyses as well as forecasting modeling that are relevant to the area will be further explored using i-Tree Eco.

Functional Analyses:

- Carbon sequestration and storage
- Hydrology effects (avoided run-off, interception, transpiration)
- Building energy effects
- Tree bio-emissions
- Ultraviolet radiation (UV) tree effects UV Report

Structure and composition analyses:

- Species condition and distribution
- Leaf area and biomass
- Species importance values
- Diversity indices and relative performance

Forecasting modeling options including:

- Tree planting inputs
- Extreme event impacts for weather and pests
- Annual mortality adjustments

Tree tags highlighting tree benefits will be created for select trees after all data is generated in alignment with Project Team. Prototype tags will be created using i-Tree My Trees.

A final report will be complete by August 2021.

APPENDIX

Scientific and corresponding Common Tree names used in I-Tree Design simulations.

Scientific Name	Common Name
Robinia sp	*Locust sp*
Acer saccharinum	*Silver Maple*
Populus deltoids	*Eastern Cottonwood*
Prunus serotina	*Black Cherry*
Quercus nigra	*Water Oak*
Quercus phellos	*Willow Oak*
Juglans nigra	*Black Walnut*
Salix nigra	*Black Willow*
Ulmus americana	*American Elm*
Ulmus rubra	*Slippery Elm*
Pinus virginiana	*Virginia Pine*
Pinus echinata	*Shortleaf Pine*