STONINGTON BOROUGH TREE RISK ASSESSMENT

Submitted by:

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T R E E F O I L

Post Office Box 124

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ABBREVIATIONS

ANSI	American National Standards Institute
ANSI A300	United States, industry-developed, national consensus standards of practice for tree care.
ANSI Z133.1	United States Safety standards for arborists
BMP	best management practice
B&B	balled & burlapped
CAES	Connecticut Agricultural Extension Service
DBH	diameter at breast height
D-tape	diameter tape
GIS	geographic information system
ISA	International Society of Arboriculture
ISA LEVEL 1	International Society of Arboriculture Level 1 (limited visual assessment, see glossary)
ISA LEVEL 2	International Society of Arboriculture Level 2 (basic assessment, see glossary)

RCA Registered Consulting Arborist

TRAQ tree risk assessment qualification

VTA visual tree assessment

EXECUTIVE SUMMARY

Consulting arborists, Treefoil LLC, completed a Level II basic visual tree risk assessment, determined eco value of assessed trees and identified future planting sites for Stonington Borough, Stonington, Connecticut from September 2020 through October 2020.

The consultants performed risk assessments of 78 trees over 50' height as directed by Warden Jeffrey Callahan and determined by Stonington Borough's Tree Inventory 2019 listed tree heights as listed by Stewardship East. An additional 2 trees were added by the consultant to the list given their height was within one foot (49') or less (49.9') of the stipulated height increasing the number of assessed trees to 80. Listed tree heights were not verified by the consultant but used only as a criteria for selecting which trees to assess as directed by Warden Callahan.

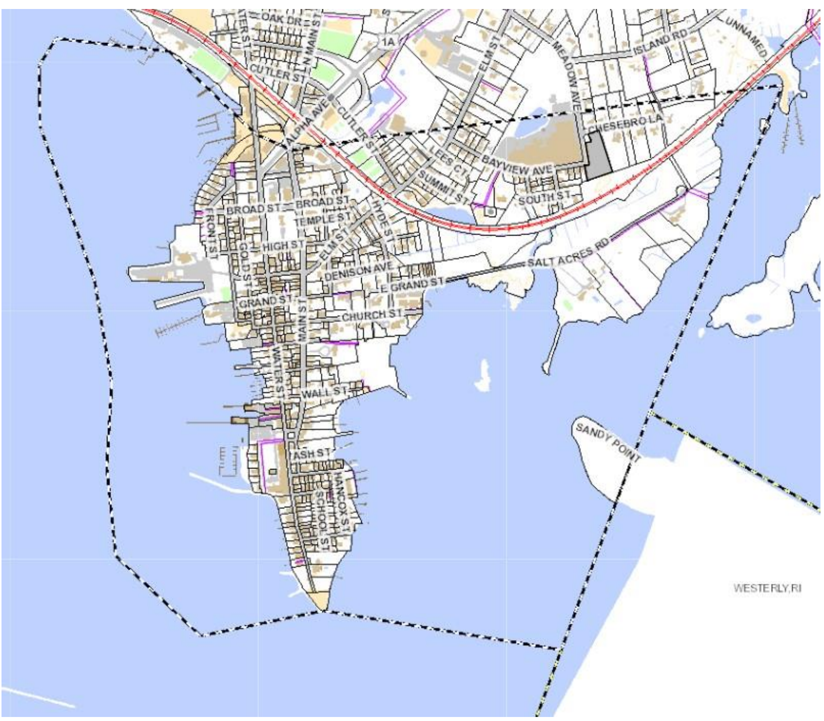


Figure 1 Stonington Borough Map and Boundary

Existing tree tag numbers, latitude, longitude, species, condition, size (diameter at 4.5' height- DBH), visual assessment of tree structure and were recorded utilizing the consultant's iPhone and supporting ArcGIS software.

The consultant inventoried for risk assessement 80 Borough of Stonington public trees. Street trees are generally considered trees that lie between the edge of sidewalks and the edge of street curbs as well as park trees (Wad Square, Mathews Park, etc.).

Tree risk assessment was classified for each of the 80 trees and was based on the International Society of Arboriculture's risk matrices. Please see Risk Assessment section for further detail. There were no trees identified for a further Advanced Assessments (a Level III). As the trees will continue to grow and site conditions evolve, the consultant recommends continual monitoring by a qualified arborist.

The risk rating distribution for trees was "low" for 69 count (86.25%), "moderate" for 10 count (12.50%) and "high" for one count (1.25%).

The consultant also recorded ecological monetary values for each tree ranging from energy savings, carbon storage, carbon sequestration, runoff prevention and more. The values were determined by the consultant's software. The values quantify the various individual monetary benefits of the assessed trees.

The eco benefits the 80 assessed trees provide annually is a total of $ 15,030. The values include runoff prevention $ 2,077 (257,248 gallons), property value contribution $ 4,147, energy savings & 1,618 (kWh saved 11,922), natural gas savings $ 5,574 (Therms 3.974), air quality monetary benefits $ 1,423 (pollutants removed 302 lbs.), carbon monetary benefit $ 191 (carbon stored 55,402 lbs., carbon avoided 35,276 lbs.).

All data recorded was collected, formatted and is deliverable in an Excel format as requested by Stonington Borough.

Trees rated as high risk (1 count) and moderate risk (10 trees) are estimated to cost $ 32,500 to prune as needed. The pruning will improve the trees resistance to storm events by removing dead wood, damaged limbs, reducing crown volume and mass.

Planting schedules recommendations are for 10 newly planted trees in the 2-2.5" caliper range. It is anticipated the costs installed should be approximated at $ 750 each for an annual cost of $ 7,500.

Figure 2 Assessed Trees Species, Location and Key

INTRODUCTION

On May 19, 2020, the Consultant was retained by the Borough of to assess a portion of its tree population. The guidance given the consultants was to risk assess trees listed at 50' height or greater in the Stonington Borough Tree Inventory 2019, Stewardship East publication as provided by Stonington Borough.

The consultant conducted the assessment September 25, 26 and 27, 2020. Follow up evaluation for eco values and planting sites was performed in October and early November.

The assessment included identifying and recording the tree tag number, species, condition, size, latitude, and longitude using ArcGIS based software. Additional data related to the tree condition was also collected for a Level II tree risk assessment and eco value.

The assessment included:

- mapping and recording tree attributes on an ArcGIS platform
- risk assessing and rating 80 trees over 50'
- establishing individual tree eco values for carbon storage and sequestration, carbon removed, overall energy savings, stormwater runoff prevention, property values, air quality benefit, and pollutants removed
- identifying, mapping, and recording potential planting sites and size of tree (small, medium, and large) using ArcGIS software
- compiling data in a deliverable Excel format

CURRENT CONDITIONS

Street Pictorial

The Borough of Stonington consists of a series of streets, many of which are very narrow with sidewalks between curbs and adjacent home foundations. There is usually none or minimal room for even small tree planting areas.

Figure 3 View of Trumbull Street looking east

There are two main thoroughfares, Water Street and Main Street that has a relatively wider street with available parking on both sides and planting strips between curbs and sidewalks. Water Street is often noticeably devoid of any current tree population with no current space to plant any due to sidewalks. The two major streets have narrow streets devoid of planting area between them. Often, they have overhead utilities that dictate the size of trees that could even be considered for planting (See Figure 3 and 4).

Figure 4 View up Water Street looking north

These confined conditions can lead to conflict with buildings, cars, people, sidewalks, and utility service (see Figure 5 below).

Figure 5 Utility Line Conflict with a London planetree on Water Street

Figure 7 Power line conflict resulting in a topped Ginkgo tree on Water Street

Figure 8 Power line conflict on Water Street

Figure 9 Main Street in the Borough looking south

The East side of the Borough contrast markedly from the West side. The main and side streets often have more space available between the curb and the sidewalk. This area is usually considered public property where municipal street trees can be found or at least considered for tree planting. Main Street also has more available space with parking on both sides, larger trees and generally more open area allowing for dispersed power lines and less congestion between buildings.

There are often planting sites that are ideal, however, it is possible they could reduce resident's views to the water. The area by the docks has a large potential for planting though there has been a history of conflict with obstructed views of adjacent residents and event use such as the Farmers Market. Using smaller trees will allow for plantings that do not obstruct views and occupy smaller lateral space. Some views may also be protected as defined by the village master plan.

Figure 10 Looking southwest over the village playground

Figure 11 Looking west over the Farmers Market lawn

Often areas such as Wad Square, Denison Avenue, Mathews Park and Wimpheimer Park have more open space and are used as park space by numerous civic organizations and residents. Wad Square has felt considerable "tree planting pressure" while residents still try to preserve open space for the summer Stonington Fair event.

Figure 12 Wadawanuck Square looking north

Figure 13 Wimpheimer Park looking east

Figure 14 Denison Avenue looking to the west

Some of the assessed trees are the largest in the overall tree population. They are older, considered mature and can be found in various locations with a few in sidewalk areas. The conditions tend to restrict root growth, be prone to drought, mechanical damage (cars, trucks, and plows) and under stress as a result. Though admired and cherished, mature trees do require more care as they age.

Figure 16 Tuliptree on Water Street

Figure 15 Tuliptree roots in conflict with street, curbing and sidewalk

Figure 17 Adjacent Zelkova on Water Street

Figure 18 Raised root system of Tuliptree looking east

Figure 19 Tuliptree on Main Street

Figure 20 Another view looking north raised roots of Tuliptree on Main Street

Observations - Characteristics - Top 10

BAR TABULAR

SHOW ALL VALUES

Observations-Characteristics	Count	Percent
Co-dominant Limbs	52	16.51%
Weak attachments	51	16.19%
Co-dominant tree	42	13.33%
Compacted Soil	33	10.48%
Deadwood	32	10.16%
Leaning trunk	28	8.89%
Soil Weakness	25	7.94%
Girdling Root	23	7.30%
Included Bark	16	5.08%
Poor Taper	13	4.13%

Table 1 Tree characteristics impacting risk ratings

Numbers and Types of Trees

Tree Size and Species Distribution

The 80 assessed trees represent a small apportion of the Borough's tree population. It is important to remember that when evaluating the numbers and results below. All 80 trees were inventoried first to gather data prior to risk assessing them. The individual tree inventory results as well as risk assessment are found in the appendices.

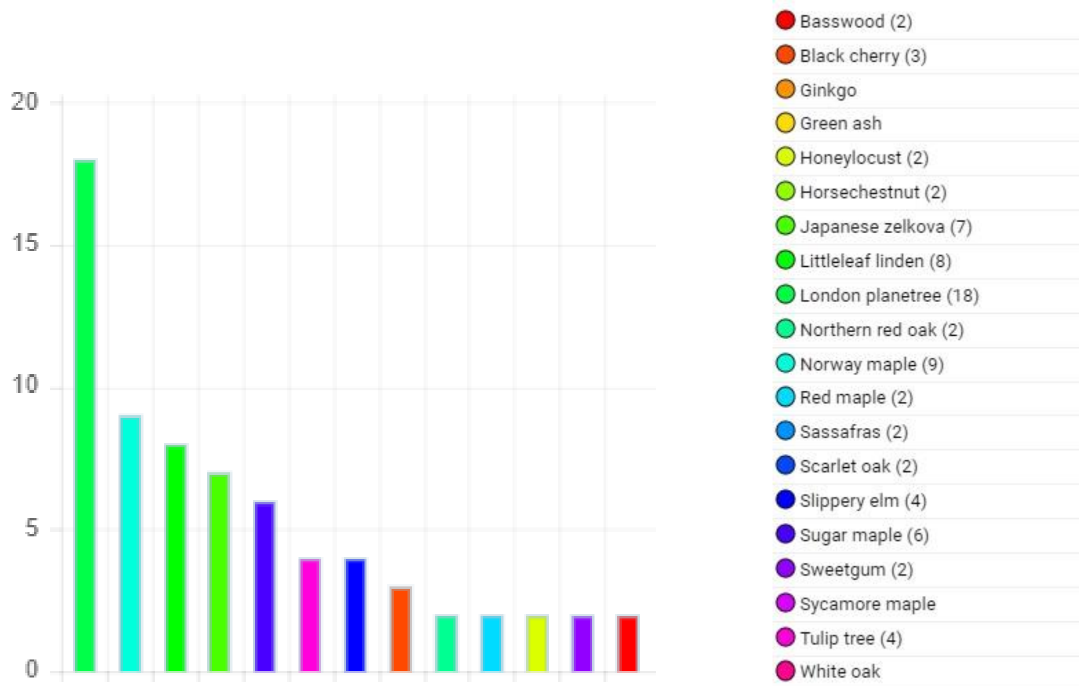


Figure 21 Species Count of the 80 assessed trees

The assessed trees of the Borough varied in condition. London planetree (*Pseudoplatanus acerifolia*) was the most common species out of the top ten species with 14 in good condition, 3 in fair condition and 1 in poor condition. Ratings are based CTLA rankings and highlighted in the Appendix.

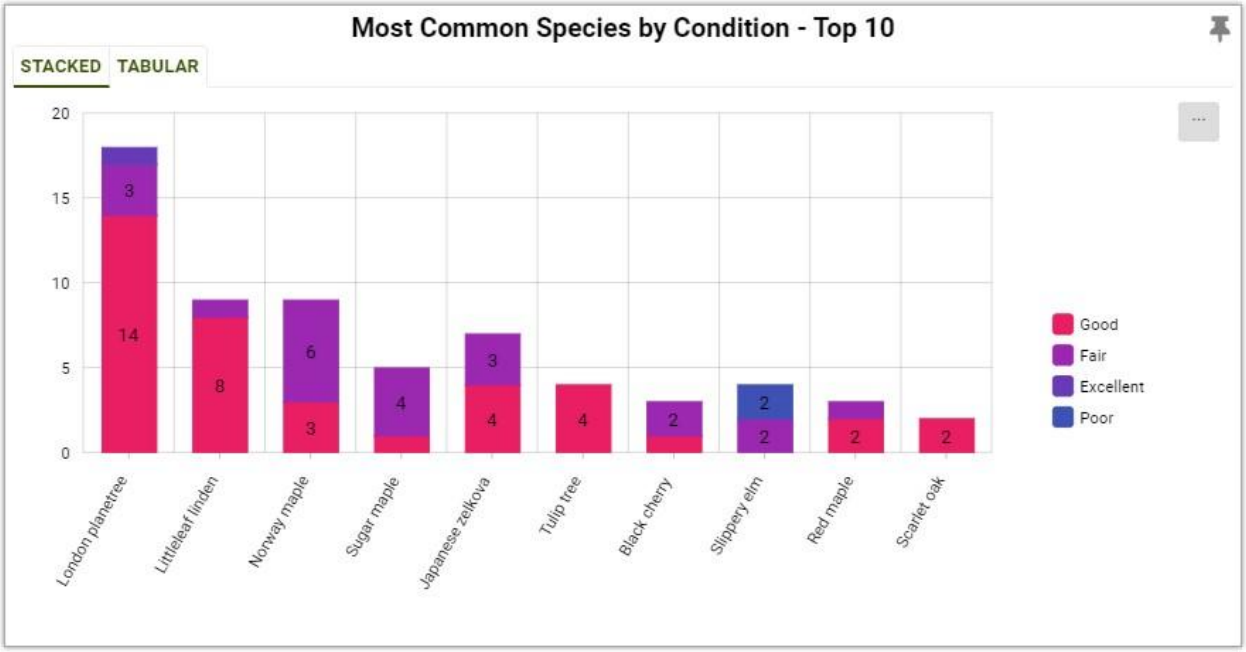


Figure 22 Top Ten Most Common Species and Condition

Not only was the London planetree the most populous species, it is also one of the largest sized (DBH) assessed species as demonstrated by the bar graph below. This is significant when considering trees for future size and species cycling.

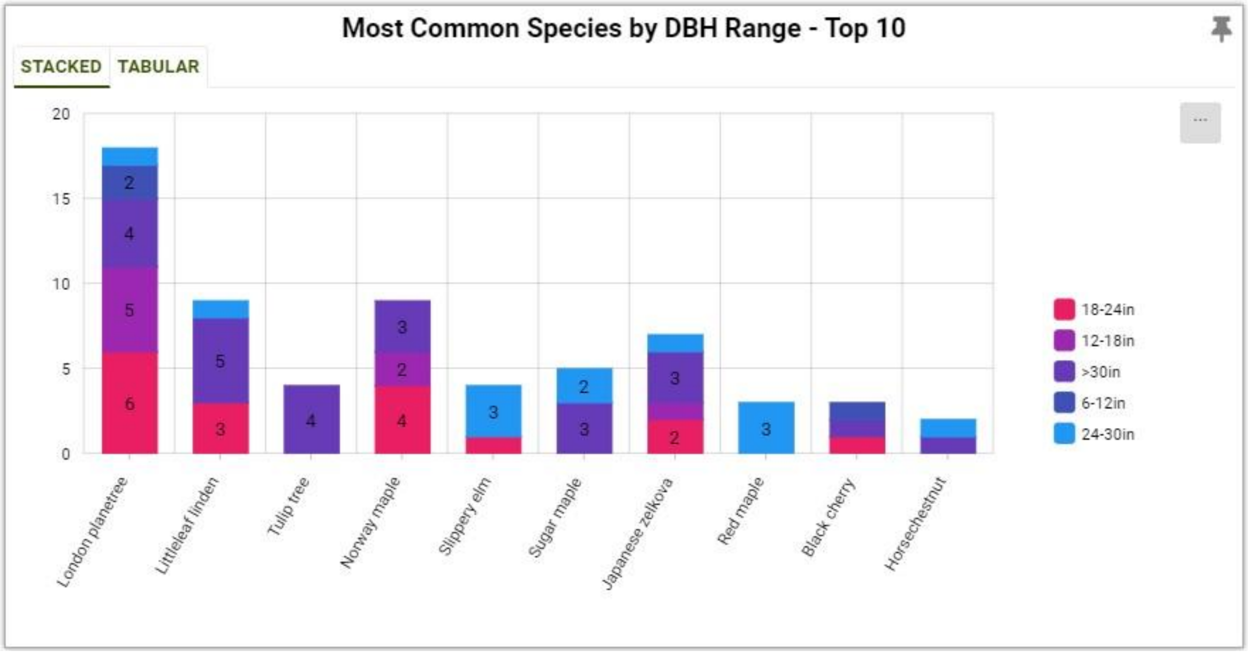


Figure 23 Most Common species by DBH (top ten species)

Overview

The consultant inventoried and risk assessed 80 Borough of Stonington public trees of height 49' or greater. Street trees are generally considered trees that lie between the edge of sidewalks and the edge of street curbs as well as park trees (Wadawanuck Square, Mathews Park, etc.).

Species Distribution

The Borough's top three assessed species distribution shows that there are 18 London planetree (*Platanus x acerifolia*), and 9 Norway maples (*Acer platanoides*) and 9 linden (*Tilia species*). The percentage of assessed population is London planetree 28.13%, and Norway maple 14.06% percent and linden 14.06%.

Common Name	Count	Percent
London planetree	18	28.13%
Norway maple	9	14.06%
Littleleaf linden	9	14.06%
Japanese zelkova	7	10.94%
Sugar maple	5	7.81%
Tulip tree	4	6.25%
Slippery elm	4	6.25%
Black cherry	3	4.69%
Red maple	3	4.69%
Honeylocust	2	3.13%

Figure 24 Ten Most Common Species

Borough Trees Ecosystem Contribution

An ecosystem analysis was created for the Borough of Stonington assessed street trees. The analysis was created using i-Tree, an open source service that quantifies ecological benefits of trees based on collected digital data fields. The i-Tree contributory structural value for the Borough is $ 15,030 for the 80 assessed trees.

Calculations are provided as annual benefits and are presented in terms of resource units and dollars. The United States Forest Service's publication Midwest Community Tree Guide details how benefits were calculated in each of the categories listed. The benefits are:

Energy: The Energy report presents the energy conservation contributions of the urban forest in terms of reduced natural gas use in winter (measured in therms) and reduced electricity use for air conditioning in summer (measured in kilowatt-hours).

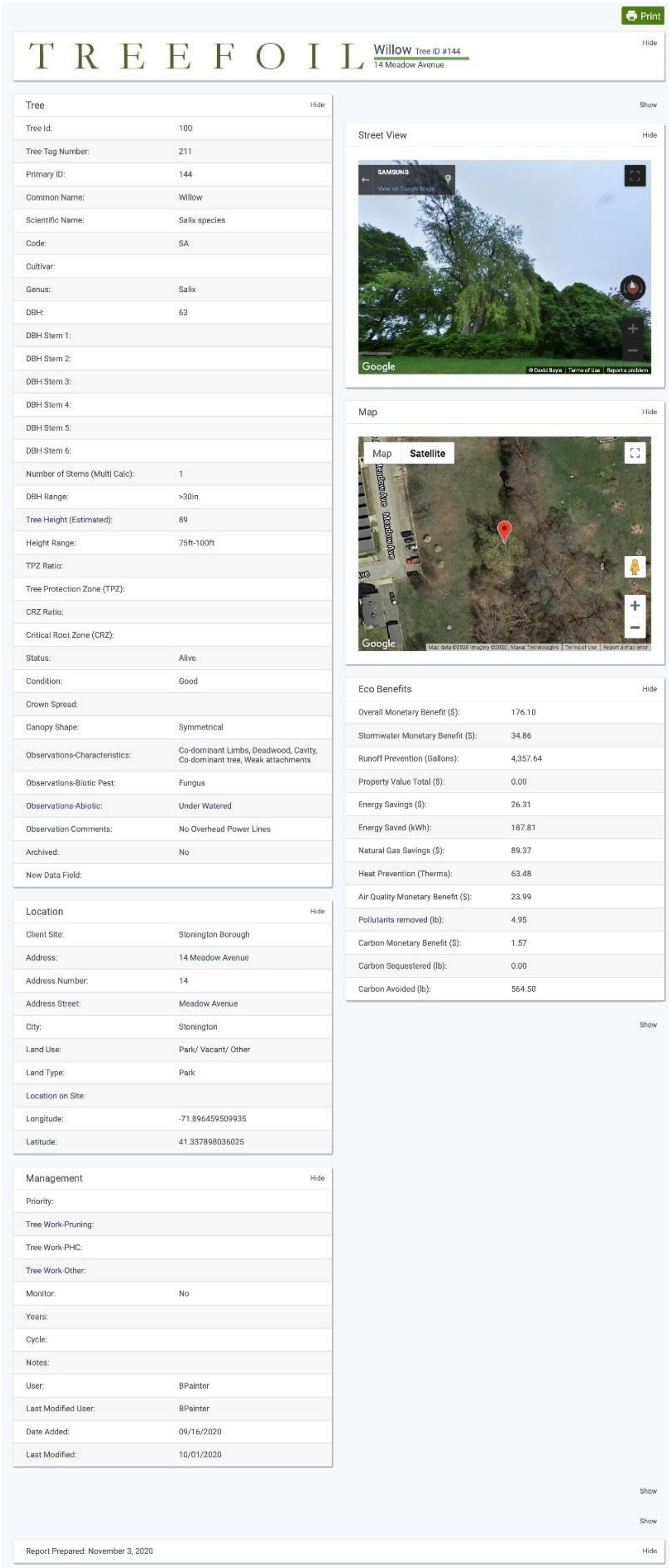
Stormwater: The Stormwater report presents the reductions in annual stormwater runoff due to rainfall interception by trees (measured in gallons or cubic meters).

Air quality: The Air Quality report quantifies the air pollutants (i.e., O3, NO2, SO2, PM10) deposited on tree surfaces and reduced emissions from power plants (i.e., NO2, PM10, VOCs, SO2) due to reduced electricity use (measured in pounds or kilograms). Also reported are the potential negative effects of trees on air quality due to Biogenic Volatile Organic Compounds (BVOC) emissions.

Carbon dioxide: The Carbon Dioxide report presents *annual* reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reduced energy use (in pounds or kilograms). The model accounts for CO_2 released as trees die and decompose as well as CO_2 released during the care and maintenance of trees. The *Carbon Stored* report tallies all the carbon dioxide stored in the urban forest *over the life of the trees* because of sequestration (in pounds or kilograms).

Property Value/Aesthetic/other: The Aesthetic/Other report presents the tangible and intangible benefits of trees reflected in increases in property values (in dollars).

Figure 25 Eco Value Totals for the Borough of Stonington



TREEFOIL

Willow Tree ID #144
14 Meadow Avenue

Tree

Tree Id:	100
Tree Tag Number:	211
Primary ID:	144
Common Name:	Willow
Scientific Name:	Salix species
Code:	SA
Cultivar:	
Genus:	Salix
DBH:	63
DBH Stem 1:	
DBH Stem 2:	
DBH Stem 3:	
DBH Stem 4:	
DBH Stem 5:	
DBH Stem 6:	
Number of Stems (Multi Calc):	1
DBH Range:	>30in
Tree Height (Estimated):	89
Height Range:	75ft-100ft
TPZ Ratio:	
Tree Protection Zone (TPZ):	
CRZ Ratio:	
Critical Root Zone (CRZ):	
Status:	Alive
Condition:	Good
Crown Spread:	
Canopy Shape:	Symmetrical
Observations-Characteristics:	Co-dominant Limbs, Deadwood, Cavity, Co-dominant tree, Weak attachments
Observations-Biotic Pest:	Fungus
Observations-Abiotic:	Under Watered
Observation Comments:	No Overhead Power Lines
Archived:	No
New Data Field:	

Location

Client Site:	Stonington Borough
Address:	14 Meadow Avenue
Address Number:	14
Address Street:	Meadow Avenue
City:	Stonington
Land Use:	Park/ Vacant/ Other
Land Type:	Park
Location on Site:	
Longitude:	-71.896459509935
Latitude:	41.337898036025

Management

Priority:	
Tree Work-Pruning:	
Tree Work-PHC:	
Tree Work-Other:	
Monitor:	No
Years:	
Cycle:	
Notes:	
User:	BPainter
Last Modified User:	BPainter
Date Added:	09/16/2020
Last Modified:	10/01/2020

Street View

Map

Eco Benefits

Overall Monetary Benefit ($):	176.10
Stormwater Monetary Benefit ($):	34.86
Runoff Prevention (Gallons):	4,357.64
Property Value Total ($):	0.00
Energy Savings ($):	26.31
Energy Saved (kWh):	187.81
Natural Gas Savings ($):	89.37
Heat Prevention (Therms):	63.48
Air Quality Monetary Benefit ($):	23.99
Pollutants removed (lb):	4.95
Carbon Monetary Benefit ($):	1.57
Carbon Sequestered (lb):	0.00
Carbon Avoided (lb):	564.50

Report Prepared: November 3, 2020

Figure 26 Individual Tree Report with Eco Values (mid-right side)

Individual ecological values ("Eco Benefits") for each tree are on each tree report located in the appendices.

The values are helpful for determining loss and gain of eco values or establishing and monitoring totals for future goals related to environmental benefits.

Plan of Conservation and Development

The Borough of Stonington could consider the tree risk assessment an opportunity to evaluate its commitment to preserving, maintaining, and developing its urban forest. The data available from the inventory and resulting risk assessment is a start to quantifying multiple environmental components such eco contributions, species distribution and pockets of canopy.

Most of the current population the consultants reviewed for tree risk is a larger more aged canopy planted multiple decades ago. Perhaps the planting site was less than ideal due to the smaller initial size planting. Often, plantings were done very informally by residents in nearby homes, employees of municipalities or perhaps a benefactor with an eye to the future.

The current available data management allows for a platform that can handle large data groups with the ability to extrapolate broad spectrums of data. This ability will only evolve, improve and be more manageable.

The Borough's ability to prioritize, categorize and deliver a realistic plan is dependent on its acknowledgement of the value of its urban canopy. A large, aging canopy without maintenance or replacement leads to a continued net loss of tree canopy.

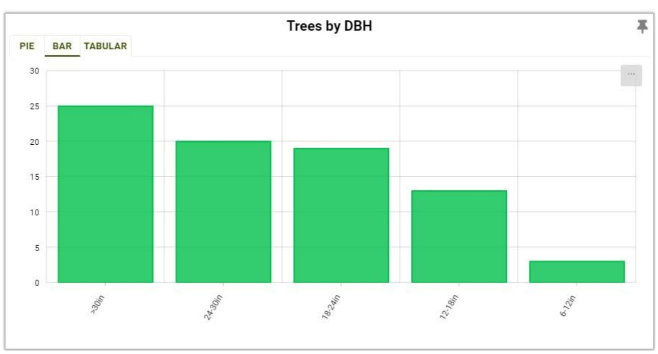


Table 2 Tree count by diameter at breast height (dbh) of assessed trees

Recommended Goals

The inventory assessment and review of the Borough street conditions provided some insight and recommendations to consider:

- Support tree commissioner with tree commission
- Preserve existing canopy through cyclic pruning maintenance
- Establish, maintain, and develop a tree fund for future plantings
- Develop new planting sites (pits) for existing streets devoid of canopy
- Increase bio-diversity with new plantings
- Install the right tree in the right place (small trees under utility line versus large)
- Identify a commitment to increasing eco values through tree planting
- Acknowledge benefits of trees: increased property values, reduced energy costs, increased quality of life
- Acknowledge risk associated with a tree canopy
- Encourage homeowner participation by supplying small trees for planting on private property
- Add tree planting requirements for new construction

RISK ASSESSMENT

The consultant's assignment was to risk assess all trees over 50' as determined by a previous tree inventory's findings. All tree risk ratings result from a combination of results derived from three matrices: the likelihood of failure, the likelihood of the failed tree part impacting a target and the consequences of a target being hit. The International Society of Arboriculture's publication *Best Management Practices Tree Risk Assessment* outlines the use of the matrices to categorize risk as low, moderate, high, or extreme at the time of inspection. It is essential to acknowledge that these conditions can change over time or post extreme weather events leading to recommendation for annual inspections of assessed trees.

The manager (Stonington Borough) should understand that all trees pose a degree of risk due to failure and to live amongst trees is to assume some degree of risk. Results from the evaluation of trees at the time of assessment and this report's recommendations and information utilized the practices found in *ISA's Best Management Practice for Tree Risk Assessment.* The manager needs to be responsible for scheduling any repeat or additional assessments, monitoring, recommendations, or mitigation. It is still possible to have tree failure, despite the tree appearing healthy, from weather events, acts of man and nature regardless of the tree risk rating.

Limitations of this report:

- Tree risk assessment is limited in scope to the specific risk(s) of interest and does not include any, and all risks.
- Tree risk assessment considers specific known and/or assigned targets and visible or detectable tree problems.
- Tree risk assessments represent the condition of the tree and site at the time of inspection.
- Not all defects are detectable and not all failures are predictable.
- The time frame for risk categorization should not be considered a "guarantee period" for the risk assessment.
- Only those trees specified in the scope of work were assessed, and assessments were performed within the limitations specified.
- Any tree, whether it has visible weakness or not, will fail if the forces applied exceed the strength of the tree or its parts.

(ISA, *Tree Risk Assessment Manual*, Second Edition, 2017)

Methodology

The 80 trees covered in this report were risk assessed using an ISA Basic Level II Assessment. This process involves a 360-degree ground-based inspection of the tree's roots, trunk, and branches. The tree is also viewed from a distance as well as up close using basic tools such as an 18" aluminum probe, binoculars, sounding mallet, and iPhone for GPS recording and pictures.

Trees were first assessed based on a combination of two factors: *the likelihood of failure;* where the likelihood of failure refers to the the tree part (roots, trunk or branches) and the *likelihood of impact* is the object of impact (people, building, cars) which is considered a "*target*". These factors are all considered within a time frame, which is considered one year for this report.

Definitions of *the likelihood of failure* is defined as follows:

Imminent: Failure has started or is most likely to occur soon, even if there is no wind or increased load. This is an infrequent occurrence for a risk assessor to encounter and may require immediate action to protect people from harm. The imminent category overrides the stated time frame.

Probable: Failure may be expected under normal weather conditions within the specified time frame.

Possible: Failure may be expected in extreme weather conditions, but it is unlikely during normal weather conditions within the specified time frame.

Improbable: The tree or tree part is not likely to fail during normal weather conditions and may not fail in extreme weather conditions within the specified time frame.

Definitions of *the likelihood of impacting a target* is defined as follows:

High: The failed tree or tree part is likely to impact the target. This is the case when there is a constant target, with no protection factors, and the direction of the fall is toward the target.

Medium: The failed tree or tree part could impact the target but is not expected to do so. This is the case for people in a frequently used area when the direction of fall may or may not be toward the target.

Low: There is a slight chance that the failed tree or tree part will impact the target.

Very Low: The chance of the failed tree or tree part impacting the specified target is remote.

Likelihood of Failure	Likelihood of Impact			
	Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Figure 27 Matrix I: Likelihood Failure / Likelihood of Impact Table

The resulting terms from the above matrix results are then applied to the second matrix below by using the resulting words (very likely, likely, somewhat likely, unlikely) to categorize the tree risk rating.

Definitions of *consequences of failure* is defined below:

Severe: Consequences that could involve serious personal injury or death, high-value property damage, or major disruption of important activities.

Significant: Consequences that involve substantial personal injury, moderate to high-value property damage, or considerable disruption of activities.

Minor: Consequences that involve minor personal injury, low to moderate-value property damage, or small disruption of activities.

Negligible: Consequences that do not result in personal injury and involve low-value property damage, or disruptions that can be replaced or repaired.

Likelihood of Failure & Impact	Consequences of Failure			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

Figure 28 Matrix 2: Risk Rating

Consequences of risk rating failure (Matrix 2): low, moderate, extreme, and high are defined as follows:

Low (risk rating): defined by its placement in the risk rating matrix (consequences are *negligible* Matrix 2); and likelihood is *unlikely*, or consequences are *minor,* and likelihood is *somewhat likely*.

Moderate (risk rating): defined by its placement in the risk rating matrix (Matrix 2); consequences are *minor,* and likelihood is *very likely* or *likely* or likelihood is *somewhat likely* and consequences are *significant* or *severe.*

Extreme (risk rating): defined by its placement in the risk rating matrix (Matrix 2); failure is *imminent* with a *high* likelihood of impacting the target, and the consequences of the failure are *severe.*

High (risk rating): defined by its placement in the risk rating matrix (Matrix 2); consequences are a *significant* and likelihood is *very likely* or *likely*, or consequences are *severe,* and the likelihood is *likely*.

Conditions Impacting Risk Ratings

The risk rating of trees can often be mitigated by a variety of options: pruning (reduction, cleaning, clearance), removals, cabling, guying, and target reduction (moving targets like picnic tables for example). These options will often reduce or even eliminate risk by reducing the amount of load (branches) on the canopy, adding structural support with cabling and guying, or moving targets or trees to eliminate risk. Trees that have a greater likelihood of failure can be cordoned off for example in a park area, though there are none currently recommended for that action with the Borough's subject trees. Removing the tree always reduces if not eliminates risk though all aesthetic, environmental and social benefits are lost. Ideally the manager will work to maintain an acceptable level of risk as they determine.

Figure 29 Cracked lateral branch on Wad Square maple

Figure 30 Poor attachments and dead wood on Wad Square maple

Most trees that were assessed have some issues that cannot be mitigated: girdling roots, lifted roots, confined roots, and limited root growth area within impervious surfaces like streets and sidewalks. This often leads to drought stress. Reducing the load on trees through pruning allows trees to have less weight and volume so storm events with steady winds, gusts, snow, and rain have a lesser likelihood to adversely impact trees with uprooting.

Figure 31 Girdling and lifted tree roots on Main Street

Roots that girdle can eventually cutoff the flow off nutrients located beneath the bark on the tree layer. This can kill the portion of tree being nourished within the girdled area resulting in portions of dead branches in the canopy. Ideally the roots are manually corrected if apparent at either the time of installation or as/if they become apparent. Roots often end up within confined better suited growing media in sidewalk and street side settings. Though not ideal, some species tend to grow better in theses settings than others.

Figure 32 Lifted tree roots within a sidewalk on Water Street

Observations - Characteristics - Top 10

BAR TABULAR

SHOW ALL VALUES

Observations-Characteristics	Count	Percent
Co-dominant Limbs	52	16.51%
Weak attachments	51	16.19%
Co-dominant tree	42	13.33%
Compacted Soil	33	10.48%
Deadwood	32	10.16%
Leaning trunk	28	8.89%
Soil Weakness	25	7.94%
Girdling Root	23	7.30%
Included Bark	16	5.08%
Poor Taper	13	4.13%

Figure 33 Tree defects considered when making assessments

It is helpful to understand that an unquantifiable degree of risk still exists with most of the assessed trees despite performing prescribed pruning mitigation due to unknown root spread and stability. Mature trees growing under preferred conditions will have spreading lateral roots 2-3’ within the soil surface resulting in ideal stability. The assessed Borough street trees tend to fall within these conditions. Many factors directly impact root conditions of the assessed trees such as compacted soil (33 trees), soil weakness (25 trees), and gridling roots (23).

The condition of assessed trees is an indicator of how species are reacting to their environmental condition they are growing in or their ability to overcome adverse conditions. London planetree species and linden are overall in better condition than sugar maples. Future planting actions should consider this data.

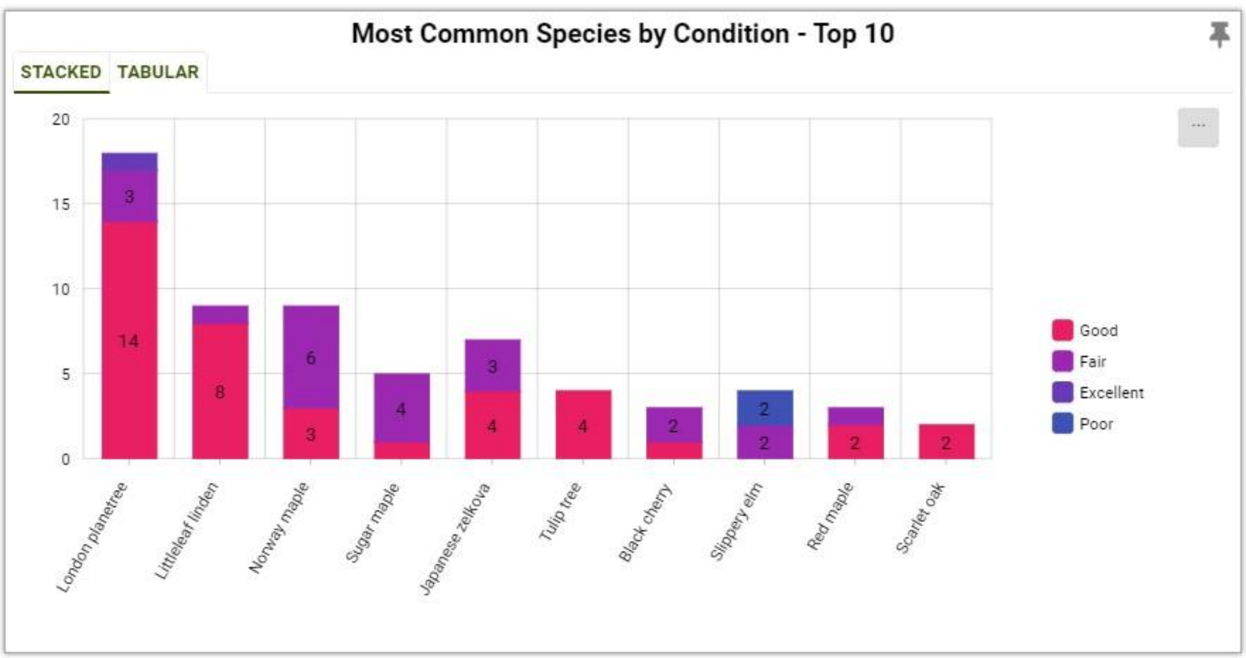


Figure 34 Ten Most Common Species by Condition

Assessment Results

The consultant found 69 trees to be a low risk, 10 to be a moderate risk and 1 a high risk. It is important to keep in mind that this only represents 80 trees of the total Borough tree population or 36.19 % of the total 221 trees according to *Stewardship Southeast Tree Inventory 2019*.

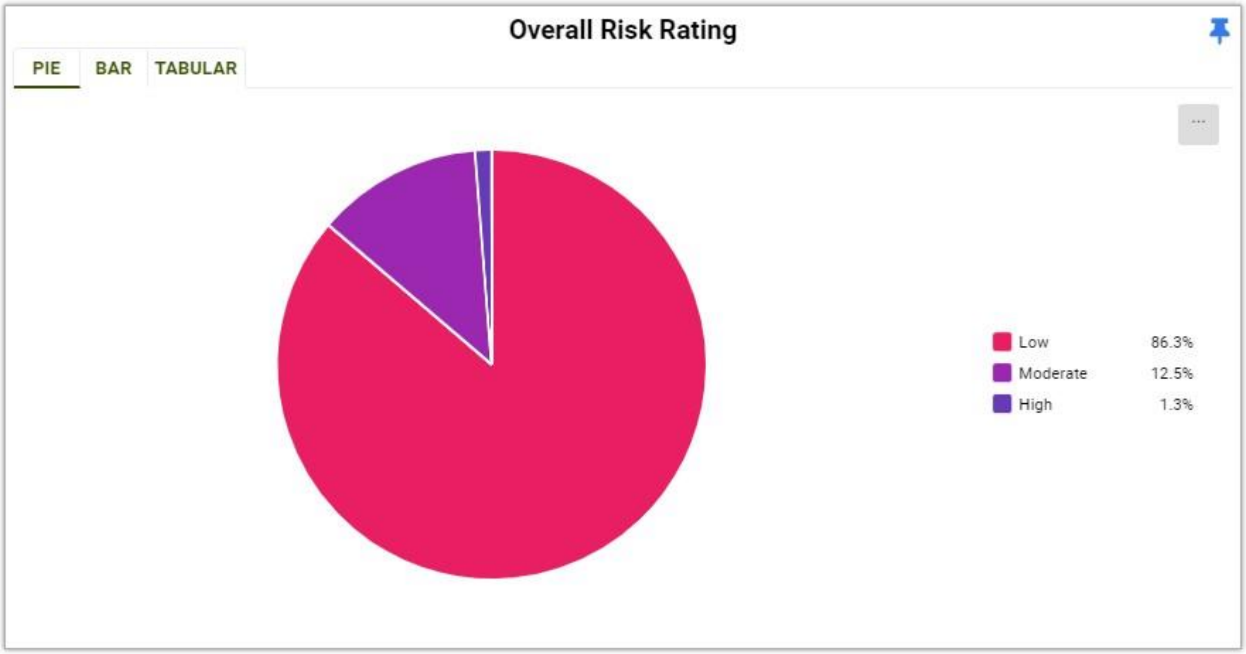


Figure 35 Risk Ratings of Assessed Trees

Overall Risk Rating   Hide

OVERALL RISK RATING	COUNT	PERCENTAGE
Low	69	86.3%
Moderate	10	12.5%
High	1	1.3%

Figure 36 Risk Ratings and Count

The overall risk rating by size (diameter at breast height -dbh) tells us that a diverse size of the population falls within a low risk rating with only one over 30" caliper falling into a higher risk rating. Larger, or more mature trees, usually require increased care as they age so this is not surprising.

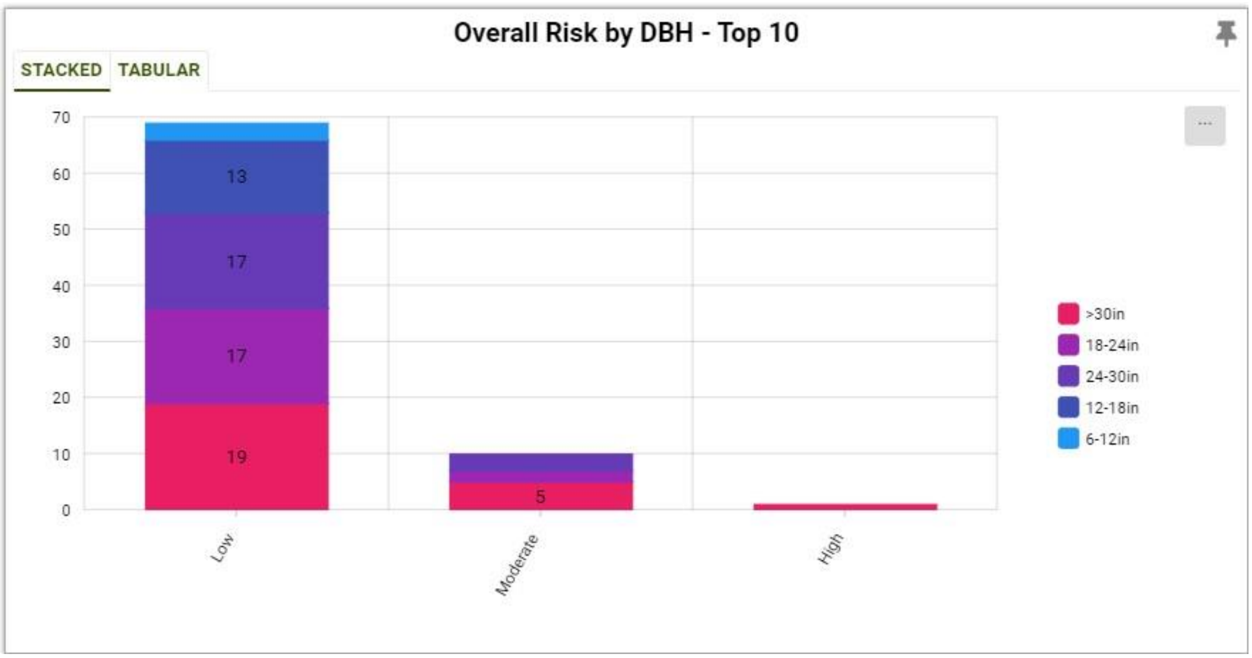
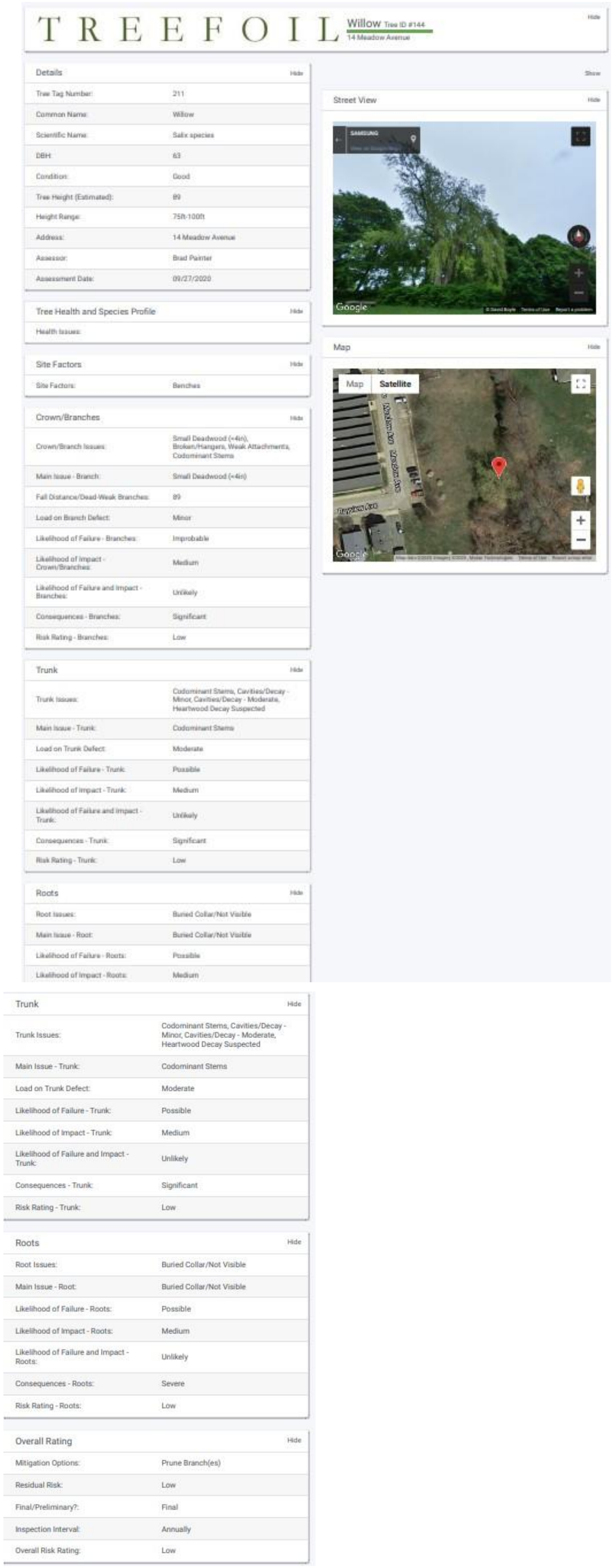


Figure 37 Top Ten Overall Risk by DBH

Tree risk rating can be reduced with mitigation though as discussed earlier most of the risk ratings remain unchanged except for a Wadawanuck Square sugar maple (*Acer saccharum)* accession # 187 could be reduced from high to moderate rating.

No trees were recommended for removal, though if recommended, the risk most always is reduced to none.



TREEFOIL

Willow Tree ID #144
14 Meadow Avenue

Details	
Tree Tag Number:	211
Common Name:	Willow
Scientific Name:	Salix species
DBH:	63
Condition:	Good
Tree Height (Estimated):	89
Height Range:	75ft-100ft
Address:	14 Meadow Avenue
Assessor:	Brad Painter
Assessment Date:	09/27/2020

Tree Health and Species Profile	
Health Issues:	

Site Factors	
Site Factors:	Benches

Crown/Branches	
Crown/Branch Issues:	Small Deadwood (<4in), Broken/Hangers, Weak Attachments, Codominant Stems
Main Issue - Branch:	Small Deadwood (<4in)
Fall Distance/Dead-Weak Branches:	89
Load on Branch Defect:	Minor
Likelihood of Failure - Branches:	Improbable
Likelihood of Impact - Crown/Branches:	Medium
Likelihood of Failure and Impact - Branches:	Unlikely
Consequences - Branches:	Significant
Risk Rating - Branches:	Low

Trunk	
Trunk Issues:	Codominant Stems, Cavities/Decay - Minor, Cavities/Decay - Moderate, Heartwood Decay Suspected
Main Issue - Trunk:	Codominant Stems
Load on Trunk Defect:	Moderate
Likelihood of Failure - Trunk:	Possible
Likelihood of Impact - Trunk:	Medium
Likelihood of Failure and Impact - Trunk:	Unlikely
Consequences - Trunk:	Significant
Risk Rating - Trunk:	Low

Roots	
Root Issues:	Buried Collar/Not Visible
Main Issue - Root:	Buried Collar/Not Visible
Likelihood of Failure - Roots:	Possible
Likelihood of Impact - Roots:	Medium

Street View

Map

Trunk	
Trunk Issues:	Codominant Stems, Cavities/Decay - Minor, Cavities/Decay - Moderate, Heartwood Decay Suspected
Main Issue - Trunk:	Codominant Stems
Load on Trunk Defect:	Moderate
Likelihood of Failure - Trunk:	Possible
Likelihood of Impact - Trunk:	Medium
Likelihood of Failure and Impact - Trunk:	Unlikely
Consequences - Trunk:	Significant
Risk Rating - Trunk:	Low

Roots	
Root Issues:	Buried Collar/Not Visible
Main Issue - Root:	Buried Collar/Not Visible
Likelihood of Failure - Roots:	Possible
Likelihood of Impact - Roots:	Medium
Likelihood of Failure and Impact - Roots:	Unlikely
Consequences - Roots:	Severe
Risk Rating - Roots:	Low

Overall Rating	
Mitigation Options:	Prune Branch(es)
Residual Risk:	Low
Final/Preliminary?:	Final
Inspection Interval:	Annually
Overall Risk Rating:	Low

Figure 38 Typical tree risk rating report

Individual Tree TRAQ reports are included separately with the assessment. The report to the left shows the ratings for crown branches, trunk and roots leading to ratings plugged into risk matrices 1 and 2 for an overall rating.

Tree risk ratings and associated data have been assembled in a separate data document for the Borough's records. A summary of locations (approximate), common name. condition, size (dbh), overall risk and residual risk (after mitigation) height and tree tag number are listed below:

Address	Common Name	Condition	DBH	Overall Risk	Resid Risk	Tree Ht	Tag #
1 Chesebro Lane	Black cherry	Fair	11	Low	None	51	198
1 Cutler Street	London planetree	Fair	20	Low	Low	61	128
200 Main Street	Basswood	Good	24	Low	Low	52	83
76 Water Street	London planetree	Fair	17	Low	Low	55	25
14 Meadow Avenue	Willow	Good	63	Low	Low	89	211
39 Bayview Avenue	Sycamore maple	Good	28.65	Low	Low	52	221
44 Bayview Avenue	Sassafras	Poor	15	Low	Low	53	200
44 Bayview Avenue	Sassafras	Good	24.41	Low	Low	67	201
1 Chesebro Lane	Black cherry	Fair	30.03	Low	Low	88	199
1 Chesebro Lane	Norway maple	Fair	16	Low	Low	64	197
1 Chesebro Lane	Norway maple	Fair	17	Low	Low	59	192
1 Chesebro Lane	Norway maple	Fair	23	Low	Low	71	193
1 Chesebro Lane	Norway maple	Fair	20	Low	Low	64	194
1 Chesebro Lane	Norway maple	Good	20	Low	Low	71	191
1 Chesebro Lane	Black cherry	Good	23	Low	Low	60	190
8 Denison Avenue	London planetree	Good	44	Low	Low	81	133
64 Main Street	Northern red oak	Good	25	Low	Low	91	40
37 Main Street	Littleleaf linden	Good	32	Low	Low	76	61
88 Water Street	London planetree	Good	19	Low	Low	56	23
84 Water Street	London planetree	Good	18	Low	Low	61	24
90 Water St	London planetree	Good	15	Low	Low	60	32
90 Water	London planetree	Good	13	Low	Low	62	31
90 Water St	London planetree	Good	19	Low	Low	58	30
Cutler/Elm	London planetree	Excellent	19	Low	Low	58	129
170 Water Street	Ginkgo	Excellent	15	Low	Low	54	17
170 Water Street	Japanese zelkova	Good	34	Moderate	Moderate	55	16
174 Water Street	Tulip tree	Good	53	Moderate	Moderate	92	14
Wad Square	Norway maple	Fair	44.5	High	Moderate	85	187
Broad St	Honeylocust	Good	18.5	Low	Low	59	98
Broad St	Honeylocust	Good	17	Low	Low	51	97
8 Pearl Street	London planetree	Good	14	Low	Low	57	115
Gold St	London planetree	Good	13	Low	Low	58	11
Front st	Japanese zelkova	Good	32.59	Low	Low	65	6
3 Wheeler Court	Japanese zelkova	Good	22.05	Low	Low	55	5
3 Wheeler Court	Japanese zelkova	Fair	32	Low	Low	65	4
182 Front Street	Japanese zelkova	Fair	24.7	Low	Low	49	3
182 Front Street	Japanese zelkova	Fair	16.5	Low	Low	50	2
Wad Square	Sugar maple	Fair	28	Low	Low	80	185
Wad Square	Norway maple	Fair	18	Low	Low	52	183
Wad Square	Horsechestnut	Good	25	Low	Low	59	177
Wad Square	Norway maple	Good	45	Low	Low	74	175
Wad Square	Horsechestnut	Excellent	46	Low	Low	78	169
Wad Square	Sugar maple	Fair	39	Low	Low	74	168
Wad Square	Scarlet oak	Good	27	Low	Low	74	167
Wad Square	Green ash	Good	24	Low	Low	58	164
Wad Square	White oak	Good	26	Low	Low	68	162

Table 3 Select Data for Trees

Address	Common Name	Condition	DBH	Overall Risk	Resid Risk	Tree Ht	Tag #
Wad Square	Scarlet oak	Good	25	Low	Low	89	161
Wad Square	Basswood	Good	17	Low	Low	53	160
Wad Square	Sugar maple	Good	32.5	Low	Low	89	159
Wad Square	Sugar maple	Fair	38	Low	Low	104	156
Wad Square	London planetree	Good	35	Low	Low	60	146
46 Main Street	Japanese zelkova	Good	22	Low	Low	62	43
29 Main Street	Sugar maple	Fair	24	Low	Low	61	46
25 Main	Red maple	Good	25	Moderate	Moderate	57	69
29 Main Street	Red maple	Good	27.5	Moderate	Moderate	59	68
31 Main Street	Tulip tree	Good	30	Low	Low	66	67
33 Main Street	Tulip tree	Good	33	Low	Low	60	66
33 Main Street	Tulip tree	Good	33	Low	Low	77	65
37 Main Street	Littleleaf linden	Good	38	Moderate	Moderate	72	62
47 Main Street	Norway maple	Good	31	Low	Low	57	58
51 Main Street	London planetree	Good	20	Low	Low	66	56
53 Main Street	London planetree	Good	24	Low	Low	67	55
73 Main Street	Sweetgum	Excellent	15.5	Low	Low	59	53
75 Main Street	Littleleaf linden	Good	25.96	Low	Low	50	51
77 Main Street	Littleleaf linden	Good	19.13	Low	Low	56	50
36 Broad Street	Slippery elm	Poor	26	Low	Low	56	108
27 Broad Street	Slippery elm	Fair	23	Low	Low	72	107
34 Broad Street	Slippery elm	Poor	28	Low	Low	82	106
Broad Street	Slippery elm	Fair	27	Low	Low	69	105
10 Denison Avenue	London planetree	Good	9	Low	Low	54	134
14 Denison Avenue	London planetree	Good	7	Low	Low	51	137
26 Grand Street	Sugar maple	Fair	25	Moderate	Moderate	66	73
16 Denison Avenue	London planetree	Fair	32	Low	Low	56	139
58 Denison Avenue	London planetree	Good	37	Low	Low	72	140
57 Main Street	Littleleaf linden	Fair	34	Moderate	Moderate	56	42
22 Church Street	Littleleaf linden	Good	41	Moderate	Moderate	64	41
60 North Main	Northern red oak	Good	24	Low		91	40
68 Main	Littleleaf linden	Good	21	Moderate	Moderate	58	38
68 Main	Littleleaf linden	Good	21.5	Moderate	Moderate	62	37
4 Elm Street	Sweetgum	Good	23	Low	Low	64	35

Table 4 Select Data for Trees (Continued)

FUTURE TREESCAPE OPTIONS

Plantings

To guarantee the long-term health and perpetuation of the urban forest, a good program must continue to plant trees on regular basis. An important element of a planting program is species diversification. The emerald ash borer is an example of how disaster can destroy poorly diversified urban forests.

The following guidelines provide direction for developing a diverse, healthy, low-maintenance, and aesthetically improved urban forest:

- Long-term (i.e., 20-year) population targets for high-quality species should hover around 5 percent of the current tree population.

- The urban forest like the Borough's often has a need for numerous smaller trees that take up less space than larger ideal trees like the white oak. The trees occupy less space and contribute less overall to tree value and benefit given their considerably smaller canopy. Planting quantities can be adjusted on a case by case basis though an established minimum tree fund is always recommended.

After a certain age, all trees decline and require greater maintenance. When large numbers of trees are planted within a short time, they become expensive and difficult to manage all at once. Multiple-aged stands are more desirable because they will disperse maintenance costs.

Slower-growing, longer-living trees minimize maintenance costs. Planting trees that live three times as long means spending approximately one third as much in removal costs over the same number of years. In general, the same slower-growing trees are higher quality and demand less pruning over their lifetime.

Stonington Borough would benefit from a balanced list of non-natives as well as native planting options. Recommended planting suggestions vary from source to source and depend on existing population diversity, present pest problems, and degree of varying climatic conditions. The consultants recommended a broader range of species for increased biodiversity as identified by University of Massachusetts in their 2019 publication, *Planting for Resilience: Selecting Urban Trees in Massachusetts,* by Ashley M. McElhinney and Richard Harper.

Regular, annually scheduled tree plantings with target goals will assist in maintaining healthy canopy conditions for the future. Unforeseen events like storms, pathogens, and insect infestations can devastate an existing urban forest. A broad, diverse, and healthy planting will offer some insurance against such events. There is often flexibility in size of trees at time of planting, giving some leeway on budgetary options. First-year care is critical and should provide and maintain watering options such as Gator bags with regular fillings.
An annual target number for new annual Borough plantings is 5% of the population or 11 trees.

Planting Locations and Size

Figure 39 Location of Possible Planting Sites (white circles)

Planting Site	Tree Size
14 Northwest Street	Proposed Site - Small
66 Main Street	Proposed Site - Small
26 Grand Street	Proposed Site - Small
4 Cliff Street	Proposed Site - Medium
26 Denison Avenue	Proposed Site - Medium
25 High Street	Proposed Site - Medium
42 Denison Avenue	Proposed Site - Medium
49 Main Street	Proposed Site - Large
19 Church Street	Proposed Site - Small
19 Church Street	Proposed Site - Small
37 Main Street	Proposed Site - Small
41 Main Street	Proposed Site - Small
37 Main Street	Proposed Site - Small
21 Harmony Street	Proposed Site - Small
33 Main Street	Proposed Site - Small
31 Main Street	Proposed Site - Small
36 Main Street	Proposed Site - Small
36 Main Street	Proposed Site - Small
36 Main Street	Proposed Site - Small
34 Main Street	Proposed Site - Medium
32 Main Street	Proposed Site - Small
32 Main Street	Proposed Site - Small
2 Wall Street	Proposed Site - Small
14 Main Street	Proposed Site - Small
14 Main Street	Proposed Site - Small
190 Mistuxet Avenue	Proposed Site - Small
2 Cannon Square No 2	Proposed Site - Small
2 Cannon Square No 2	Proposed Site - Small
4 Cannon Square No 2	Proposed Site - Small
25 High Street	Proposed Site - Small
4 Elm Street	Proposed Site - Small
14 Northwest Street	Proposed Site - Small
14 Northwest Street	Proposed Site - Small
14 Northwest Street	Proposed Site - Small
14 Northwest Street	Proposed Site - Small
4 High Street	Proposed Site - Small
4 High Street	Proposed Site - Small
4 High Street	Proposed Site - Small
4 High Street	Proposed Site - Medium
11 Broad Street	Proposed Site - Small
178 Water Street	Proposed Site - Small
176 Water Street	Proposed Site - Small
32 Broad Street	Proposed Site - Medium
95 Mathews Street	Proposed Site - Small
99 Mathews Street	Proposed Site - Small
99 Mathews Street	Proposed Site - Small
200 Main Street	Proposed Site - Small
3906 Alpha Avenue	Proposed Site - Medium
3906 Alpha Avenue	Proposed Site - Medium
3906 Alpha Avenue	Proposed Site - Large

Table 5 Address and proposed size (small, medium, large) tree at planting site

Planting sites are limited in the Borough due to the restricted space present of most of the sidewalk space. Most of the planting sites readily available have small strips of lawn. Though far from ideal some limited planting space can accommodate drought resistant and urban tolerant species such as the honey locust (*Gleditsia species*) pictured to the left.

Figure 41 Honeylocust trees on Broad Street growing well in narrow planting strips

It is also possible to introduce considerably more planting area by claiming larger planting space from sidewalk area. The saying, "plant a $5 dollar tree in a $ 50 hole" applies. This approach requires additional budget expenditure and effort, though canopy can be introduced in areas currently devoid of canopy. This requires commitment and understanding with the residents as the manager

Figure 40 Small tree growing in small planting pit

RECOMMENDATIONS

Timeline

The tree population provides numerous economic and environmental benefits to the community. Larger trees produce considerably more aesthetic and environmental benefits than younger trees and should be maintained at a higher level of care, which ultimately reduces maintenance costs while improving safety and aesthetics. Regular maintenance such as cyclical pruning, monitoring, pest and disease management, inspections, and planting can identify current deficiencies and will improve future urban canopy conditions.

Trees with the highest risk should receive priority attention. Trees recommended for removal often pose the greatest risk, especially larger dead trees in higher pedestrian or vehicular traffic areas. There are no trees identified for removal in this assessment. Proactive cyclical pruning can also identify individual tree limbs that pose a risk.

Most trees assessed require some pruning, though those with the most risk, high (1 tree) and moderate (10 trees) should be prioritized with work suggested during the winter of 2020-2021.

Trees listed for “Prune”. This list consisted of all A300 recommended pruning and would require one or more of the following:

- ***Cleaning***–Removal of all dead, crossing, and diseased branches in the trees. Crown cleaning is the industry standard for conducting a comprehensive arboricultural maintenance action on a tree.

- ***Clearance–***Pruning to reduce a range of obstructions. These included street, sidewalk, and line-of-sight clearances.

- ***Reduction–***An arboricultural practice that serves to meet a range of goals. These include reducing weight on a high-stress point or reducing building obstructions.

Tree Inspections

As noted, tree inspections provide the information to monitor and manage a tree population. Tree inspections for the assessed trees are recommended to enhance the Borough's overall vegetation management program.

Inspection Cycle. The consultant recommends a five-year cyclic inspection interval. This is a common inspection interval for a proactive urban forestry program in the United States and should apply to all Borough trees though not addressed with this assessment of 80 trees.

Inspection Type. The standard inspection should be the equivalent of an ISA Level 1–Limited Visual Inspection.

Inspection Methodology. Each Level 1 inspection should include an assessment of the trunk, scaffold branches, and crown

Inspection Scheduling. The optimum time for the inspection cycle to take place is during the summer when the trees have leaves and are fully leafed out. The optimum scheduling would have the trees that are scheduled for pruning during the forthcoming winter season be the trees scheduled for inspection during the prior summer.

- ***Structural*** – An arboricultural practice typically assigned to younger trees. The primary purpose of structural pruning is to prepare the form of the tree for its mature phase and to reduce future risk issues.

Cost Estimates

Pruning

The pruning requirements for trees at risk in the Borough can be quantified by risk rating. In this case the trees of priority are 10 moderate risk trees and one high priority tree. The sizes vary and costs will increase exponentially the greater the size (dbh) as depicted by the table below. The initial costs of pruning should be considered for an annual event with reevaluation for risk annually after.

This is not to say that trees with lower risk ratings should be ignored but the initial annual pruning costs should prioritize the moderate to high priority trees. Tree rated as low risk should also be evaluated for pruning annually.

Overall Risk by DBH - Top 10

STACKED TABULAR

SHOW ALL VALUES

Overall Risk Rating	DBH Range	Count	Percent
Low	>30in	19	23.75%
Low	18-24in	17	21.25%
Low	24-30in	17	21.25%
Low	12-18in	13	16.25%
Moderate	>30in	5	6.25%
Moderate	24-30in	3	3.75%
Low	6-12in	3	3.75%
Moderate	18-24in	2	2.50%
High	>30in	1	1.25%

Table 6 Overall risk by dbh

Diameter Distribution of Estimated Pruning Cost	
Diameter Class and cost per tree (Risk moderate-high trees)	**Cost**
19 – 24" $2000 (2)	$4,000
25 - 30" $2500 (3)	$7,500
31 - 42" $3500 (6)	$21,000
Total	$32,500

Table 7 Costs by diameter distribution

Plantings

To guarantee the long-term health and perpetuation of the urban forest, a good program must continue to plant trees on regular basis. An important element of a planting program is species diversification.

Current plant vulnerabilities exist due to increases in seasonal temperature. The temperatures then increase the likelihood of drought conditions due to increased evaporation. This puts additional stress on the tree increasing its susceptibility to pests and pathogens. Not all species will most likely thrive, however, and a broader selection of species with varying degrees of resistance to climate swings will increase the depth of an urban forest.

As with any ecosystem, species diversity within the Borough insures against a single disease or blight destroying large sections of the urban forest. The number of different high-quality species should be greatly increased and perpetuated to maximize benefits and minimize hazards. The following guidelines provide direction for developing a diverse, healthy, low-maintenance, and aesthetically improved urban forest:

- Long-term (i.e., 20-year) population targets for high-quality species should hover around 5 percent of the current tree population. The trees should be distributed over time: planted in small numbers on a regular basis. Adjustments to tree size such as selecting a smaller size and planting by in house Borough crews will lower costs. It is important to be aware that often, even with ideal initial years care, trees may be lost to unanticipated pests, disease, drought, storm damage and vandalism. It is critical to the urban forest to have a steady stream of new plantings to maintain the benefits the trees provide lower-quality species should have targets of less than 5 percent.

- The urban forest like the Borough often has a need for numerous smaller trees that minimize space occupancy. The trees occupy less space and contribute less overall to tree value and benefit given their considerably smaller canopy. Planting quantities can be adjusted on a case by case basis though an established minimum tree fund is always recommended.

Annual Planting			
Borough	**Quantity**	**2" – 2.5" cal. Annual Tree Budget**	**Totals**
Year 1	10	$ 750 each	$7,500
Year 2	10	$ 750	$7,500
Year 3	10	$ 750	$7,500
Year 4	10	$ 750	$7,500
Year 5	10		
Total	50	$ 7,500	$30,000

Table 8 Recommended Planting Quantities and Costs

- Trees should be chosen based on their moisture, soil, and light requirements and their growth rate.
- Inspect nursery stock before planting and avoid any trees with damaged trunks, poor form, or girdled roots.
- Planting sites should always be selected that maximize tree growth and health and minimize long-term infrastructure conflicts. Soil content, climate, and site size, and surrounding obstacles should be taken into consideration.
- Several species should be avoided when selecting street trees because they may have a high maintenance cost, short life expectancy, high storm damage potential, and/or a high hazard potential.
- If a uniform visual appearance is desired, choose different species that have similar forms. When selecting trees for their visual effect, consider the tree's size, texture, form, and coloring.
- Species concentrations should be monitored both at the overall university and campus levels.

- Watering at time of planting is three gallons per trunk-inch caliper.
- Basic rule of initial planting care is one year per one-inch caliper DBH.
- Maintain soil moisture during the growing season the first year or two, depending on size and soil conditions. This may be every day or once a week, depending on moisture level in the planting medium.
- Usually fertilizer and other additives (bio-stimulants, anti-transpirants are not recommended unless analysis determines otherwise,
- Mulch covering over the root ball area is recommended at two to three inches with nothing adjacent or against the trunk.

After a certain age, all trees decline and require greater maintenance. When large numbers of trees are planted within a short time, they become expensive and difficult to manage all at once. Multiple-aged stands are more desirable because they will disperse maintenance costs.

Slower-growing, longer-living trees minimize maintenance costs. Planting trees that live three times as long means spending approximately one third as much in removal costs over the same number of years. In general, the same slower-growing trees are higher quality and demand less pruning over their lifetime.

Finally, most urban trees have little utilization potential after their removal. Some underused species, such as swamp white oak, provide an opportunity to divert wood from the waste stream when the tree is removed. There are growing opportunities for converting resilient hardwood trees into high-quality firewood or low- and medium-grade lumber for the large secondary-wood industry in the Connecticut area. This activity also introduces a possibility of generating revenue.

The following plants are listed as invasive and should not be planted. That being said, the benefits of a large, existing invasive tree producing environmental benefits such as cooling, pollution capture, oxygen production, stormwater capture, and carbon storage and sequestration, can outweigh the negative aspect of invasive plants, including their having a competitive advantage over desirable trees, and often too self-propagating.

Connecticut Invasive Tree List

Amur maple (*Acer ginnala*)
Norway maple (*Acer platanoides*)
Sycamore maple (*Acer pseudoplatanus*)
Tree-of-Heaven (*Ailanthus altissima*)
Princess tree (*Paulownia tomentosa*)
White poplar (*Populus alba*)
Black locust (*Robinia pseudoacacia*)

GLOSSARY

10-20-30 guideline for planting a diverse urban forest wherein a single species should make up no more than 10 percent of the tree population, a single genus no more than 20 percent, and a single family no more than 30 percent (Santamour, 1990)

absorbing roots – fine, fibrous roots that take up water and minerals. Most absorbing roots are within the top 12 inches (30cm) of soil. (ISA, 2010).

acceptable risk – a degree of risk that is within the tolerance or threshold of the owner, manager, or controlling authority. (ISA, 2011).

adaptability – genetic ability of plants and other living organisms to adjust or acclimate to different environments. (ISA, 2010).

ANSI A300 – in the United States, industry-developed, national consensus standards of practice for tree care. (ISA, 2010).

ANSI Z133.1 – in the United States, industry-developed, national consensus standards of practice for tree care. (ISA, 2010).

approved – in the contest of guidelines, standards, and specifications, that which is acceptable to federal, state, provincial, or local enforcement authorities or is an accepted industry practice. (ISA, 2010).

arboriculture – practice and study of the care of trees and other woody plants in the landscape. (ISA, 2010).

available water – water remaining in the soil after gravitational water has drained and before the permanent wilting point has been reached. Compare to *field capacity*, *gravitational water*, and *permanent wilting point*. (ISA, 2010).

balled and burlapped (B&B) – tree or other plant dug and removed from the ground for replanting, with the roots and soil wrapped in burlap or a burlap -like fabric. Contrast with *bare root*, *container grown*, and *containerized*. (ISA, 2010).

basic assessment (Level 2) - detailed visual inspection of a tree and surrounding site that may include the use of simple tools. It requires that the assessor inspect completely around the tree trunk looking at the visible aboveground roots, trunk, branches, and site.

best management practices (BMPs) – best-available, industry-recognized courses of action, in consideration of the benefits and limitations, based on scientific research and current knowledge. (ISA, 2010).

buttress roots – roots at the trunk base that help support the tree and equalize mechanical stress. (ISA, 2010).

canker – localized disease area on stems, roots, and branches. Often shrunken and discolored. (ISA, 2010).

carbon sequestration – capturing and long-term storage of carbon. Most often used about the capturing of atmospheric carbon dioxide through biological, chemical, or physical processes. Trees sequester carbon through photosynthesis. (ISA, 2010).

cavity – open or closed hollow within a tree stem, usually associated with decay. (ISA, 2010).

codominant stems – forked stems nearly the same size in diameter, arising from a common junction and lacking a normal branch union. (ISA, 2010).

compaction – see *soil compaction*. (ISA, 2010).

conk – fruiting body or nonfruiting body (sterile conk) of a fungus. Often associated with decay. (ISA, 2010).

consequences – outcome of an event affecting objectives (ISO, 2018). Effects or outcome of an event. In tree risk assessment, consequences include personal injury, property damage, or disruption of activities or services due to the event (ISA, 2011).

containerized – field grown plant placed into a container for a time and then sold as a potted plant. Term does not include a plant initially grown in a container. Contrast with *balled and burlapped, bare root.* (ISA, 2010).

crown cleaning – in pruning, the selective removal of dead, dying, diseased, and broken branches from the crown. (ISA, 2010).

data – facts and statistics collected for reference or analysis

data point – an identifiable element in a data set

diameter at breast height (dbh) – a U.S. custom means of expressing a diameter of a tree, as measured 4.5 feet (or 1.37 m) above the ground. (ISA 2019).

diameter tape – a diameter tape (D-tape) is used by foresters to measure the diameter of a tree. Since trees are swelled at the base, measurements are made 4.5 feet above the ground to give an average diameter estimate.

decay – (1) (*noun*) an area of wood that is undergoing decomposition. (2) (*verb*) decomposition of organic tissues by fungi or bacteria. (ISA, 2010).

deciduous – tree or other plant that sheds all its leaves according to a genetically scheduled cycle as impacted by climate factors (usually during the cold season in temperate zones). Contrast with *evergreen*. (ISA, 2010).

defoliation – loss of leaves from a tree or other plant by biological or mechanical means. (ISA, 2010).

dieback – condition in which the branches in the tree crown die from the tips toward the center. (ISA, 2010).

drought– A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term (see Box 3-3), therefore any discussion in terms of precipitation deficit must refer to the precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture)

duty of care – legal obligation that requires an individual to use a reasonable standard of care when performing tasks that may potentially harm others. (ISA, 2010).

event – occurrence of a set of circumstances (ISA, 2018).

failure potential – in tree risk assessment, the professional assessment of the likelihood for a tree to fail within a defined period. (ISA, 2010).

foliage – leaves of a plant. (ISA, 2010).

fruiting body – reproductive structure of a fungus. The presence of certain species may indicate decay in a tree. See *conk*. (ISA, 2010).

gall – abnormal swelling of plant tissues caused by gall wasps, mites, nematodes, and various insects and less commonly by fungi or bacteria. (ISA, 2010).

genus – taxonomic group, composed of species having similar fundamental traits. Botanical classification under the family level and above the specific epithet level. (ISA, 2010).

geographic information system (GIS) – computer application used to store, view, and analyze geographic information typically maps. (ISA, 2010).

girdling roots – root that encircles all or part of the trunk of a tree or other roots and constricts the vascular tissue and inhibits secondary growth and the movement of water and photosynthates. (ISA, 2010).

growth rate – speed at which something grows. (ISA, 2010).

habit – characteristic form or manner of growth. (ISA, 2010).

hardiness – genetically determined ability of a plant to survive low temperatures. (ISA, 2010).

hardscape – constructed inanimate elements of a landscape, such as walls, pathways, and seats made of wood, stone, and/or other materials. (ISA, 2010).

hazard – a situation or condition that is likely to lead to a loss, personal injury, property damage, or disruption of activities or services, a likely source of harm. In relation to trees, a hazard is the tree part(s) identified as a likely source of harm (ISA, 2011).

hazard tree – a tree, or tree part, identified as a likely source of significant harm (ISA, 2011).

inspection interval – time between inspections (ISA, 2011).

i- Tree – suite of software products and management tools that allows the user to inventory the urban forest and analyze its costs, benefits, and management needs. (ISA, 2010).

included bark – bark that becomes embedded in a crotch (union) between branch and trunk or between codominant stems. Causes a weak structure. (ISA, 2010).

liability – something for which one is responsible. Legal responsibility. (ISA, 2010).

likelihood – chance of something happening (ISO, 2018). Within the ISO narrative, the word "likelihood" is used "to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically." The term "probability" while often having a narrower definition in English is considered an equivalent term for the purposes of the ISO narrative.

limited visual assessment (Level 1) – a visual assessment from a specified perspective such as foot, vehicle, or aerial patrol of an individual tree or a population of trees near specified targets to identify conditions or obvious defects of concern (ISA, 2017).

lion tailing (lion's tailing) – poor pruning practice in which an excessive number of branches are thinned from the inside and lower part of specific limbs or a tree crown, leaving mostly terminal foliage. Results in poor branch taper, poor wind load distribution, and a higher risk of branch failure. (ISA, 2010).

load – (1) general term used to indicate the magnitude of a force, bending movement, torque, pressure, etc. applied to a substance or material. (2) cargo; weight to be borne or conveyed. (ISA, 2010).

mitigation – in tree risk management, reducing, alleviating, or minimizing risk of harm (damage or injury). (ISA, 2010).

monitoring – keeping a close watch. Performing regular checks or inspections. (ISA, 2010).

pathogen – causal agent of disease. Usually refers to microorganisms. (ISA, 2010).

permit – written order granting permission to do something. (ISA, 2010).

phloem – plant vascular tissue that transports photosynthates and growth regulators. Situated on the inside of the bark, just outside the cambium. Is bidirectional (transports up and down). Contrast with *xylem*. (ISA, 2010).

prevention – proactive process intended to guard against adverse impact by avoiding or reducing the risk of its occurrence. (ISA, 2010).

raising – selective pruning to provide vertical clearance. (ISA, 2010).

reduction – pruning to decrease height and/or spread of a branch or crown. (ISA, 2010).

risk – (1) The uncertainty of a result, happening, or loss; the chance of injury, damage, or loss (Black, 2009). - effect of uncertainty on objectives (ISO, 2018).
The ISO provides several relevant considerations to this definition. These include: "An effect is a deviation from the expected. It can be positive, negative or both, and can address, create or result in opportunities and threats." And "risk is usually expressed in terms of risk sources, potential events, their consequences and their likelihood. the

combination of the likelihood of an event and the severity of the potential consequences." (ISA, 2011).

risk, inherent – (2) A common risk that people bear whenever they decide to engage in a certain activity (Black, 2009).

risk analysis – the systematic use of information to identify sources and to estimate risk exposure (ISA, 2011).

risk assessment – process of evaluating what unexpected things could happen, how likely they are to happen, and what the likely outcomes are. In tree management, the systematic process to determine the level of risk posed by a tree, tree part, or group of trees. (ISA, 2010) and/or the process of risk identification, analysis, and evaluation (ISA, 2011).

risk evaluation – the process of comparing the assessed risk against given risk criteria to determine the significance of the risk (ISA, 2011).

risk management – coordinate activities to direct and control an organization about risk (ISO, 2018). The application of policies, procedures, and practices used to identify, evaluate, mitigate, monitor, and communicate risk (ISA, 2011).

root ball – soil containing all (e.g. containerized) or a portion (e.g., B&B) of the roots that are moved with a plant when it is planted or transplanted. (ISA, 2010).

root collar/root crown excavation – process of removing soil to expose and assess the root collar (root crown) of a tree. (ISA, 2010).

root crown – area where the main roots join the plant stem, usually at or near ground level. Root collar. (ISA, 2010).

runoff – that part of precipitation that does not evaporate and is not transpired but flows through the ground or over the ground surface and returns to bodies of water.

rust – disease caused by a certain group of fungi and characterized by reddish brown spots on the foliage and/or the formation of stem galls. (ISA, 2010)

sapwood – outer wood (xylem) is active in longitudinal transport of water and minerals. (ISA, 2010).

scaffold branches – permanent or structural branches that form the scaffold architecture or structure of a tree. (ISA, 2010).

shall – word that designates a mandatory requirement within the ANSI standards or contract documents. Contrast with *should.* (ISA, 2010).

should – word that designates an advisory recommendation in the ANSI standards or contract documents. Contrast with *shall.* (ISA, 2010).

sign – physical evidence of a causal agent (e.g. insect eggs, borer hole, frass). Contrast with *symptoms*. (ISA, 2010).

site considerations – factors that must be considered when assessing a site for planting, tree conservation, or preservation or any operation. (ISA, 2010).

soil compaction – compression of the soil, often because of vehicle or heavy-equipment traffic, that breaks down soil aggregates and reduces soil volume and total pore space, especially macropore space. (ISA, 2010).

soil moisture - water stored in or at the land surface and available for evapotranspiration. (ISA, 2010)

species – taxonomic group of organisms composed of individuals of the same genus that can reproduce among themselves and have similar offspring. (ISA, 2010).

species diversity – measure of the number and variety of different species found in each area. (ISA, 2010).

specifications – detailed plans, requirements, and statements of procedures and/or standards used to define and guide work. (ISA, 2010).

stakeholder – person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity (ISO, 2018).

standard of care – in the law of negligence, the degree of care that a reasonable person should exercise (Black, 2009).

stormwater runoff – water originating from precipitation (rain or melting snow and ice) that flows above ground rather than infiltrating into the soil. May occur if soils are frozen or saturated or if the rate at which precipitation falls is greater than the infiltration rate of a soil. (ISA, 2010).

structural defects – any naturally occurring or secondary conditions such as cavities, poor branch attachments, cracks, or decayed wood in the trunk, crown, or roots of a tree root growth. (ISA, 2010).

structural pruning – pruning to establish a strong arrangement or system of scaffold branches. (ISA, 2010).

sustainability – the ability to maintain ecological, social, and economic benefits over time. (ISA, 2010).

symptom – plant reaction to disease or disorder (e.g. wilting, dieback). Contrast to *sign*. (ISA, 2010).

systemic – (1) substance that moves throughout an organism after it is absorbed. (2) any condition, disease, disorder, pest that affects the entire organism. (ISA, 2010).

taper – change in diameter over the length of trunks, branches, and roots. (ISA, 2010).

target – people, property, or activities or services that could be injured, damaged, or disrupted by a tree or tree part (ISA, 2011).

target zone – the area where a tree or tree part is likely to land if it were to fail (ISA, 2011).

thinning – in pruning, the selective removal of live branches to provide light or air penetration through the tree or to lighten the weight of the remaining branches. (ISA, 2010).

tomogram – image generated by tomography. Created by sending waves through an object; a computer then produces images of cross sections of the object by using information about how the waves change. (ISA, 2010).

topping – inappropriate pruning technique to reduce tree size. Cutting back a tree to predetermined crown limit, often at internodes. (ISA, 2010).

tree inventory – record of each tree within a designated population; typically includes species, size, location, condition, and maintenance requirements. (ISA, 2010).

tree protection zone (TPZ) – defined area within which certain activities are prohibited or restricted to prevent or minimize potential injury to designated trees, especially during construction or development. (ISA, 2010).

tree risk assessment – a systematic, technical process used to identify, analyze, and evaluate the risk associated with a singular tree (ISA, 2011).

trenching – linear, open excavation, often used to install utilities or structural footings. Can cause tree root damage. (ISA, 2010).

trunk flare – transition zone from trunk to roots where the trunk expands into the buttress or structural roots. Root flare. (ISA, 2010).

urban forestry – management of naturally occurring and planted trees and associated plants in urban areas. (ISA, 2010).

urban heat island - the relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols, and so on.

vigor – overall health. Capacity to grow and resist stress. Sometimes limited to reference to genetic capacity. (ISA, 2010).

visual tree assessment (VTA) – method of assessing the structural integrity of trees using external symptoms of mechanical stress (such as bulges, reactive growth, etc.) and defects (cracks, cavities, etc). (ISA, 2010).

xylem – main water- and mineral-conducting (unidirectional, up only) tissue in trees and other plants. Provides structural support. Arises (inward) from the cambium and becomes wood after lignifying. Contrast with *phloem*. (ISA, 2010).

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APPENDIX 1. RECOMMENDED PLANTINGS

SMALL TREES = UP TO 30', MEDIUM TREES = UP TO 50', LARGE = OVER 50'

Common Name	Scientific Name	Zone	Height (Ft)	Width (Ft)	Native	Utility Line Compatible	Notably Urban	Candidate for Assisted Migration	Page #
White Fir	*Abies concolor*	4A	30-50	15-30	✓				17
Trident Maple	*Acer buergerianum*	5B	20-30	15-25		✓	✓		18
Hedge Maple	*Acer campestre*	5A	25-35	25-35			✓		19
Paperbark Maple	*Acer griseum*	5A	20-30	20-30		✓			20
Miyabe Maple	*Acer miyabei*	4B	30-45	30-40					21
Red Maple	*Acer rubrum*	3B	40-60	30-70	✓		✓		22
Sugar Maple	*Acer sacharrum*	3B	60-75	35-50	✓				23
Purpleblow Maple	*Acer truncatum*	4B	25-30	25-30		✓	✓		24
Freeman Maple	*Acer* x *freemanii*	4A	40-75	Varies	✓				25
Red Horsechestnut	*Aesculus* x *carnea*	5A	30-50	30					26
Serviceberry	*Amelanchier* spp.	4A	15-25	15-30	✓	✓			27
River Birch	*Betula nigra*	4A	40-70	40-60	✓				28
Common Hornbeam	*Carpinus betulus*	5A	35-60	30-40					29
American Hornbeam	*Carpinus caroliniana*	3A	20-30	20-30	✓	✓			30
Northern Catalpa	*Catalpa speciosa*	4A	40-60	20-40	✓		✓		31
Sugar Hackberry	*Celtis laevigata*	5A	60-80	50	✓		✓	✓	32
Common Hackberry	*Celtis occidentalis*	3A	40-60	40-60	✓		✓	✓	33
Katsura Tree	*Cercidiphyllum japonicum*	4A	40-60	25-60					34
Eastern Redbud	*Cercis canadensis*	4A	20-30	25-35	✓	✓	✓	✓	35
Atlantic White Cedar	*Chamaecyparis thyoides*	4B	40-60	10-20	✓				36

White Fringetree	*Chionanthus virginicus*	5A	15-25	10-25	✓	✓	✓		37
Yellowwood	*Cladrastis kentukea*	4A	30-50	40-55	✓				38
Japanese Clethra	*Clethra barbinervis*	5B	10-20	10-20		✓			39
Kousa Dogwood	*Cornus kousa*	5A	15-30	15-30		✓			40
Corneliancherry Dogwood	*Cornus mas*	5A	15-25	15-20		✓			41
Dogwood Hybrids	*Cornus* x *rutgersensis*	5A	10-20	10-20		✓		✓	42

Common Name	**Scientific Name**	**Zone**	**Height (Ft)**	**Width (Ft)**	**Native**	**Utility Line Compatible**	**Notably Urban**	**Candidate for Assisted Migration**	**Page #**
Turkish Filbert	*Corylus colurna*	4A	40-50	15-35			✓		43
American Smoketree	*Cotinus obovatus*	4A	20-30	15-30	✓	✓	✓		44
Thornless Cockspur	*Crataegus crusgalli* var. *inermis*	4A	20-30	20-35	✓	✓	✓		45
'Winter King' Hawthorn	*Crataegus virdis* 'Winter King'	4A	25	25	✓	✓	✓		46
Hardy Rubber Tree	*Eucommia ulmoides*	5A	40-60	40-60			✓		47
Gingko	*Gingko biloba*	4B	50-80	30-40			✓		48
Thornless Honeylocust	*Gleditsia triacanthos* var. *inermis*	4B	40-60	30-70	✓		✓		49
Kentucky Coffeetree	*Gymnocladus dioicus*	3A	50-75	40-50	✓		✓		50
Carolina Silverbell	*Halesia carolina*	5A	20-40	20-35	✓				51
Witchhazel	*Hamamelis virginiana*	4A	10-30	15-20	✓	✓			52
Eastern Red Cedar	*Juniperus virginiana*	3B	40-50	8-20	✓		✓	✓	53
Goldenraintree	*Koelreuteria paniculata*	5A	30-40	30-40			✓		54

American Sweetgum	*Liquidambar styraciflua*	5B	50-75	40-65	✓			✓	55
Tuliptree	*Liriodendron tulipifera*	5A	70-90	35-50	✓			✓	56
Amur Maackia	*Maackia amurensis*	4A	20-30	20-30		✓	✓		57
Thornless Osage Orange	*Maclura pomifera* var. *inermis*	5B	20-50	20-50	✓		✓	✓	58
Flowering Crabapple	*Malus* spp.	4B	10-25	10-25		✓			59
Dawn Redwood	*Metasequoia glyptostroboides*	5A	70-100	25-50					60
Black Gum	*Nyssa sylvatica*	4A	30-60	20-40	✓				61
American Hophornbeam	*Ostrya virginiana*	4A	25-40	20-40	✓				62
Persian Parrotia	*Parrotia persica*	5A	20-30	15-30		✓	✓		63
Serbian Spruce	*Picea omorika*	4B	50-60	20-25					64
Swiss Stone Pine	*Pinus cembra*	4A	30-40	15-25					65
London Planetree	*Platanus* x *acerifolia*	5A	70-100	65-80			✓		66
Accolade Cherry	*Prunus* 'Accolade'	5A	20-30	15-25		✓			67
Common Hoptree	*Ptelea trifoliata*	4A	15-20	15-20	✓	✓			68

Common Name	**Scientific Name**	**Zone**	**Height (Ft)**	**Width (Ft)**	**Native**	**Utility Line Compatible**	**Notably Urban**	**Candidate for Assisted Migration**	**Page #**
White Oak	*Quercus alba*	4A	45-80	45-80	✓			✓	69
Swamp White Oak	*Quercus bicolor*	4A	45-70	45-60	✓		✓		70
Scarlet Oak	*Quercus coccinea*	5A	60-75	40-50	✓			✓	71
Shingle Oak	*Quercus imbricaria*	4A	40-60	40-65	✓			✓	72
Bur Oak	*Quercus macrocarpa*	3A	60-80	60-90	✓		✓	✓	73
Chestnut Oak	*Quercus montana*	5A	60-70	60-70	✓			✓	74

Chinkapin Oak	*Quercus muehlenbergii*	4B	35-50	35-60	✓			✓	75
Pin Oak	*Quercus palustris*	4A	50-70	25-40	✓				76
Willow Oak	*Quercus phellos*	6A	40-60	40-60	✓		✓	✓	77
English Oak	*Quercus robur*	5A	40-60	40-60			✓		78
Northern Red Oak	*Quercus rubra*	4A	60-75	60-75	✓		✓		79
Shumard Oak	*Quercus shumardii*	5B	40-60	45-65	✓		✓		80
Common Sassafras	*Sassafras albidum*	4B	30-60	25-40	✓				81
Japanese Umbrella Pine	*Sciadopitys verticillata*	5B	20-30	15-20		✓			82
Japanese Pagodatree	*Styphnolobium japonicum*	5A	50-70	35-55			✓		83
Japanese Tree Lilac	*Syringa reticulata*	3A	20-30	15-25		✓	✓		84
Bald cypress	*Taxodium distichum*	5A	50-70	20-40	✓		✓	✓	85
Arbor vitae	*Thuja occidentalis*	3A	40-60	10-15	✓		✓		86
American Linden	*Tilia americana*	3A	60-80	20-40	✓				87
Littleleaf Linden	*Tilia cordata*	3B	50-70	30-50					88
Silver Linden	*Tilia tomentosa*	5A	50-70	25-55			✓		89
American Elm Cultivars	*Ulmus americana*	3B-5A	60-80	30-60	✓		✓		90
Lacebark Elm	*Ulmus parvifolia*	5B	40-75	30-75			✓		91
Elms Hybrids	*Ulmus* x spp.	3B-5A	50-70	40-60			✓		92
Siebold Viburnum	*Viburnum sieboldii*	4B	15-20	10-15		✓			93
Japanese Zelkova	*Zelkova serrata*	5A	50-80	40-60			✓		94

1.1 Tree species

A comprehensive, broad-based literature review was undertaken to decide which tree species would be included in Planting for Resilience: Selecting Urban Trees in Massachusetts. This began by determining which trees were recommended in other selection guides produced by university extension programs, state agencies, and the industry (i.e., nurseries). Once an initial list relevant to growing conditions in the Northeast was composed, characteristics and attributes of each tree (i.e., preferred environmental conditions, site adaptability, optimal growing conditions) were assessed. This information was gathered from not only the aforementioned selection guides, but tree identification books, encyclopedias, and online resources generated from various stakeholders (see pages 104-106).

Individual tree species were carefully scrutinized and eliminated based on invasive potential (i.e., *Robinia pseudoacacia*), pest susceptibility (i.e., *Fraxinus* spp., *Sorbus* spp.), management considerations (i.e., *Pyrus calleryana*) and overall compatibility to adverse urban environments (i.e., *Acer saccharinum, Pinus strobus*).Tree species' sensitivity and adaptability to common stress factors found in the urban environment (i.e., alkaline soil, drought, heat, salt, pollution, poorly drained soils, mechanical damage), were specifically considered; from there, current and future habitat suitability was analyzed in an attempt to ensure that remaining tree species would be well-adapted to future climate projections of the Northeast (see Methods 1.5).

1.2 Criteria

Tree species data is often anecdotal, based on observations of industry professionals, agency/university specialists and tree enthusiasts from the public. Discrepancies concerning tree attributes and characteristics often occurred between reference materials. Thus, consistency and agreement among sources was an important consideration relevant to determining the information that was deemed acceptable to include. Generally, information presented in this guide has been verified by at least two other references. Though no single claim or piece of information was casually dispensed with, a hierarchy of trust was established where isolated claims and observations in sole sources were not included to conservatively consider discrepancies. For example, the "highest" or most conservative hardiness zone rating found in the literature for each species was listed on their profile, if it could be verified by two or more sources. This was done so that a tree would not be planted in a zone that would be too cold, beyond what it could tolerate. A range was presented regarding each tree species' height and width, that generally included the smallest and largest values found in the literature.

1.3 Limitations

Urban forestry is a relatively new field of study, and unlike traditional forestry where trees have been studied and observed for many centuries, there is a dearth of data concerning the growth and response of trees in our expanding towns and cities. Climatic projections themselves also vary. Being such long-lived organisms, trees may not perform as predicted relative to their response to shifting habitat suitability, over extended periods of time.

1.4 Urban tree suitability

"Urban" tree species must be able to tolerate a host of difficult conditions including soils that often feature extreme pH, prolonged periods of dryness, salt, pollution, and poor drainage. Although not all species here are well-suited for tough, urban sites, we highlight species (using an icon in the top corner of its profile page) that are notably adaptable to these adverse conditions. Some references (Dirr, University of Connecticut, Cornell University) presented a list of species that were recommended to plant in tough, urban sites, which were considered.

APPROACH

1.5 Trees and assisted migration

This table displays our interpretation of data obtained from the US Forest Service10,20. This data set was specific to Massachusetts, and was divided into 1° latitude x 1° longitude sectors, which essentially coincide with what is considered western, central, and eastern Massachusetts. Species marked with * were not included in this data set. but were found in the US Forest Service's Climate Change Tree Atlas. Highlighted species are projected to gain habitat suitability, therefore were chosen as 'Candidates for assisted migration'.

Model reliability

1= most reliable, 3= least reliable.

Current abundance

Tree species abundance varies across the state, due to numerous factors. To determine each species' mean state-wide current abundance, we averaged the data from the three sectors of Massachusetts by assigning a value to each abundance class [0: absent; 1: rare; 2: common; 3: abundant].

Changes in habitat suitability
Possible change in habitat suitability by 2100 according to the ratios of future (2070-2099) suitable habitat for an average of 3 climate models to current (1981-2010) modeled habitat at RCP4.5 (low emissions) and RCP8.5 (high emissions) scenarios. This does not necessarily mean the species' *abundance* will change in the area by 2100, only that the habitat is expected to change in suitability for that species over time. Further, it is important to note that this data is not specific to urban environments, meaning these projections may differ in the urban forest. To determine each species' mean state- wide change in habitat suitability, we averaged data from the three sectors of Massachusetts by assigning a value to each change class [-3: extirpated; -2: large decrease; -1: small decrease; 0: no change, unknown; +1: small increase; +2: large increase; +3: new habitat].

Adaptability
This score is based on a literature review of 12 disturbance (i.e., disease, drought, pollution) and 9 biological characteristics (i.e., shade tolerance, seedling establishment, environmental habitat specificity) for each species. It aims to account for factors that may affect how a species will respond to climate change that the models do not take into consideration. Scores have been classified as High (5.2-9.0), Medium (3.4-5.1), and Low (0.1-3.3). However, these scores may differ based on specific location-based factors. (McElhinney, 2019)