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APPENDIX A: SPECIES CLASSIFICATION METHODOLOGY

Summary

Using multispectral 2018 satellite imagery, augmented with 2018 LiDAR data, the tree canopy extent in the City of Cambridge was mapped and its tree species components classified. The mapping and classification project, with ground-truthing and other quality control measures, required the use of eCognition, an object-based classification tool, as well as processing of LiDAR data, and additional processing using ArcGIS and the Orfeo Toolbox. The mapping and classification process resulted in an overall accuracy in the classification of the tree species in Cambridge's forest canopy of 97.1 percent. Details of the methods used are presented below.

Mapping and Species Classification Method

With the goal of mapping the extent and species composition of the current Cambridge forest canopy, AES used recent multispectral satellite imagery and LiDAR data. Satellite imagery is essential for mapping forest canopy extent and tree species classification, while LiDAR data are used to augment the mapping and classification process.

Multi-spectral satellite imagery and LiDAR data were obtained for the year 2018. First, each satellite image was georeferenced to the base ArcGIS data obtained from the City of Cambridge using a minimum of 30 tie points for each satellite image. The georeferenced raw satellite data were then converted to represent atmospheric reflectance using the Optical Calibration tool in the Orfeo Toolbox version 6.4.0. Next, the LiDAR data were incorporated in the GIS dataset. Since the LiDAR data received were unclassified, AES created a LiDAR data exchange (or LAS file) dataset from the raw LiDAR data. From this, a digital terrain model (DTM) and a digital surface model (DSM) were created. A DTM models the elevation of the general land surface and a DSM gives the height of surface features, such as buildings and trees. The DTM is then subtracted from the DSM to obtain canopy heights at the same resolution as the satellite imagery (0.46 meters). This process produced a rasterized map of canopy height. The canopy height data, in raster form, along with satellite imagery were imported into eCognition software for classification.

Individual tree detection and species classifications were accomplished using a process termed "multi-resolution segmentation". Segmentation is a computing process that groups pixels in the satellite image-LiDAR raster data based on similar values within the raster data. Segmentation creates "objects"—hence the term for this method, "object-oriented classification"—which internally are relatively homogeneous. The segmentation process works in a similar way to how eyes and the brain process visual data, by recognizing objects that have edges and are internally a single thing. The size of the resulting groups of pixels is dependent on predefined parameters of scale, shape, and compactness. The eCognition software was used instead of ArcGIS's segmentation tool because it allows greater flexibility in the classification parameters that are optimally used for best classification results. For example, with eCognition, trees can be delineated by their spectral signature, shape, height, and density. ArcGIS's capabilities do not offer this flexibility.

Once individual trees are delineated—that is, their boundaries defined—the average value of each object, in terms of all reflectance bands in each satellite image together with the canopy height rasters (from LiDAR), is exported from eCognition and imported into ArcGIS for final classification. The resulting objects are examined and manually processed further, mostly in two ways. Some objects were combined, such as isolated branches protruding from the main canopy of a large oak tree. Some objects were divided, such as a dense grove of maples with intersecting canopies.

After this processing, the objects were classified into tree species by using both an unsupervised and supervised classification. The thousands of objects were provisionally classified into 65 broad groups, a standard approach to begin a classification process of many objects. After that, each broad group was further divided into 30 subgroups using unsupervised classification. In an unsupervised classification, the software splits objects into a predefined number of groups based on the band reflectance and canopy height using a nearest-neighbor statistical approach. The number of broad groups and subgroups was determined by examining the statistical distribution of the tree object values in the entire tree object dataset for each of the broad groups and subgroups. This resulted in 1,950 subgroups. Each subgroup was then classified into unique tree species using a supervised classification method. In a supervised classification, the software is "taught" to recognize a specific class of objects in the satellite image by manually associating the location of a known object with the object class characteristics; these locations are called training sites. The training sites are then used as a reference to classify all other objects in the satellite image. Specifically, the training sites were a selection of the tree subgroups that belonged to a particular tree species.

To determine the tree species for a training site, AES used a "learning set" of trees that were identified and mapped on the ground by Certified Master Arborists at Bartlett Tree Experts. (Bartlett sampled five percent of the City's surface area, generating a large data learning set for the classification.) This process resulted in the aggregation of subgroups into a classification of 153 unique tree species, consistent with the number of tree species identified in the Bartlett sample. The reduction in the number of subgroups from 1,950 to 153 was expected because a single tree species could occur in many subgroups due to small differences in leaf reflectivity, tree height,

canopy size, and tree health. The supervised classification process allowed AES to combine subgroups of the same tree species despite small differences in source data and produce the final tree species classification.

After the classification was completed, the classified tree species raster was converted to polygons for spatial analysis—species summaries, neighborhood statistics, change analysis, and other analyses—and then ground-truthed to improve mapping and classification accuracy.

A major challenge when using multi-spectral imagery and LiDAR data to create a classification is the issue of parallax often associated with satellite imagery. Parallax is the displacement in the apparent position of an object (tree, building, etc.) due to the satellite viewing angle. The greater the viewing angle, the more parallax in the imagery. Because LiDAR data are obtained from a nadir point of view (i.e., straight down) and satellite imagery typically is taken at an angle, trees and buildings are often displaced from their actual position in satellite imagery and do not match the position mapped in LiDAR data. Due to parallax, a satellite image may detect a tree at a slightly different location than identified by LiDAR, a building in satellite imagery may conceal some or all of a tree's canopy, or small trees may be obscured by nearby larger trees. The last two problems eliminated portions of the canopy that would have been included in the canopy mapping if no buildings were present. For trees that were previously concealed due to the parallax issue in the satellite imagery, a small fraction was manually digitized by AES using LiDAR data and the tree identity confirmed by visually inspecting imagery from the National Agriculture Imagery Program (NAIP) and Google Earth. The manually digitized tree canopy and species identification was only performed when tree species, such as Callery pear or thornless common honeylocust, were readily apparent in the NAIP and Google Earth imagery. These additional imagery datasets also served as a means of confirming the existence of trees at locations where their existence may have been obscured.

Neither NAIP nor Google imagery can be used in a supervised classification, however. NAIP imagery consists only of red-green-blue (RGB) radiation bands, which is not enough information to create a classification. NAIP lacks the infrared (IR) band, for instance, which is a drawback in classification work. Google Earth imagery consists of RGB radiation bands and also the IR band in select locations. However, Google Earth imagery is proprietary and therefore not available unless one is under contract with Google.

A second challenge was impervious cover that was classified as tree canopy cover. The appearance of vegetation where there was actually impervious cover was due to potted plants on rooftops and flowering/vegetated baskets hanging on street lights, among other reasons. These "false positive" tree canopies were corrected by manually examining the tree canopy layer with NAIP and Google Earth imagery and removing the erroneous tree canopy from the final tree species classification dataset.

The tree classification was ground-truthed to improve its accuracy. A Trimble GPS unit was used to locate trees of known identity that had been identified on the ground by the City of Cambridge or by the arborists at Bartlett Tree Experts. The City data were part of its continuous tree inventory efforts, and the 2018 Bartlett data were from a five percent sampling of the Cambridge forest canopy.

Field-checking was completed at locations where:

the city tree inventory data indicated a tree was present but canopy mapping by AES did not identify a tree at that location;

the tree canopy was sparse;

the tree canopy was dense;

trees were growing beneath a higher canopy; and

problematic features existed, such as high-hanging vegetation baskets on street corners, which appeared to be trees from a satellite's perspective.

Ground-truthing detected differences in tree presence, species identity, and tree location between the City and Bartlett data sets. AES assumed that the Bartlett data were more accurate than City data because Bartlett's five percent sample was more recently collected, and its tree identities were confirmed by two expert arborists.

Data obtained in these quality control measures, including ground-truthing, were incorporated into ArcGIS to improve the mapping and classification accuracy. The classification accuracy—that is, whether the classification correctly identified a tree species at a specific location—was determined by comparing trees in Bartlett's five percent sample with trees in AES's classification. Tree species encountered in Bartlett's survey and AES's classification were arrayed along x and y axes of a correct/incorrect identification matrix. For example, if a London plane tree was correctly classified by both Bartlett's survey and AES's classification, the matrix cell corresponding to London plane tree in both the Bartlett survey and AES classification was marked. This represented a correct classification of a tree species at a specific location. A total of 1,024 trees from the Bartlett survey were used to check the tree species classification. The number of correct classifications for a species was divided by the total number of trees of that species in the sample, and the classification accuracy for that species was expressed as a percent of all trees correctly classified. A similar exercise was completed for all trees in the sample. The refinements in mapping and classification resulted in an overall classification accuracy of 97.1 percent. The accuracy check also showed that species that were more common had higher accuracies than those that were rare.

APPENDIX B: CURRENT FOREST COMPOSITION SUMMARY FROM SPECIES CLASSIFICATION

LAND USE CALCULATIONS - AES

Land Use Type	2018 Acres of Land Use Overall	Total Canopy Acres (2018)	% canopy cover within that land use type	% of total canopy	% of land use as % of total area		
ROW	812	229.3	28.2%	22%	20%	3.54	0.282389163
Commercial	452	46	10%	4%	11%	9.83	0.101769912
Industrial	216	21.5	10%	2%	5%	10.05	0.099537037
Institutional	436	86.3	20%	8%	11%	5.05	0.19793578
Open Space	521	227.14	44%	22%	13%	2.29	0.43596929
Public	128	22.6	18%	2%	3%	5.66	0.1765625
Residential	1501	409.4	27%	39%	37%	3.67	0.272751499
Over water (mostly open space)		13.76				0.00	
TOTAL	4066	1056					
all public	1245	421.3	0.338393574				
Public open space	433	192					

Per CDD, 4087 total land area in Cambridge

2009-2018 canopy change

Land Use Type	tree loss (gross) acres	% canopy change	% canopy loss by land use area	tree gain (gross)	% tree gain	% tree gain by total land use area	net change (acres)		% net change
ROW	71.2	31.1%	8.8%	59.2	25.8%	7.3%	-12	7%	-5.2%
Commercial	20.7	45.0%	4.6%	15.6	33.9%	3.5%	-5.1	3%	-11.1%
Industrial	10.7	49.8%	5.0%	5.6	26.0%	2.6%	-5.1	3%	-23.7%
Institutional	35.2	40.8%	8.1%	18.2	21.1%	4.2%	-17	10%	-19.7%
Open Space	47.4	20.9%	9.1%	42.3	18.6%	8.1%	-5.1	3%	-2.2%
Public	7	31.0%	5.5%	5.8	25.7%	4.5%	-1.2	1%	-5.3%
Residential	200	48.9%	13.3%	80.8	19.7%	5.4%	-119.2	72%	-29.1%
Over water (mostly open space)									
TOTAL	392.2			227.5			-164.7		

67.5

16.47

CANOPY LOSS STATS

Cambridge Forest Change Statistics by Time Period

Time Period	Canopy Area at Start of Period (ac.)	Canopy Polygon Area Lost in Period (ac.)	Canopy Polygon Area Gained in Period (ac.)	Canopy Area of No Polygon Change in Period (ac.)	Canopy Loss Minus Canopy Gain in Period (ac.)	Loss Minus Gain as Percent of Starting Canopy in Period (%)	Annual Average Loss Minus Gain in Period (ac.)	Annual Negative Compounded Loss Minus Gain Rate in Period (%)	*Table acres at end of period = B-C+D*	*Check: Measured acres in GIS at end of period*	*Comment*
2009-2014	1,219.7	216.6	163.7	1,003.1	52.9	4.34	10.6	0.95	1166.8	1182.4	2009-2014 loss rate most similar to 2009-2018 loss rate; City 2014 acres includes ca. 20 acres outside City boundary
2014-2018	1,166.8	335.6	212.0	844.1	123.6	10.59	30.9	2.70	1043.3	1056.3	2014-2018 loss rate appears to be anomalous compared to other two periods
2009-2018	1,219.7	397.2	233.4	822.5	163.8	13.43	18.2	0.24	1055.9	1056.3	

Annual Gross Canopy Loss Rate Estimate (2009-2018)

Year	Acres	0.0024	Annual loss rate
2009	241.3		From table above
2010	240.7		
2011	240.1		
2012	239.6		
2013	239.0		
2014	238.4		
2015	237.8		
2016	237.3		
2017	236.7		
2018	236.1	1,055.9	From table above
2019	235.6		
2020	235.0		
2021	234.4		
2022	233.9		
2023	233.3		
2024	232.8		
2025	232.2		
2026	231.6		
2027	231.1		
2028	230.5		
2029	230.0		
2030	229.4	0.056	

Annual Gross Canopy Loss Rate Estimate (2014-2018)

Year	Acres	0.027	Annual loss rate
2014	1,166.8		From table above
2015	1,135.3		
2016	1,104.7		
2017	1,074.8		
2018	1,045.8	1,043.3	From table above
2019	1,017.6		
2020	990.1		
2021	963.4		
2022	937.4		
2023	912.1		
2024	887.4		
2025	863.5		
2026	840.2		
2027	817.5		
2028	795.4		
2029	773.9		
2030	753.0	0.1852	

Annual Gross Canopy Loss Rate Estimate (2009-2014)

Year	Acres	0.0095	Annual loss rate
2009	1,219.7		From table above
2010	1,208.1		
2011	1,196.6		
2012	1,185.3		
2013	1,174.0		
2014	1,162.8	1,166.8	From table above

APPENDIX C: TREE HEALTH ANALYSIS METHODOLOGY

Cambridge Urban Forest
Tree Health Analysis
Applied Ecological Services
8.23.2019

The health status of trees in a city affects the timing and degree of effort for replacing trees and maintaining the urban tree canopy. Determining the health of trees is consequently an important element of urban forest planning and management.

Determining tree health in the City of Cambridge was a multi-step process, combining tree survey data, tree canopy classification, spatial analysis, and canopy mapping. First, tree health from a survey of five percent of the Cambridge tree canopy was completed by Bartlett Tree Research Laboratories (Bartlett). This sample of the tree canopy was combined with a tree canopy classification of the entire City developed by Applied Ecological Services (AES) from satellite imagery, LiDAR data, and field data. Each tree sampled by Bartlett was intersected with a tree canopy polygon created by AES. This resulted in a subset of the City's tree canopy mapped as poor, fair, or good condition.

The next step was to establish a relationship between the characteristics of the digital data in the satellite image with the known condition of the tree canopy at the same location. The satellite image (obtained Aug. 11, 2017) was used to generate a Normalized Difference Vegetation Index (NDVI) for each tree canopy polygon in the City. A linear relationship was then established between the NDVI and the tree health data documented in the ground survey. This resulted in an approximate unique range of NDVI values for each tree condition and tree species. This relationship was then extrapolated across the City to trees of the same species, as classified by AES. For species with few individual canopy polygons, the linear relationship was not strong enough to use; hence, trees of species with few individual polygons were grouped by genus to generate a linear relationship.

Post-processing of the results was needed to improve the accuracy of the outcome. In one example, a single AES tree canopy polygon could contain several trees identified by Bartlett in the field. These were typically understory trees which a tree canopy classification based on satellite imagery cannot detect. Already discussed was the issue of too few individuals in a species to produce a robust linear relationship. Lastly, the satellite data itself had slight variations which did not align with the linear relationship. This is called "noise." Imagery noise resulted in differences between the classification of tree health in the field and the satellite image. For instance, a tree identified as fair condition in the field may have been classified as good in the satellite-derived NDVI. The primary reason for this appeared to be the presence of grass beneath trees classified by Bartlett as fair condition, which the satellite image and NDVI classification interpreted as tree canopy and hence considered to be in good condition. This increased the number of tree canopy polygons classified as better than they actually were in the field. Those species for which a strong statistical relationship existed between NDVI and the field data were the most accurately classified in terms of tree health condition.

Despite the limitations of the analysis, the condition ratings give a general overview of relative tree health in the City because the statistical distribution of tree conditions in the field data and the satellite-derived data are approximately equal. It is also possible that, since the field data covered only five percent of the City, there are locations not field surveyed which have more trees in poorer condition than reflected in the field data. In conclusion, however, it would be accurate to assume that tree conditions in the City are not as good as the classification based on satellite data indicate.

APPENDIX D: 5% REPRESENTATIVE TREE INVENTORY REPORT

Cambridge Urban Forest Management Plan: Sample Tree Inventory Summary | 2018

Submitted by:
Bartlett Tree Experts

Nicholas A. Martin, Bartlett Inventory Solutions Assistant Manager
ISA Board Certified Master Arborist & Municipal Specialist #SO-6537BM, ISA Tree Risk Assessment Qualified, Registered Consulting Arborist #552

Michael Sherwood, Bartlett Inventory Solutions Manager
ISA Board Certified Master Arborist & Municipal Specialist #SO-1845BM, ISA Tree Risk Assessment Qualified, Registered Consulting Arborist #524

BARTLETT TREE EXPERTS
SCIENTIFIC TREE CARE SINCE 1907

Bartlett Tree Experts
13768 Hamilton Road
Charlotte NC 28278
704-588-1150
www.bartlett.com

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Cambridge Urban Forest Management Plan – Sample Tree Inventory Summary

Bartlett Tree Experts was tasked by Reed Hilderbrand, LLC with conducting a 5% sample tree inventory throughout Cambridge, MA, summarizing the information, and extrapolating the 5% sample out to 100% to provide estimates for the entire Cambridge, MA urban forest, per the Request for Qualifications for Urban Forest Master Plan for City of Cambridge. The focus of the sample inventory was to provide current, up-to-date tree attribute data.

Sample Tree Inventory Methods

The 5% sample tree inventory was conducted by first creating randomly located, 200, 1-acre, circular plots on public and private properties throughout the City of Cambridge, MA. The 200, 1-acre plots represented a total of 200 acres, which is approximately 5% of the total acreage of the City of Cambridge, MA. All trees that landed within the sample plots that were on public property were inventoried. Any trees within the sample plots that were on commercial property and could be accessed by the Inventory Team were inventoried. Any trees within the sample plot that were on private property were inventoried visually from City property and estimations made when necessary. All trees greater than 2 inches of diameter at 4.5 ft. above the ground within the sample plots (on accessible property) were inventoried.

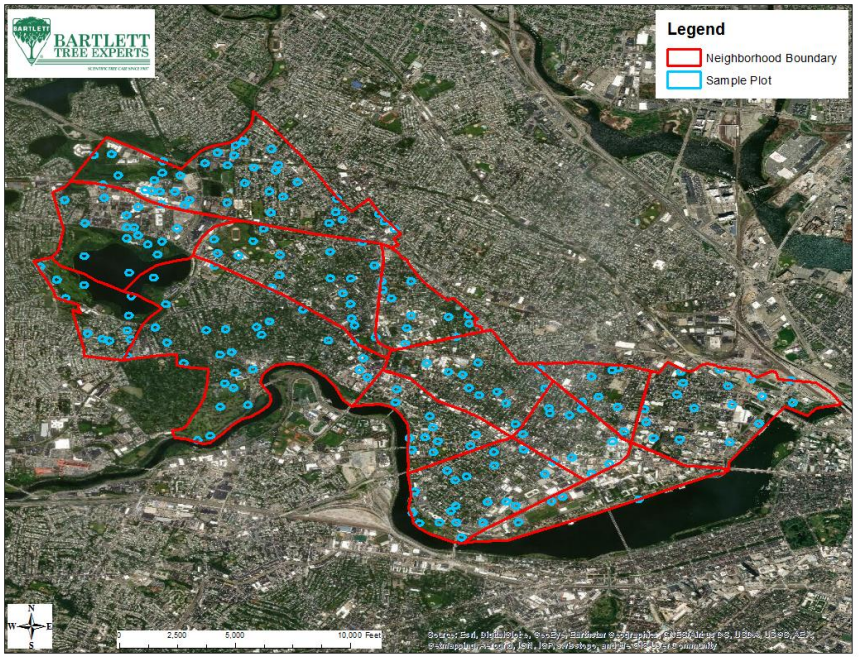
Attributes collected for each accessible tree were:

- Tree ID Number
- Neighborhood
- Inventory Date
- Tree Species Code
- Tree Botanical Name and Common Name
- DBH (Diameter at Breast Height = 4.5 feet)
- Condition Class (Good, Fair, Poor or Dead)
- Age Class (New planting, Young, Semi-mature, Mature, Over-mature)
- Observed Pests/Diseases
- Native to Massachusetts*
- Location Type (City property, Commercial, Private, University)
- Location Information (tree pit, park tree, median tree, lawn, private)
- Approximate Size of Planting Bed/Tree Pit
- Material (grate, porous pavement, compacted soil, planting bed, flexipave, turf)

*Native to Massachusetts was determined using the i-Tree Eco software.

The following sections summarize the attribute data collected. Individual summary pages are provided for the entire 5% sample, for each neighborhood, and for the estimated city-wide extrapolation.

MAP OF THE 200 RANDOM SAMPLE PLOTS



City-wide Summary of Sample Inventory Data

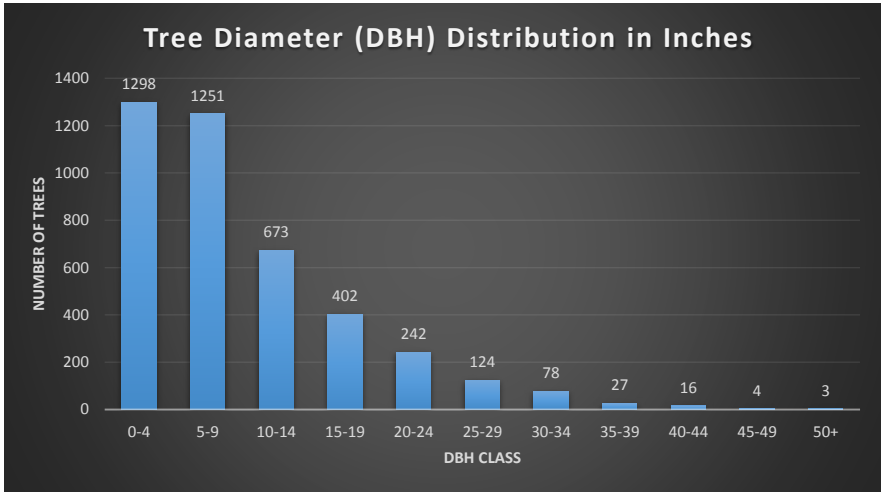
The 5% sample tree inventory resulted in 4,118 trees being inventoried in the sample plots located throughout Cambridge, MA. Of the original 200 sample plots, 179 had accessible trees located within them (21 plots did not have any trees associated with them due to them being located in water, completely on private properties that could not be accessed, or there were no trees present within the plot boundaries). The data are summarized below.

CITY-WIDE SUMMARY OF SAMPLE INVENTORY DATA

	Total Trees	Percent of 5% Sample
Trees Inventoried:	4,118	…
Number of Species:	140	…
Number of Trees with Pests Observed:	80	1.94%
Number of Trees Native to Massachusetts:	1,911	46.41%
Location Type:		
City Property	2,339	56.80%
Commercial	321	7.80%
Private	1,235	29.99%
University	223	5.42%
Location:		
Lawn	1,541	37.42%
Median	38	0.92%
Park	230	5.59%
Private	1,730	42.01%
Tree Pit	579	14.06%
Material:		
Compacted Soil	1,230	29.87%
Flexipave	10	0.24%
Grate	37	0.90%
Planting Bed	555	13.48%
Porous Pavement	18	0.44%
Turf	2,268	55.08%
Condition:		
Good	2,563	62.24%
Fair	1,050	25.50%
Poor	329	7.99%
Dead	176	4.27%
Age Class:		
New Planting	50	1.21%
Young	1,302	31.62%
Semi-mature	1,375	33.39%
Mature	1,358	32.98%

	Total Trees	Percent of 5% Sample
Over-mature	33	0.80%
Neighborhood Tree Totals:		
Agassiz	182	4.42%
Cambridge Highlands	589	14.30%
Cambridgeport	368	8.94%
East Cambridge	148	3.59%
Mid-Cambridge	210	5.10%
MIT/Area 2	60	1.46%
Neighborhood 9	247	6.00%
North Cambridge	650	15.78%
Riverside	193	4.69%
Strawberry Hill	532	12.92%
The Port (Area 4)	113	2.74%
Wellington Harrington	111	2.70%
West Cambridge (Neighborhood 10)	715	17.36%

CITY-WIDE SAMPLE TREE DIAMETER DISTRIBUTION CHART



INVENTORIED TREE SPECIES BREAKDOWN TABLE

Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
Abies	*balsamea*	Fir-Balsam	1	0.02%	Yes
	concolor	Fir-White	2	0.05%	No
***Abies* Total**			**3**	**0.07%**	
Acer	*campestre*	Maple-Hedge	4	0.10%	No
	griseum	Maple-Paperbark	7	0.17%	No
	negundo	Boxelder	41	1.00%	Yes
	palmatum	Maple-Japanese	34	0.83%	No
	platanoides	Maple-Crimson King Norway	9	0.22%	No
	platanoides	Maple-Norway	450	10.93%	No
	pseudoplatanus	Maple-Sycamore	26	0.63%	No
	rubrum	Maple-Red	216	5.25%	Yes
	saccharinum	Maple-Silver	33	0.80%	Yes
	saccharum	Maple-Sugar	209	5.08%	Yes
	sp	Maple sp.	2	0.05%	No
	x *freemanii*	Maple-Freeman	11	0.27%	No
***Acer* Total**			**1042**	**25.30%**	
Aesculus	*glabra*	Buckeye-Ohio	1	0.02%	No
	hippocastanum	Horsechestnut	8	0.19%	No
	x *carnea*	Horsechestnut-Red	1	0.02%	No
***Aesculus* Total**			**10**	**0.24%**	
Ailanthus	*altissima*	Tree-of-Heaven	122	2.96%	No
Albizia	*julibrissin*	Mimosa	1	0.02%	No
Alnus	*glutinosa*	Alder-Common	11	0.27%	No
Amelanchier	*arborea*	Serviceberry-Downy	15	0.36%	Yes
	sp	Serviceberry sp.	10	0.24%	No
***Amelanchier* Total**			**25**	**0.61%**	

Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
Betula	*nigra*	Birch-River	83	2.02%	Yes
	papyrifera	Birch-Paper	27	0.66%	Yes
	pendula	Birch-European White	1	0.02%	No
	populifolia	Birch-Gray	9	0.22%	Yes
	sp	Birch sp.	2	0.05%	No
***Betula* Total**			**122**	**2.96%**	
Carpinus	*betulus*	Hornbeam-European	6	0.15%	No
	caroliniana	Hornbeam-American	1	0.02%	Yes
***Carpinus* Total**			**7**	**0.17%**	
Carya	*ovata*	Hickory-Shagbark	10	0.24%	Yes
	tomentosa	Hickory-Mockernut	22	0.53%	Yes
***Carya* Total**			**32**	**0.78%**	
Catalpa	*speciosa*	Catalpa-Northern	11	0.27%	No
Cedrus	*atlantica*	Cedar-Atlas	2	0.05%	No
Celtis	*occidentalis*	Hackberry	10	0.24%	Yes
Cercidiphyllum	*japonicum*	Katsuratree	12	0.29%	No
Cercis	*canadensis*	Redbud-Eastern	13	0.32%	No
Chamaecyparis	*obtusa*	Falsecypress-Hinoki	28	0.68%	No
	pisifera	Falsecypress-Sawara	1	0.02%	No
	sp	Falsecypress sp.	7	0.17%	No
***Chamaecyparis* Total**			**36**	**0.87%**	
Cladrastis	*kentukea*	Yellowwood	2	0.05%	Yes
Cornus	*florida*	Dogwood-Flowering	35	0.85%	Yes
	kousa	Dogwood-Kousa	26	0.63%	No
***Cornus* Total**			**61**	**1.48%**	
Cotinus	*coggygria*	Smoketree-Common	6	0.15%	No
	obovatus	Smoketree-American	7	0.17%	No
***Cotinus* Total**			**13**	**0.32%**	
Crataegus	sp	Hawthorn sp.	20	0.49%	No

Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
Elaeagnus	*angustifolia*	Russian Olive	1	0.02%	No
Fagus	*grandifolia*	Beech-American	7	0.17%	Yes
	sylvatica	Beech-European	24	0.58%	No
***Fagus* Total**			**31**	**0.75%**	
Fraxinus	*americana*	Ash-White	128	3.11%	Yes
	nigra	Ash-Black	1	0.02%	Yes
	pennsylvanica	Ash-Green	99	2.40%	Yes
***Fraxinus* Total**			**228**	**5.54%**	
Ginkgo	*biloba*	Ginkgo	23	0.56%	No
Gleditsia	*triacanthos* var. inermis	Honeylocust-Thornless Common	230	5.59%	No
Gymnocladus	*dioicus*	Coffeetree-Kentucky	7	0.17%	No
Halesia	*carolina*	Silverbell-Carolina	3	0.07%	No
Hamamelis	sp	Witchhazel sp.	1	0.02%	No
Hydrangea	*arborescens*	Hydrangea	2	0.05%	No
Ilex	*opaca*	Holly-American	22	0.53%	Yes
	sp	Holly sp.	1	0.02%	No
***Ilex* Total**			**23**	**0.56%**	
Juglans	*nigra*	Walnut-Black	29	0.70%	Yes
	regia	Walnut-English	1	0.02%	No
***Juglans* Total**			**30**	**0.73%**	
Juniperus	sp	Juniper sp.	1	0.02%	No
	virginiana	Redcedar-Eastern	40	0.97%	Yes
***Juniperus* Total**			**41**	**1.00%**	
Koelreuteria	*paniculata*	Goldenraintree-Panicled	9	0.22%	No
Larix	*laricina*	Tamarack	6	0.15%	Yes
Liquidambar	*styraciflua*	Sweetgum	14	0.34%	No
Liriodendron	*tulipifera*	Tuliptree	10	0.24%	Yes
Maackia	*amurensis*	Maackia-Amur	4	0.10%	No
Magnolia	*macrophylla*	Magnolia-Bigleaf	1	0.02%	No

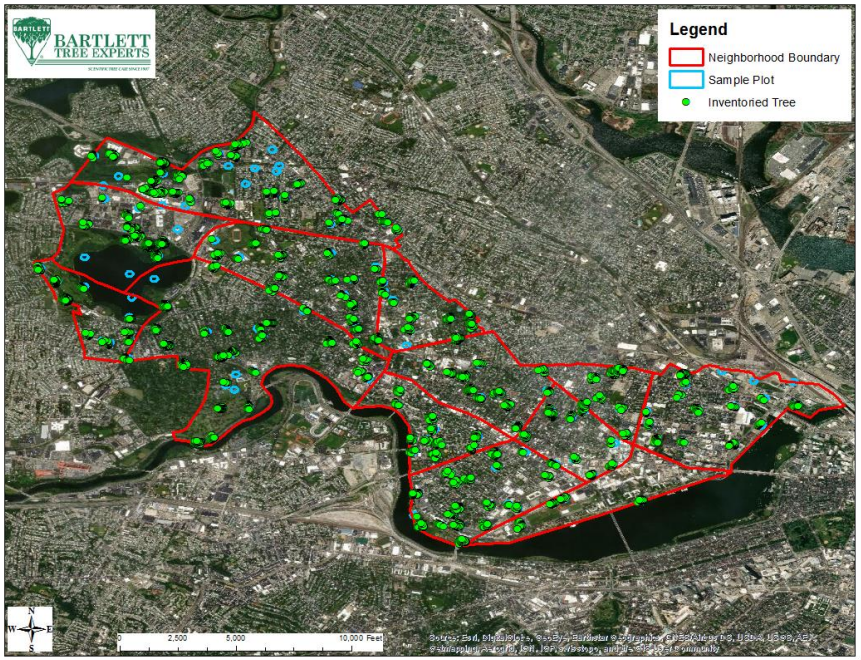
Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
	sp	Magnolia sp.	7	0.17%	No
	stellata	Magnolia-Star	18	0.44%	No
	x *soulangiana*	Magnolia-Saucer	5	0.12%	No
***Magnolia* Total**			**31**	**0.75%**	
Malus	*pumila*	Apple	1	0.02%	No
	sp	Crabapple-Flowering	143	3.47%	No
***Malus* Total**			**144**	**3.50%**	
Morus	*alba*	Mulberry-White	17	0.41%	No
	rubra	Mulberry-Red	23	0.56%	Yes
***Morus* Total**			**40**	**0.97%**	
Nyssa	*sylvatica*	Tupelo-Black	4	0.10%	Yes
Ostrya	*virginiana*	Hophornbeam-American	1	0.02%	Yes
Phellodendron	*amurense*	Corktree-Amur	12	0.29%	No
Picea	*abies*	Spruce-Norway	46	1.12%	No
	glauca	Spruce-White	4	0.10%	Yes
	orientalis	Spruce-Oriental	1	0.02%	No
	pungens	Spruce-Colorado	13	0.32%	No
	rubens	Spruce-Red	1	0.02%	Yes
	sp	Spruce sp.	3	0.07%	No
***Picea* Total**			**68**	**1.65%**	
Pinus	*banksiana*	Pine-Jack	1	0.02%	No
	mugo	Pine-Mugo	1	0.02%	No
	nigra	Pine-Austrian	24	0.58%	No
	strobus	Pine-Eastern White	60	1.46%	Yes
	sylvestris	Pine-Scotch	4	0.10%	No
***Pinus* Total**			**90**	**2.19%**	
Platanus	*occidentalis*	Sycamore	5	0.12%	Yes
	x *acerifolia*	Planetree-London	37	0.90%	No
***Platanus* Total**			**42**	**1.02%**	

Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
Populus	*deltoides*	Poplar-Eastern	32	0.78%	Yes
	tremuloides	Aspen-Quaking	65	1.58%	Yes
***Populus* Total**			**97**	**2.36%**	
Prunus	*cerasifera*	Plum-Purple Leaf	5	0.12%	No
	pennsylvanica	Cherry-Pin	7	0.17%	Yes
	serotina	Cherry-Black	74	1.80%	Yes
	serrulata	Cherry-Flowering	80	1.94%	No
	sp	Cherry sp.	34	0.83%	No
	subhirtella	Cherry-Weeping	4	0.10%	No
***Prunus* Total**			**204**	**4.95%**	
Pseudotsuga	*menziesii*	Fir-Douglas	3	0.07%	No
Pyrus	*calleryana*	Pear-Callery	53	1.29%	No
	communis	Pear-Common	1	0.02%	No
***Pyrus* Total**			**54**	**1.31%**	
Quercus	*alba*	Oak-White	8	0.19%	Yes
	bicolor	Oak-Swamp White	16	0.39%	Yes
	coccinea	Oak-Scarlet	1	0.02%	Yes
	palustris	Oak-Pin	110	2.67%	Yes
	phellos	Oak-Willow	1	0.02%	Yes
	prinus	Oak-Chestnut	2	0.05%	Yes
	robur	Oak-English	3	0.07%	No
	rubra	Oak-Northern Red	196	4.76%	Yes
	velutina	Oak-Eastern Black	2	0.05%	Yes
***Quercus* Total**			**339**	**8.23%**	
Rhamnus	*cathartica*	Buckthorn-European	58	1.41%	No
	frangula	Buckthorn-Glossy	115	2.79%	No
***Rhamnus* Total**			**173**	**4.20%**	
Rhododendron	sp	Rhododenron sp.	1	0.02%	No
Robinia	*pseudoacacia*	Locust-Black	72	1.75%	No

Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
Salix	*alba*	Willow-White	11	0.27%	No
	babylonica	Willow-Weeping	2	0.05%	No
	discolor	Willow-Pussy	4	0.10%	Yes
	sp	Willow sp.	20	0.49%	No
***Salix* Total**			**37**	**0.90%**	
Sophora	*japonica*	Pagodatree-Japanese	19	0.46%	No
Syringa	*reticulata*	Lilac-Japanese Tree	17	0.41%	No
	vulgaris	Lilac-Common	2	0.05%	No
***Syringa* Total**			**19**	**0.46%**	
Taxus	*cuspidata*	Yew-Japanese	13	0.32%	No
	sp	Yew sp.	8	0.19%	No
***Taxus* Total**			**21**	**0.51%**	
Thuja	*occidentalis*	Arborvitae-Eastern	40	0.97%	Yes
	plicata	Redcedar-Western	24	0.58%	No
***Thuja* Total**			**64**	**1.55%**	
Tilia	*americana*	Basswood	20	0.49%	Yes
	cordata	Linden-Littleleaf	75	1.82%	No
	tomentosa	Linden-Silver	20	0.49%	No
***Tilia* Total**			**115**	**2.79%**	
Tsuga	*canadensis*	Hemlock-Canadian	40	0.97%	Yes
Ulmus	*americana*	Elm-American	127	3.08%	Yes
	glabra	Elm-Scotch	2	0.05%	No
	parvifolia	Elm-Chinese	4	0.10%	No
	pumila	Elm-Siberian	9	0.22%	No
	rubra	Elm-Slippery	12	0.29%	Yes
	sp	Elm sp.	27	0.66%	No
***Ulmus* Total**			**181**	**4.40%**	
Unknown	*unknown*	Unknown	1	0.02%	No
Viburnum	sp	Viburnum sp.	4	0.10%	No

Genus	Species	Common Name	Total Trees	Percent Distribution Total	Native to Massachusetts
Zelkova	*serrata*	Zelkova	24	0.58%	No
Total			**4118**	**100.00%**	

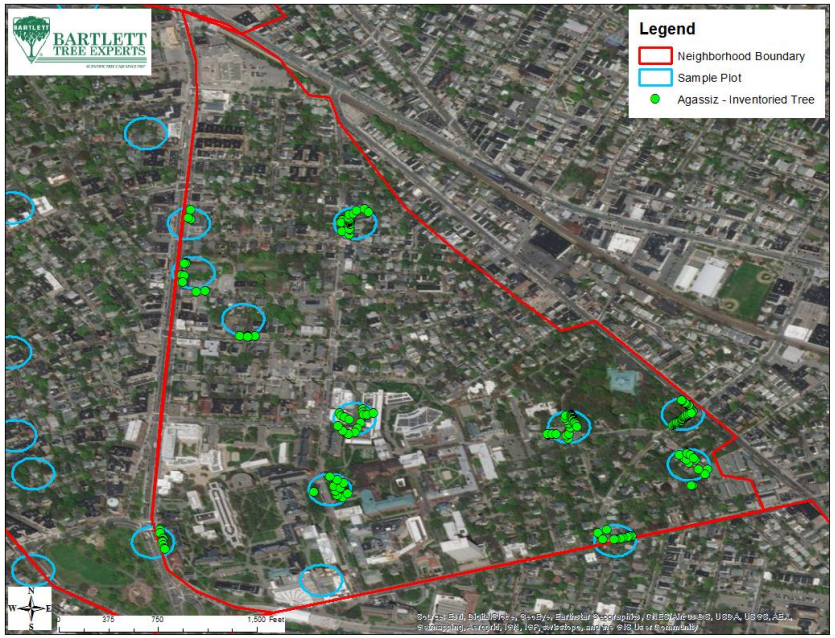
MAP OF TREES IDENTIFIED IN THE 5% SAMPLE TREE INVENTORY



Agassiz Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 182 trees being inventoried in the sample plots located throughout the Agassiz Neighborhood. The data are summarized below.

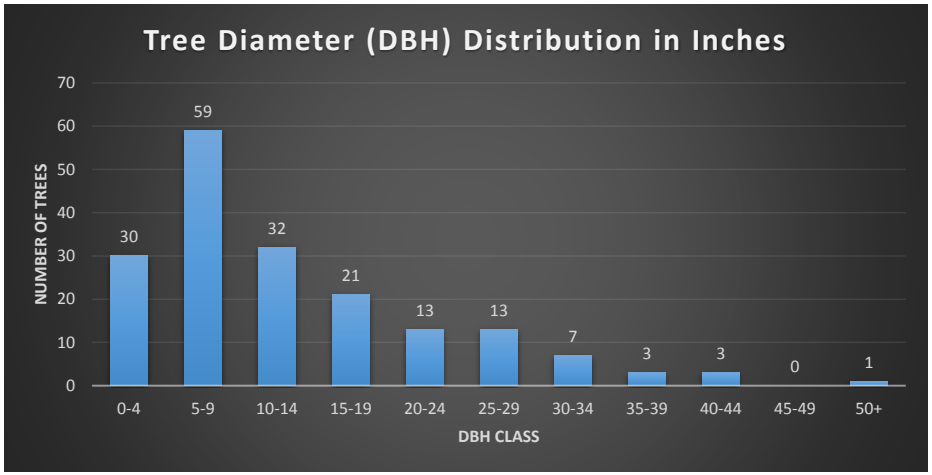
MAP OF INVENTORIED TREES LOCATED IN THE AGASSIZ NEIGHBORHOOD



AGASSIZ NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	182	...
Number of Species:	44	...
Number of Trees with Pests Observed:	7	3.85%
Number of Trees Native to Massachusetts:	60	32.97%
Location Type:		
City Property	19	10.44%
Private	127	69.78%
University	36	19.78%
Location:		
Lawn	8	4.40%
Private	156	85.71%
Tree Pit	18	9.89%
Material:		
Compacted Soil	85	46.70%
Turf	97	53.30%
Condition:		
Good	139	76.37%
Fair	31	17.03%
Poor	9	4.95%
Dead	3	1.65%
Age Class:		
New Planting	2	1.10%
Young	37	20.33%
Semi-mature	40	21.98%
Mature	99	54.40%
Over-mature	4	2.20%

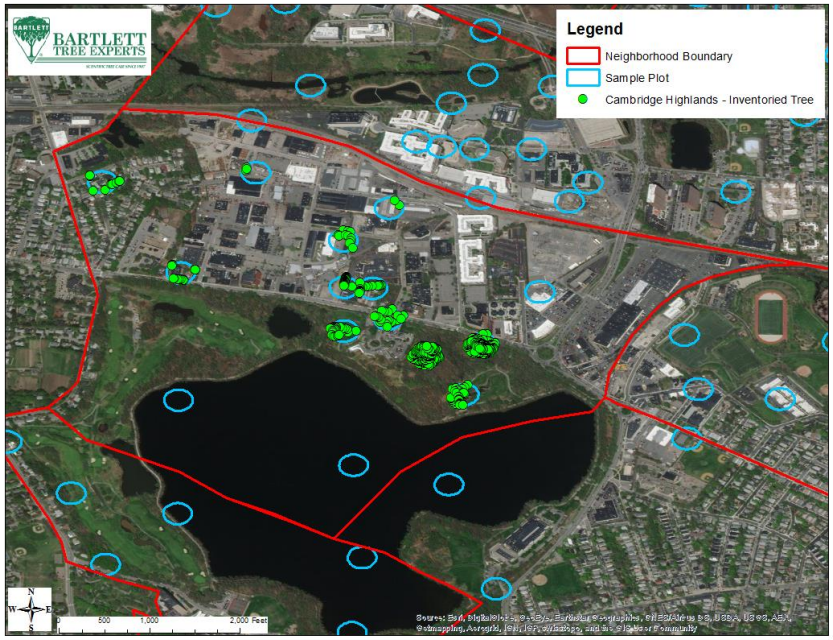
AGASSIZ NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Cambridge Highlands Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 589 trees being inventoried in the sample plots located throughout the Cambridge Highlands Neighborhood. The data are summarized below.

MAP OF INVENTORIED TREES IDENTIFIED IN THE CAMBRIDGE HIGHLANDS NEIGHBORHOOD

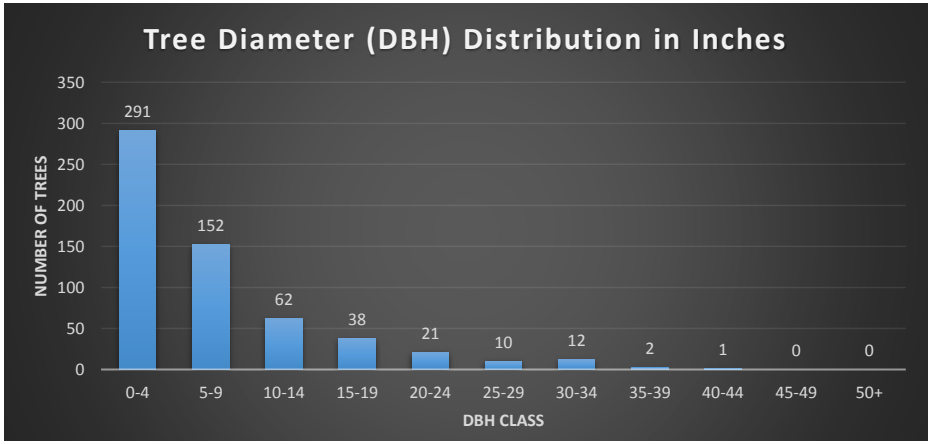


CAMBRIDGE HIGHLANDS NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	589	…
Number of Species:	54	…
Number of Trees with Pests Observed:	9	1.53%
Number of Trees Native to Massachusetts:	352	59.76%
Location Type:		
City Property	477	80.98%
Commercial	65	11.04%

	Total Trees	Percent of Neighborhood Total
Private	47	7.98%
Location:		
Lawn	466	79.12%
Park	7	1.19%
Private	112	19.02%
Tree Pit	4	0.68%
Material:		
Compacted Soil	120	20.37%
Planting Bed	42	7.13%
Porous Pavement	1	0.17%
Turf	426	72.33%
Condition:		
Good	248	42.11%
Fair	218	37.01%
Poor	85	14.43%
Dead	38	6.45%
Age Class:		
New Planting	4	0.68%
Young	231	39.22%
Semi-mature	159	26.99%
Mature	193	32.77%
Over-mature	2	0.34%

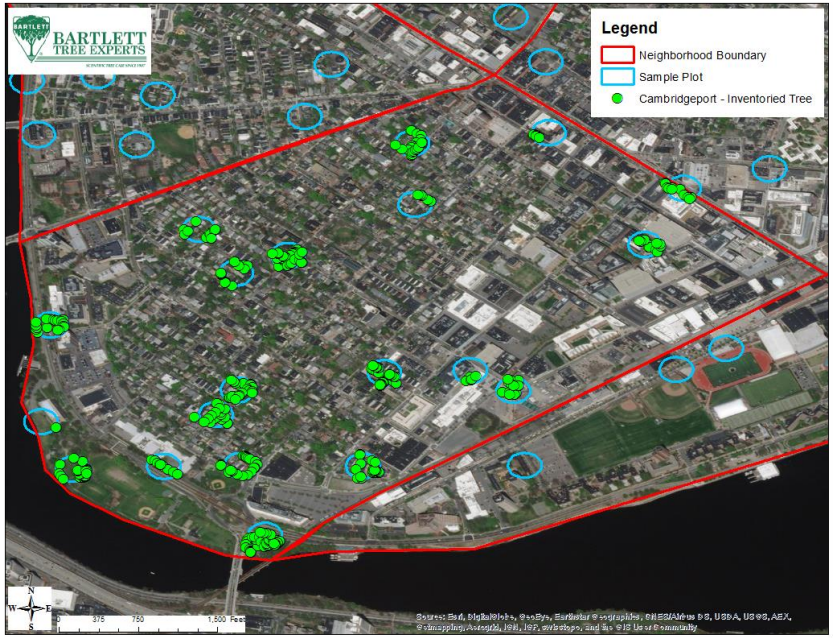
CAMBRIDGE HIGHLANDS NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Cambridgeport Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 368 trees being inventoried in the sample plots located throughout the Cambridgeport Neighborhood. The data are summarized below.

MAP OF INVENTORIED TREES IDENTIFIED IN THE CAMBRIDGEPORT NEIGHBORHOOD

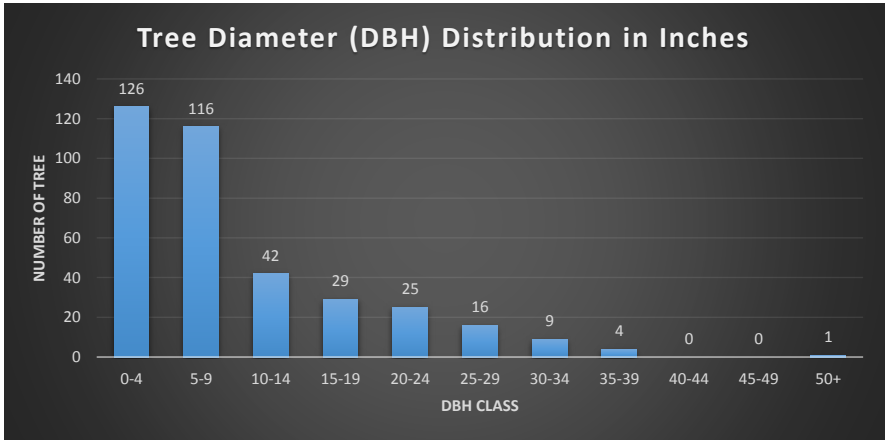


CAMBRIDGEPORT NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	368	...
Number of Species:	54	...
Number of Trees with Pests Observed:	3	0.82%
Number of Trees Native to Massachusetts:	175	47.55%
Location Type:		
City Property	185	50.27%
Commercial	40	10.87%

	Total Trees	Percent of Neighborhood Total
Private	140	38.04%
University	3	0.82%
Location:		
Lawn	33	8.97%
Park	63	17.12%
Private	183	49.73%
Tree Pit	89	24.18%
Material:		
Compacted Soil	131	35.60%
Grate	11	2.99%
Planting Bed	94	25.54%
Porous Pavement	6	1.63%
Turf	126	34.24%
Condition:		
Good	259	70.38%
Fair	90	24.46%
Poor	18	4.89%
Dead	1	0.27%
Age Class:		
New Planting	4	1.09%
Young	137	37.23%
Semi-mature	155	42.12%
Mature	72	19.57%

CAMBRIDGEPORT NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



East Cambridge Neighborhood Sample Inventory Summary

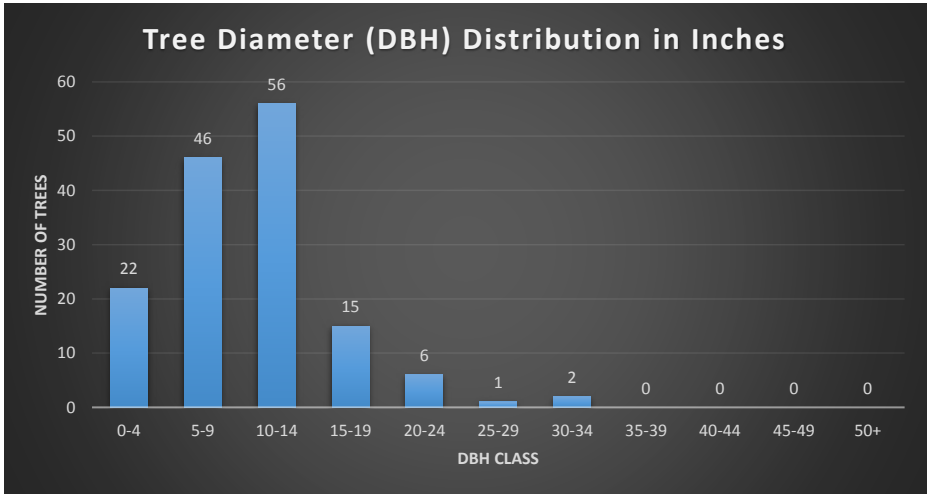
The 5% sample tree inventory resulted in 148 trees being inventoried in the sample plots located throughout the East Cambridge Neighborhood. The data are summarized below.

MAP OF INVENTORIED TREES IDENTIFIED IN THE EAST CAMBRIDGE NEIGHBORHOOD

EAST CAMBRIDGE NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	148	...
Number of Species:	31	...
Number of Trees with Pests Observed:	3	2.03%
Number of Trees Native to Massachusetts:	26	17.57%
Location Type:		
City Property	87	58.78%
Commercial	35	23.65%
Private	26	17.57%
Location:		
Lawn	10	6.76%
Median	3	2.03%
Park	29	19.59%
Private	61	41.22%
Tree Pit	45	30.41%
Material:		
Compacted Soil	61	41.22%
Flexipave	5	3.38%
Grate	18	12.16%
Planting Bed	34	22.97%
Porous Pavement	4	2.70%
Turf	26	17.57%
Condition:		
Good	81	54.73%
Fair	45	30.41%
Poor	22	14.86%
Age Class:		
New Planting	4	2.70%
Young	18	12.16%
Semi-mature	55	37.16%
Mature	71	47.97%

EAST CAMBRIDGE NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Mid-Cambridge Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 210 trees being inventoried in the sample plots located throughout the Mid-Cambridge Neighborhood. The data are summarized below.

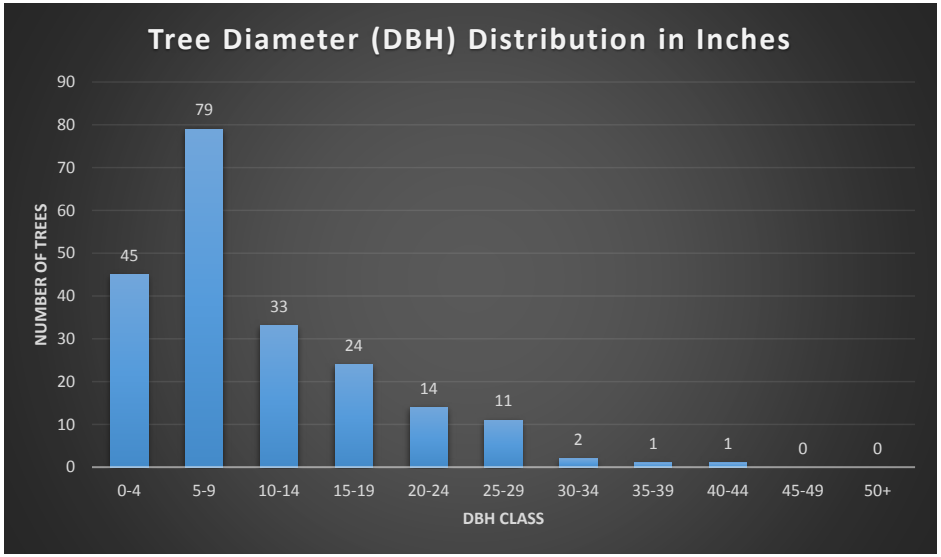
MAP OF INVENTORIED TREES IDENTIFIED IN THE MID-CAMBRIDGE NEIGHBORHOOD

MID-CAMBRIDGE NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	210	...
Number of Species:	48	...
Number of Trees with Pests Observed:	0	0.00%
Number of Trees Native to Massachusetts:	48	22.86%
Location Type:		
City Property	88	41.90%
Commercial	1	0.48%
Private	121	57.62%

	Total Trees	Percent of Neighborhood Total
Location:		
Median	1	0.48%
Park	17	8.10%
Private	121	57.62%
Tree Pit	71	33.81%
Material:		
Compacted Soil	141	67.14%
Porous Pavement	1	0.48%
Turf	68	32.38%
Condition:		
Good	172	81.90%
Fair	25	11.90%
Poor	8	3.81%
Dead	5	2.38%
Age Class:		
New Planting	6	2.86%
Young	51	24.29%
Semi-mature	59	28.10%
Mature	90	42.86%
Over-mature	4	1.90%

MID-CAMBRIDGE NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



MIT/Area 2 Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 60 trees being inventoried in the sample plots located throughout the MIT/Area 2 Neighborhood. The data are summarized below.

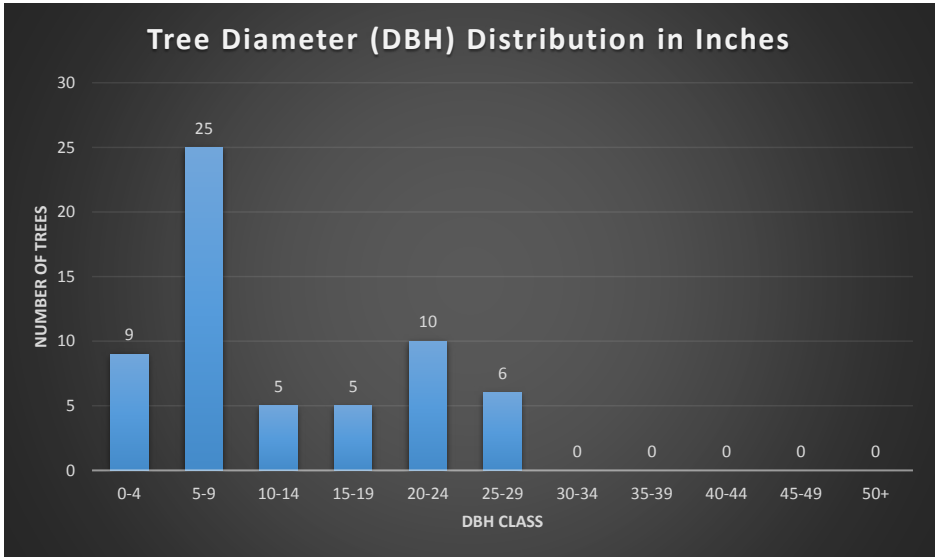
MAP OF INVENTORIED TREES IDENTIFIED IN THE MIT/AREA 2 NEIGHBORHOOD

MIT/AREA 2 NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	60	...
Number of Species:	13	...
Number of Trees with Pests Observed:	1	1.67%
Number of Trees Native to Massachusetts:	46	76.67%
Location Type:		
City Property	36	60.00%
University	24	40.00%
Location:		

	Total Trees	Percent of Neighborhood Total
Median	7	11.67%
Park	4	6.67%
Private	24	40.00%
Tree Pit	25	41.67%
Material:		
Compacted Soil	27	45.00%
Turf	33	55.00%
Condition:		
Good	33	55.00%
Fair	21	35.00%
Poor	5	8.33%
Dead	1	1.67%
Age Class:		
New Planting	5	8.33%
Young	6	10.00%
Semi-mature	35	58.33%
Mature	14	23.33%

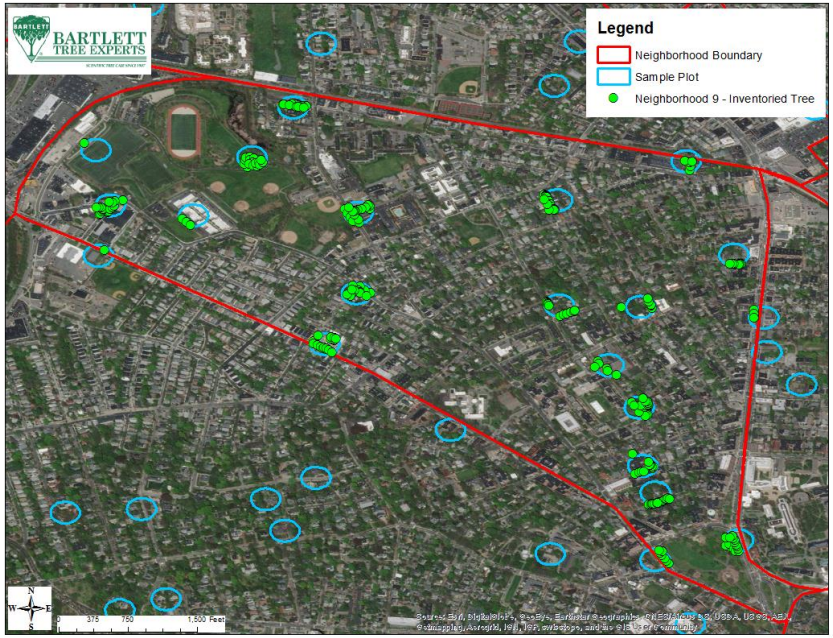
MIT/AREA 2 NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Neighborhood 9 Sample Inventory Summary

The 5% sample tree inventory resulted in 247 trees being inventoried in the sample plots located throughout Neighborhood 9. The data are summarized below.

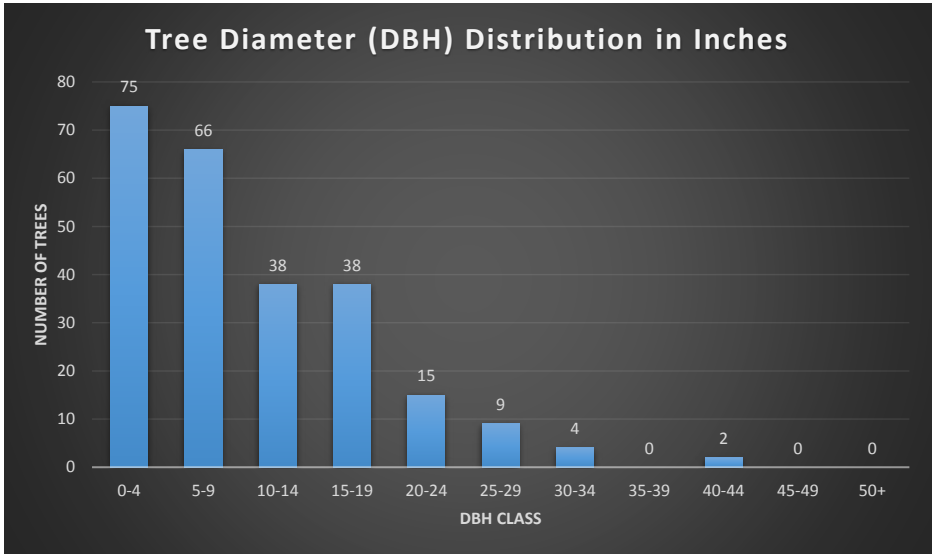
MAP OF INVENTORIED TREES IDENTIFIED IN NEIGHBORHOOD 9



NEIGHBORHOOD 9 SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	247	...
Number of Species:	51	...
Number of Trees with Pests Observed:	15	6.07%
Number of Trees Native to Massachusetts:	120	48.58%
Location Type:		
City Property	106	42.91%
Commercial	22	8.91%
Private	100	40.49%
University	19	7.69%
Location:		
Lawn	28	11.34%
Park	27	10.93%
Private	141	57.09%
Tree Pit	51	20.65%
Material:		
Compacted Soil	80	32.39%
Planting Bed	56	22.67%
Turf	111	44.94%
Condition:		
Good	178	72.06%
Fair	55	22.27%
Poor	12	4.86%
Dead	2	0.81%
Age Class:		
New Planting	10	4.05%
Young	69	27.94%
Semi-mature	120	48.58%
Mature	48	19.43%

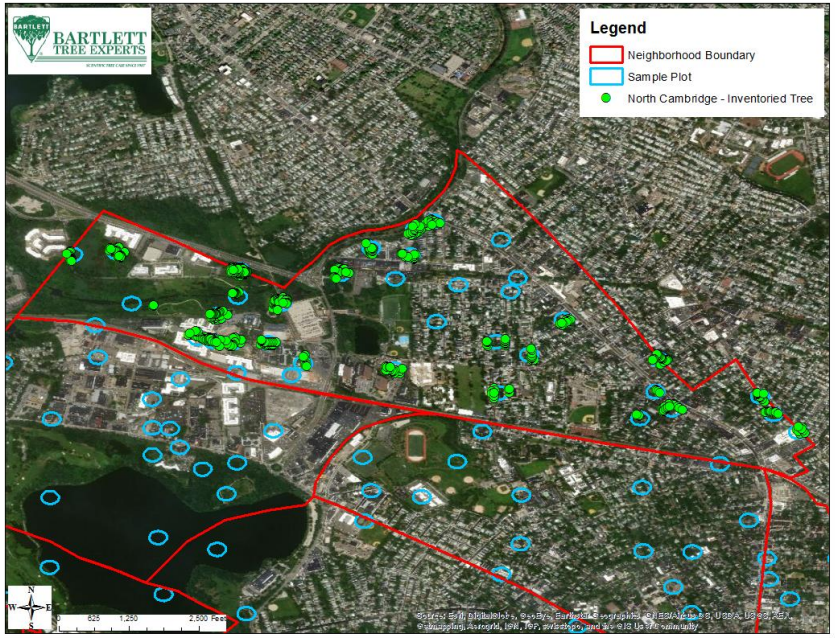
NEIGHBORHOOD 9 TREE DIAMETER DISTRIBUTION CHART



North Cambridge Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 650 trees being inventoried in the sample plots located throughout the North Cambridge Neighborhood. The data are summarized below.

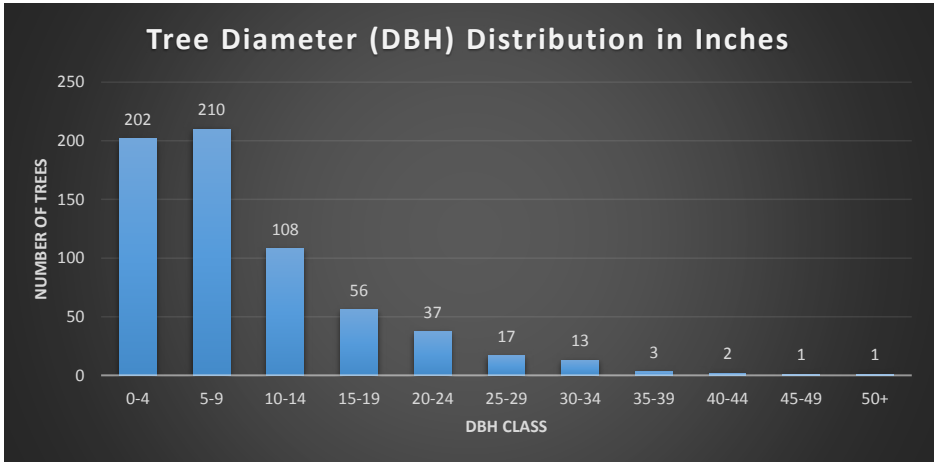
MAP OF INVENTORIED TREES IDENTIFIED IN THE NORTH CAMBRIDGE NEIGHBORHOOD



NORTH CAMBRIDGE NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	650	...
Number of Species:	66	...
Number of Trees with Pests Observed:	30	4.62%
Number of Trees Native to Massachusetts:	350	53.85%
Location Type:		
City Property	405	62.31%
Commercial	93	14.31%
Private	152	23.38%
Location:		
Lawn	317	48.77%
Median	7	1.08%
Park	4	0.62%
Private	239	36.77%
Tree Pit	83	12.77%
Material:		
Compacted Soil	187	28.77%
Planting Bed	70	10.77%
Porous Pavement	1	0.15%
Turf	392	60.31%
Condition:		
Good	424	65.23%
Fair	147	22.62%
Poor	46	7.08%
Dead	33	5.08%
Age Class:		
New Planting	7	1.08%
Young	244	37.54%
Semi-mature	165	25.38%
Mature	230	35.38%
Over-mature	4	0.62%

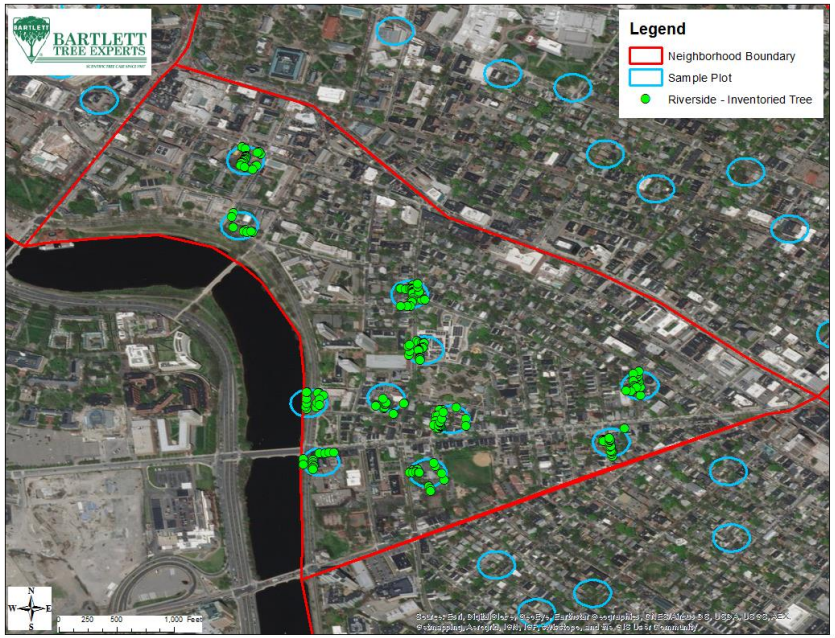
NORTH CAMBRIDGE NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Riverside Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 193 trees being inventoried in the sample plots located throughout the Riverside Neighborhood. The data are summarized below.

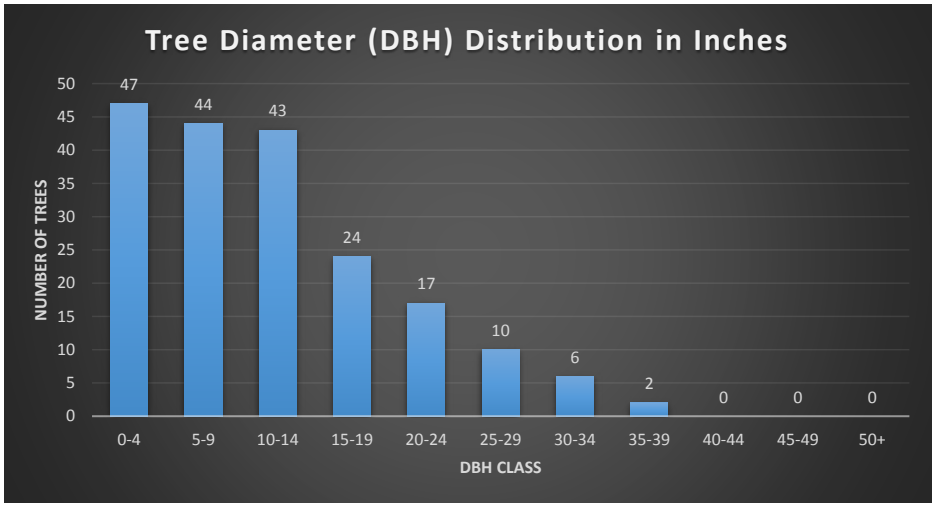
MAP OF INVENTORIED TREES IDENTIFIED IN THE RIVERSIDE NEIGHBORHOOD



RIVERSIDE NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	193	...
Number of Species:	44	...
Number of Trees with Pests Observed:	0	0.00%
Number of Trees Native to Massachusetts:	69	35.75%
Location Type:		
City Property	78	40.41%
Commercial	16	8.29%
Private	77	39.90%
University	22	11.40%
Location:		
Lawn	34	17.62%
Private	115	59.59%
Tree Pit	44	22.80%
Material:		
Compacted Soil	109	56.48%
Planting Bed	51	26.42%
Porous Pavement	2	1.04%
Turf	31	16.06%
Condition:		
Good	74	38.34%
Fair	103	53.37%
Poor	14	7.25%
Dead	2	1.04%
Age Class:		
Young	53	27.46%
Semi-mature	107	55.44%
Mature	33	17.10%

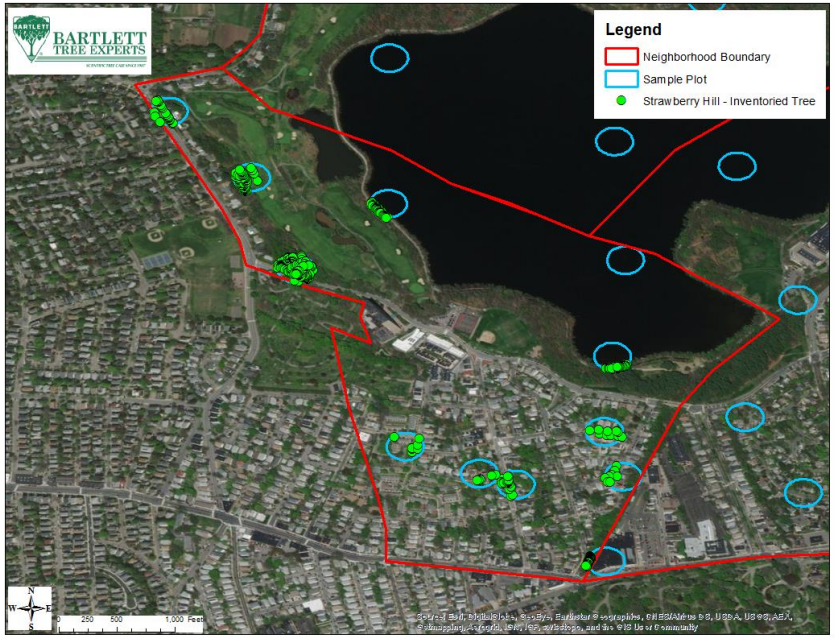
RIVERSIDE NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Strawberry Hill Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 532 trees being inventoried in the sample plots located throughout the Strawberry Hill Neighborhood. The data are summarized below.

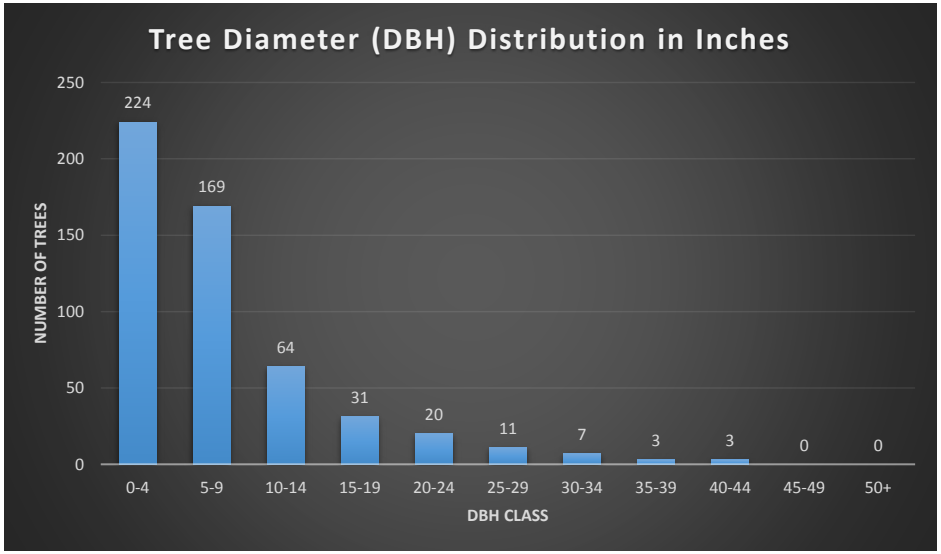
MAP OF INVENTORIED TREES IDENTIFIED IN THE STRAWBERRY HILL NEIGHBORHOOD



STRAWBERRY HILL NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	532	...
Number of Species:	45	...
Number of Trees with Pests Observed:	3	0.56%
Number of Trees Native to Massachusetts:	275	51.69%
Location Type:		
City Property	413	77.63%
Private	119	22.37%
Location:		
Lawn	387	72.74%
Park	4	0.75%
Private	117	21.99%
Tree Pit	24	4.51%
Material:		
Compacted Soil	86	16.17%
Turf	446	83.83%
Condition:		
Good	326	61.28%
Fair	127	23.87%
Poor	37	6.95%
Dead	42	7.89%
Age Class:		
New Planting	1	0.19%
Young	273	51.32%
Semi-mature	138	25.94%
Mature	112	21.05%
Over-mature	8	1.50%

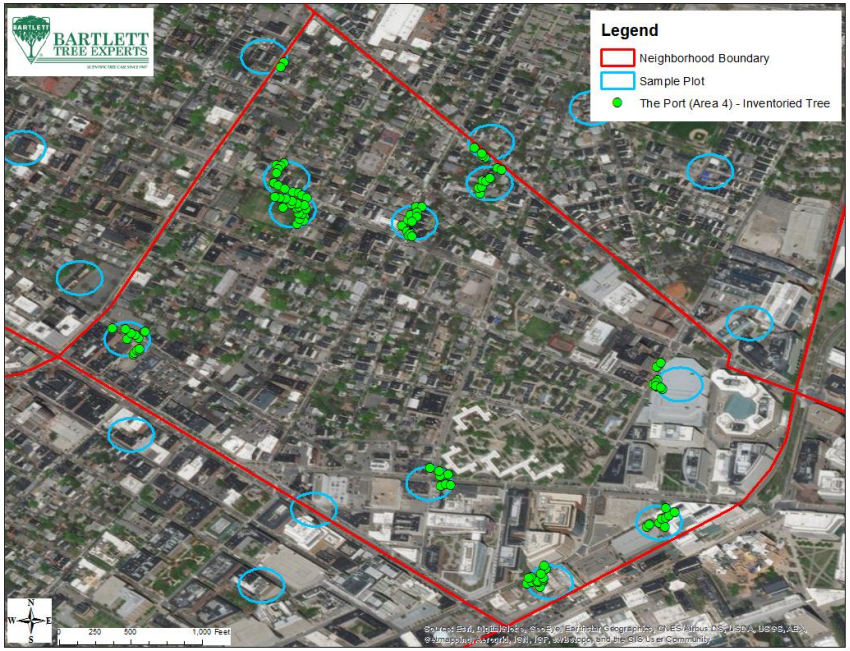
STRAWBERRY HILL NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



The Port (Area 4) Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 113 trees being inventoried in the sample plots located throughout The Port (Area 4) Neighborhood. The data are summarized below.

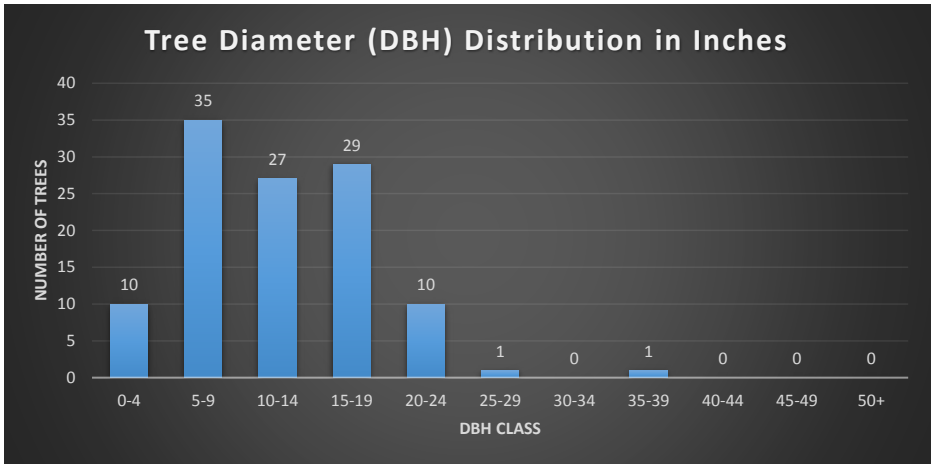
MAP OF INVENTORIED TREES IDENTIFIED IN THE PORT (AREA 4) NEIGHBORHOOD



THE PORT (AREA 4) NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	113	...
Number of Species:	22	...
Number of Trees with Pests Observed:	2	1.77%
Number of Trees Native to Massachusetts:	43	38.05%
Location Type:		
City Property	71	62.83%
Commercial	17	15.04%
Private	10	8.85%
University	15	13.27%
Location:		
Lawn	6	5.31%
Median	5	4.42%
Park	20	17.70%
Private	30	26.55%
Tree Pit	52	46.02%
Material:		
Compacted Soil	88	77.88%
Planting Bed	15	13.27%
Porous Pavement	2	1.77%
Turf	8	7.08%
Condition:		
Good	66	58.41%
Fair	31	27.43%
Poor	6	5.31%
Dead	10	8.85%
Age Class:		
New Planting	1	0.88%
Young	11	9.73%
Semi-mature	38	33.63%
Mature	63	55.75%

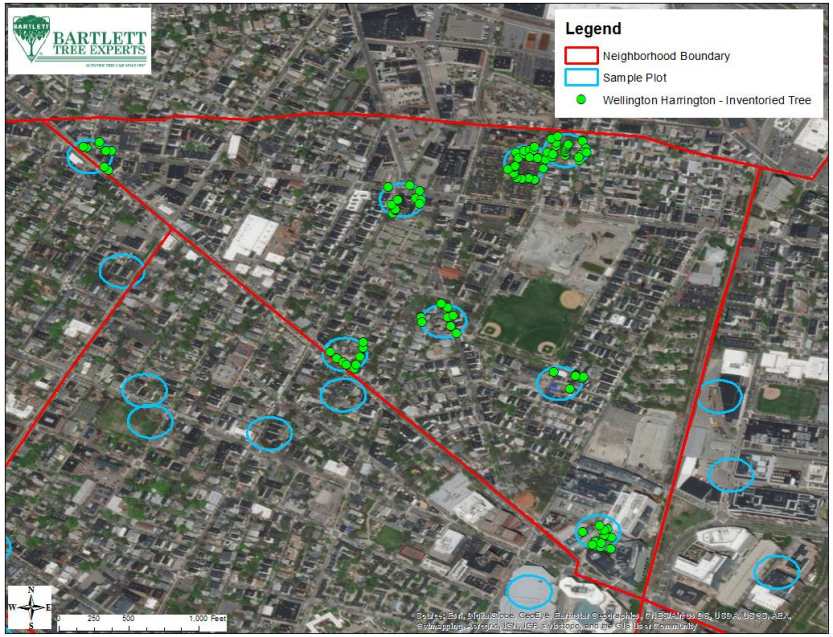
THE PORT (AREA 4) NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



Wellington Harrington Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 111 trees being inventoried in the sample plots located throughout the Wellington Harrington Neighborhood. The data are summarized below.

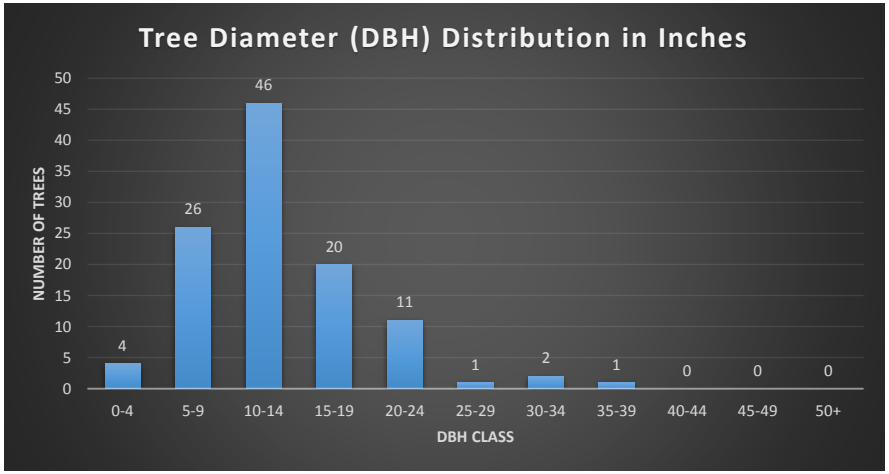
MAP OF INVENTORIED TREES IDENTIFIED IN THE WELLINGTON HARRINGTON NEIGHBORHOOD



WELLINGTON HARRINGTON NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	111	...
Number of Species:	29	...
Number of Trees with Pests Observed:	0	0.00%
Number of Trees Native to Massachusetts:	29	26.13%
Location Type:		
City Property	74	66.67%
Commercial	13	11.71%
Private	24	21.62%
Location:		
Park	28	25.23%
Private	37	33.33%
Tree Pit	46	41.44%
Material:		
Compacted Soil	99	89.19%
Grate	3	2.70%
Turf	9	8.11%
Condition:		
Good	83	74.77%
Fair	18	16.22%
Poor	7	6.31%
Dead	3	2.70%
Age Class:		
New Planting	2	1.80%
Young	3	2.70%
Semi-mature	11	9.91%
Mature	94	84.68%
Over-mature	1	0.90%

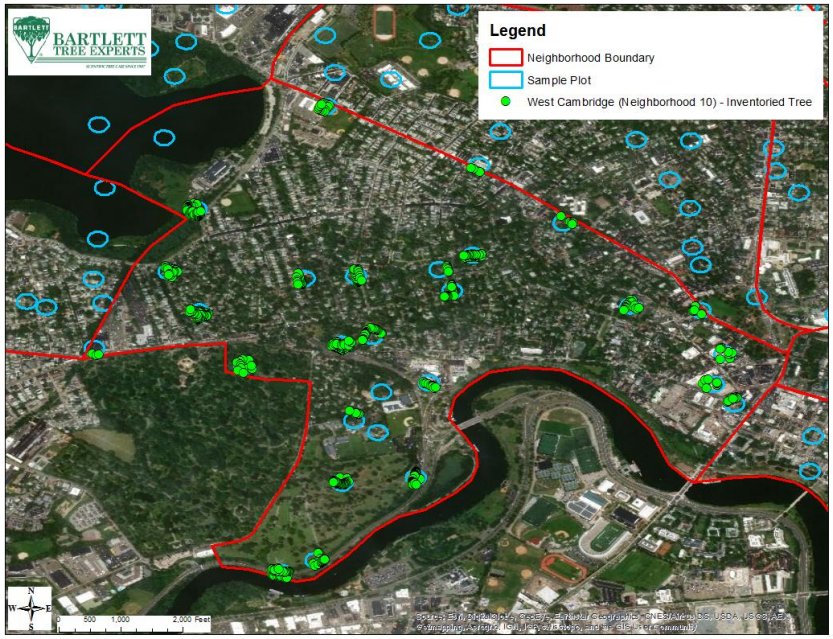
WELLINGTON HARRINGTON NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



West Cambridge (Neighborhood 10) Neighborhood Sample Inventory Summary

The 5% sample tree inventory resulted in 715 trees being inventoried in the sample plots located throughout the West Cambridge (Neighborhood 10) Neighborhood. The data are summarized below.

MAP OF INVENTORIED TREES IDENTIFIED IN THE WEST CAMBRIDGE (NEIGHBORHOOD 10) NEIGHBORHOOD

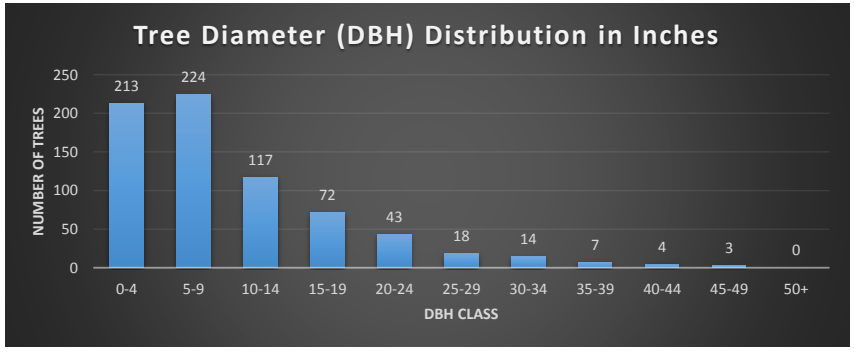


WEST CAMBRIDGE (NEIGHBORHOOD 10) NEIGHBORHOOD SAMPLE INVENTORY SUMMARY

	Total Trees	Percent of Neighborhood Total
Total Trees Inventoried:	715	...
Number of Species:	83	...
Number of Trees with Pests Observed:	7	0.98%
Number of Trees Native to Massachusetts:	318	44.48%
Location Type:		
City Property	300	41.96%
Commercial	19	2.66%

	Total Trees	Percent of Neighborhood Total
Private	292	40.84%
University	104	14.55%
Location:		
Lawn	252	35.24%
Median	15	2.10%
Park	27	3.78%
Private	394	55.10%
Tree Pit	27	3.78%
Material:		
Compacted Soil	16	2.24%
Flexipave	5	0.70%
Grate	5	0.70%
Planting Bed	193	26.99%
Porous Pavement	1	0.14%
Turf	495	69.23%
Condition:		
Good	480	67.13%
Fair	139	19.44%
Poor	60	8.39%
Dead	36	5.03%
Age Class:		
New Planting	4	0.56%
Young	169	23.64%
Semi-mature	293	40.98%
Mature	239	33.43%
Over-mature	10	1.40%

WEST CAMBRIDGE (NEIGHBORHOOD 10) NEIGHBORHOOD TREE DIAMETER DISTRIBUTION CHART



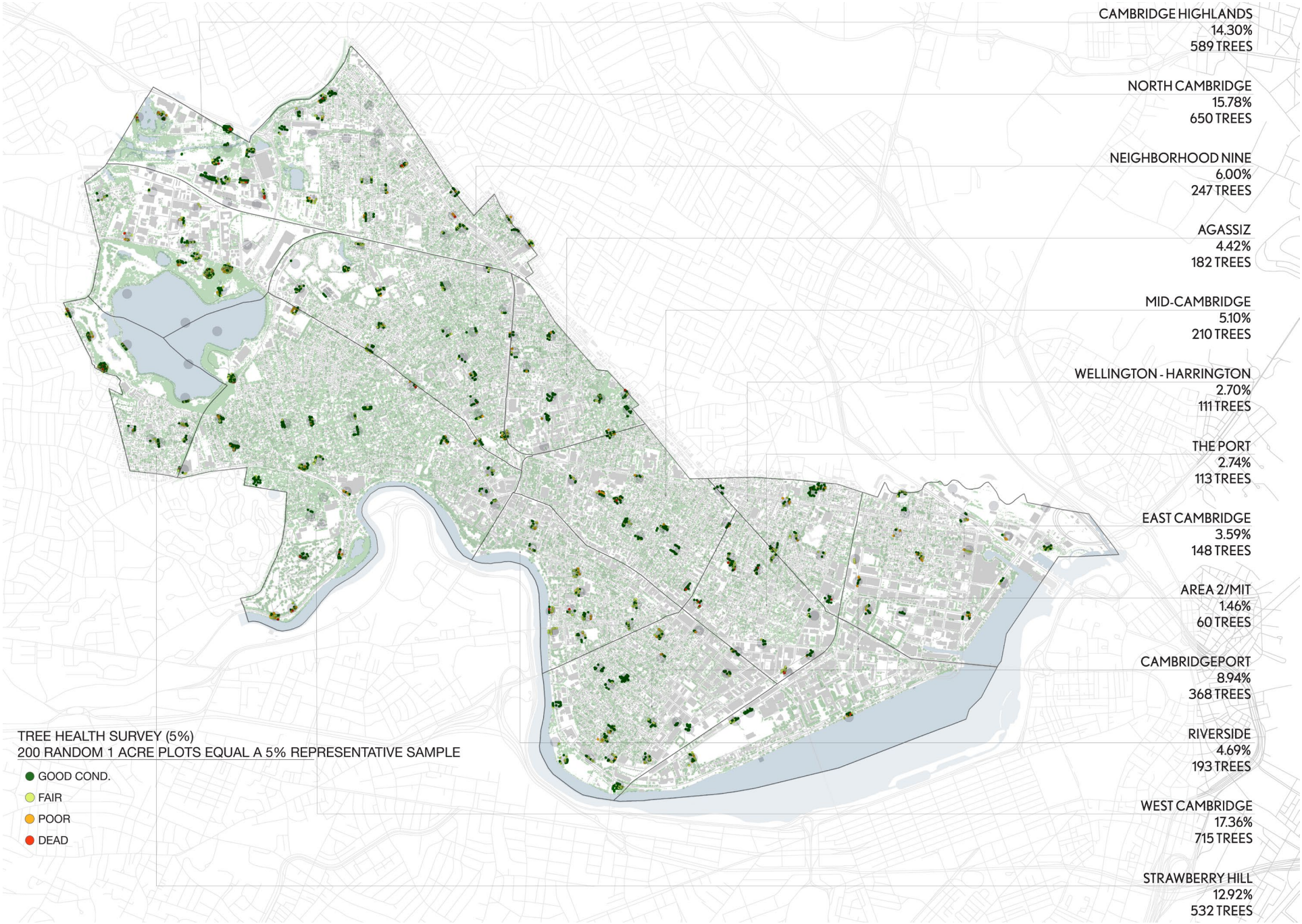
City-wide Summary of the Extrapolation Out to 100%

The 5% sample was extrapolated out to 100% to provide estimates for the entire Cambridge, MA urban forest. The data are summarized below.

CITY-WIDE SUMMARY OF THE EXTRAPOLATION OUT TO 100%

	Total Trees in 5% Sample Inventory	Estimated Tree Totals in 100% Extrapolation	Percent of Total
Trees Inventoried:	4,118	82,360	…
Number of Species:	140	…	…
Number of Trees with Pests Observed:	80	1,600	1.94%
Number of Trees Native to Massachusetts:	1,911	38,220	46.41%
Location Type:			
City Property	2,339	46,780	56.80%
Commercial	321	6,420	7.80%
Private	1,235	24,700	29.99%
University	223	4,460	5.42%
Location:			
Lawn	1,541	30,820	37.42%
Median	38	760	0.92%
Park	230	4,600	5.59%
Private	1,730	34,600	42.01%
Tree Pit	579	11,580	14.06%
Material:			
Compacted Soil	1,230	24,600	29.87%
Flexipave	10	200	0.24%
Grate	37	740	0.90%
Planting Bed	555	11,100	13.48%
Porous Pavement	18	360	0.44%
Turf	2,268	45,360	55.08%
Condition:			
Good	2,563	51,260	62.24%
Fair	1,050	21,000	25.50%
Poor	329	6,580	7.99%
Dead	176	3,520	4.27%
Age Class:			
New Planting	50	1,000	1.21%
Young	1,302	26,040	31.62%
Semi-mature	1,375	27,500	33.39%
Mature	1,358	27,160	32.98%
Over-mature	33	660	0.80%

	Total Trees in 5% Sample Inventory	Estimated Tree Totals in 100% Extrapolation	Percent of Total
Neighborhood Tree Totals:			
Agassiz	182	3,640	4.42%
The Port (Area 4)	113	2,260	2.74%
Cambridge Highlands	589	11,780	14.30%
Cambridgeport	368	7,360	8.94%
East Cambridge	148	2,960	3.59%
Mid-Cambridge	210	4,200	5.10%
MIT/Area 2	60	1,200	1.46%
West Cambridge (Neighborhood 10)	715	14,300	17.36%
Neighborhood 9	247	4,940	6.00%
North Cambridge	650	13,000	15.78%
Riverside	193	3,860	4.69%
Strawberry Hill	532	10,640	12.92%
Wellington Harrington	111	2,220	2.70%


CAMBRIDGE HIGHLANDS
14.30%
589 TREES
NORTH CAMBRIDGE
15.78%
650 TREES
NEIGHBORHOOD NINE
6.00%
247 TREES
AGASSIZ
4.42%
182 TREES
MID-CAMBRIDGE
5.10%
210 TREES
WELLINGTON - HARRINGTON
2.70%
111 TREES
THE PORT
2.74%
113 TREES
EAST CAMBRIDGE
3.59%
148 TREES
AREA 2/MIT
1.46%
60 TREES
CAMBRIDGEPORT
8.94%
368 TREES
RIVERSIDE
4.69%
193 TREES
WEST CAMBRIDGE
17.36%
715 TREES
STRAWBERRY HILL
12.92%
532 TREES
TREE HEALTH SURVEY (5%)
200 RANDOM 1 ACRE PLOTS EQUAL A 5% REPRESENTATIVE SAMPLE
GOOD COND.
FAIR
POOR
DEAD

APPENDIX E: CITY OF CAMBRIDGE CANOPY VALUATION

i-Tree

Ecosystem Analysis

Cambridge

Urban Forest Effects and Values

January 2019

Page 1

Summary

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetation structure, function, and value of the Cambridge urban forest was conducted during 2018. Data from 4117 trees located throughout Cambridge were analyzed using the i-Tree Eco model developed by the U.S. Forest Service, Northern Research Station.

- Number of trees: 4,117
- Tree Cover: 30.47 acres
- Most common species of trees: Norway maple, locust spp, Red maple
- Percentage of trees less than 6" (15.2 cm) diameter: 46.6%
- Pollution Removal: 1351 pounds/year ($35.2 thousand/year)
- Carbon Storage: 1.441 thousand tons ($246 thousand)
- Carbon Sequestration: 38.87 tons ($6.63 thousand/year)
- Oxygen Production: 103.7 tons/year
- Avoided Runoff: 45.3 thousand cubic feet/year ($3.03 thousand/year)
- Building energy savings: N/A – data not collected
- Avoided carbon emissions: N/A – data not collected
- Structural values: $4.67 million

Ton: short ton (U.S.) (2,000 lbs)
Monetary values $ are reported in US Dollars throughout the report except where noted.
Ecosystem service estimates are reported for trees.

For an overview of i-Tree Eco methodology, see Appendix I. Data collection quality is determined by the local data collectors, over which i-Tree has no control.

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I. Tree Characteristics of the Urban Forest

The urban forest of Cambridge has 4,117 trees with a tree cover of Norway maple. The three most common species are Norway maple (10.9 percent), locust spp (5.5 percent), and Red maple (5.2 percent).

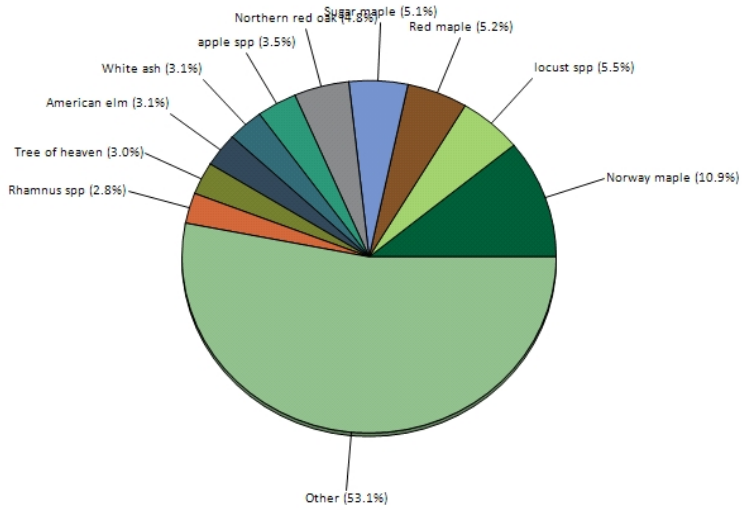


Figure 1. Tree species composition in Cambridge

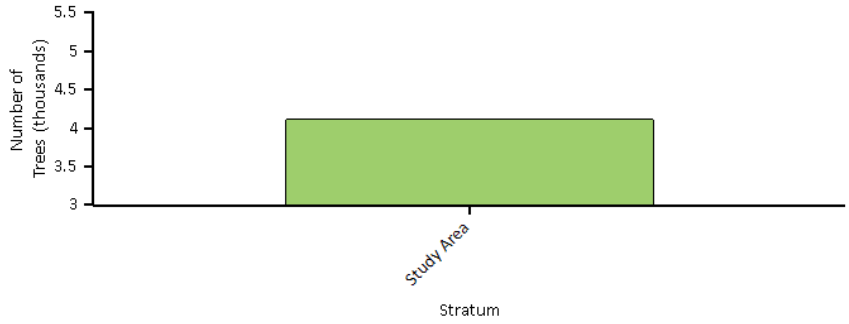


Figure 2. Number of trees in Cambridge by stratum

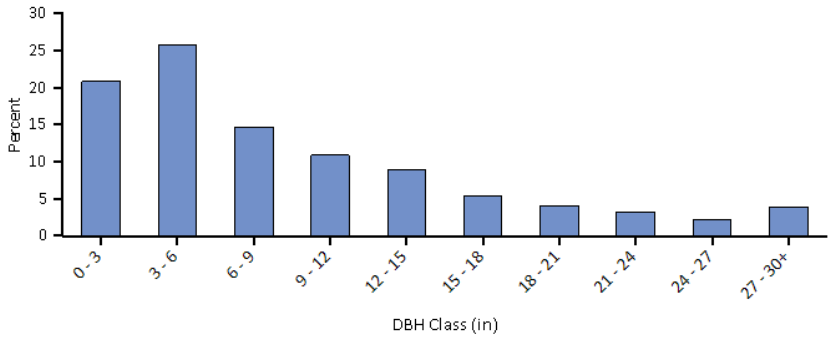


Figure 3. Percent of tree population by diameter class (DBH - stem diameter at 4.5 feet)

Urban forests are composed of a mix of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. Increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Cambridge, about 57 percent of the trees are species native to North America, while 46 percent are native to Massachusetts. Species exotic to North America make up 43 percent of the population. Most exotic tree species have an origin from Europe & Asia (17 percent of the species).

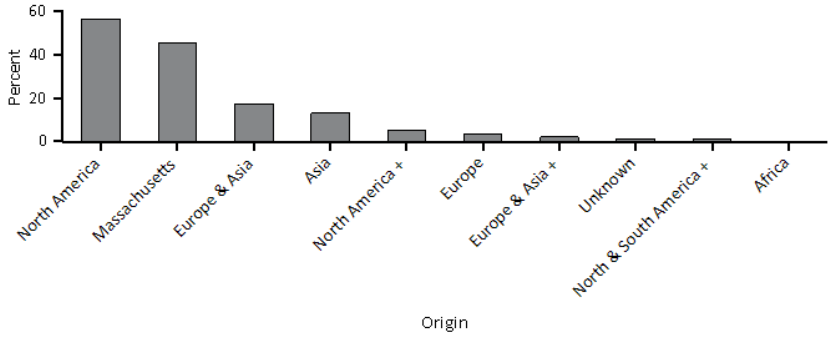


Figure 4. Percent of live tree population by area of native origin, Cambridge

The plus sign (+) indicates the tree species is native to another continent other than the ones listed in the grouping.

Invasive plant species are often characterized by their vigor, ability to adapt, reproductive capacity, and general lack of natural enemies. These abilities enable them to displace native plants and make them a threat to natural areas. Five of the 140 tree species in Cambridge are identified as invasive on the state invasive species list (Massachusetts Invasive Plant Advisory Group 2005). These invasive species comprise 17.7 percent of the tree population though they may only cause a minimal level of impact. The three most common invasive species are Norway maple (10.9 percent of population), Tree of heaven (3.0 percent), and Black locust (1.7 percent) (see Appendix V for a complete list of invasive species).

II. Urban Forest Cover and Leaf Area

Many tree benefits equate directly to the amount of healthy leaf surface area of the plant. Trees cover about 30.47 acres of Cambridge and provide 133.3 acres of leaf area.

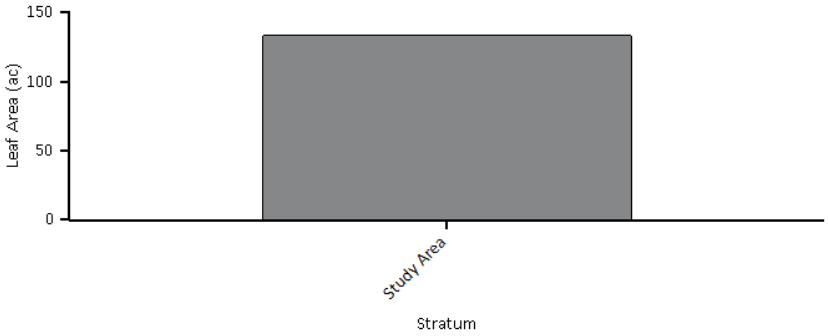


Figure 5. Leaf area by stratum, Cambridge

In Cambridge, the most dominant species in terms of leaf area are Norway maple, Northern red oak, and Red maple. The 10 species with the greatest importance values are listed in Table 1. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values do not mean that these trees should necessarily be encouraged in the future; rather these species currently dominate the urban forest structure.

Table 1. Most important species in Cambridge

Species Name	*Percent Population*	*Percent Leaf Area*	*IV*
Norway maple	10.9	17.2	28.1
Northern red oak	4.8	9.3	14.1
Red maple	5.2	6.1	11.3
Sugar maple	5.1	4.6	9.6
locust spp	5.5	4.0	9.5
American elm	3.1	4.6	7.6
Pin oak	2.7	4.3	7.0
White ash	3.1	2.7	5.8
Tree of heaven	3.0	2.0	5.0
apple spp	3.5	1.5	5.0

Common ground cover classes (including cover types beneath trees and shrubs) in Cambridge are not available since they are configured not to be collected.

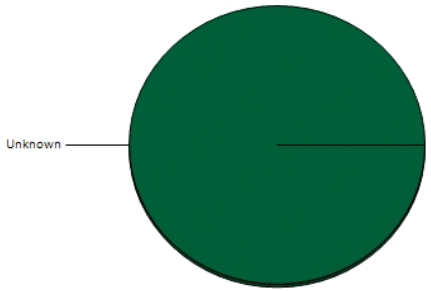


Figure 6. Percent of land by ground cover classes, Cambridge

III. Air Pollution Removal by Urban Trees

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power sources. Trees also emit volatile organic compounds that can contribute to ozone formation. However, integrative studies have revealed that an increase in tree cover leads to reduced ozone formation (Nowak and Dwyer 2000).

Pollution removal[1] by trees in Cambridge was estimated using field data and recent available pollution and weather data available. Pollution removal was greatest for ozone (Figure 7). It is estimated that trees remove 1351 pounds of air pollution (ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 2.5 microns (PM2.5)[2], and sulfur dioxide (SO2)) per year with an associated value of $35.2 thousand (see Appendix I for more details).

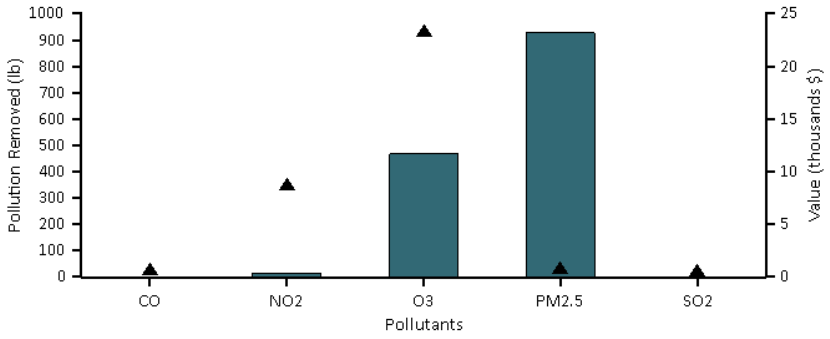


Figure 7. Annual pollution removal (points) and value (bars) by urban trees, Cambridge

[1] Particulate matter less than 10 microns is a significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

[2] Trees remove PM2.5 when particulate matter is deposited on leaf surfaces. This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors (see Appendix I for more details).

In 2018, trees in Cambridge emitted an estimated 669.8 pounds of volatile organic compounds (VOCs) (512.1 pounds of isoprene and 157.7 pounds of monoterpenes). Emissions vary among species based on species characteristics (e.g. some genera such as oaks are high isoprene emitters) and amount of leaf biomass. Fifty- seven percent of the urban forest's VOC emissions were from Northern red oak and Pin oak. These VOCs are precursor chemicals to ozone formation.[3]

General recommendations for improving air quality with trees are given in Appendix VIII.

[3] Some economic studies have estimated VOC emission costs. These costs are not included here as there is a tendency to add positive dollar estimates of ozone removal effects with negative dollar values of VOC emission effects to determine whether tree effects are positive or negative in relation to ozone. This combining of dollar values to determine tree effects should not be done, rather estimates of VOC effects on ozone formation (e.g., via photochemical models) should be conducted and directly contrasted with ozone removal by trees (i.e., ozone effects should be directly compared, not dollar estimates). In addition, air temperature reductions by trees have been shown to significantly reduce ozone concentrations (Cardelino and Chameides 1990; Nowak et al 2000), but are not considered in this analysis. Photochemical modeling that integrates tree effects on air temperature, pollution removal, VOC emissions, and emissions from power plants can be used to determine the overall effect of trees on ozone concentrations.

IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power sources (Abdollahi et al 2000).

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Cambridge trees is about 38.87 tons of carbon per year with an associated value of $6.63 thousand. See Appendix I for more details on methods.

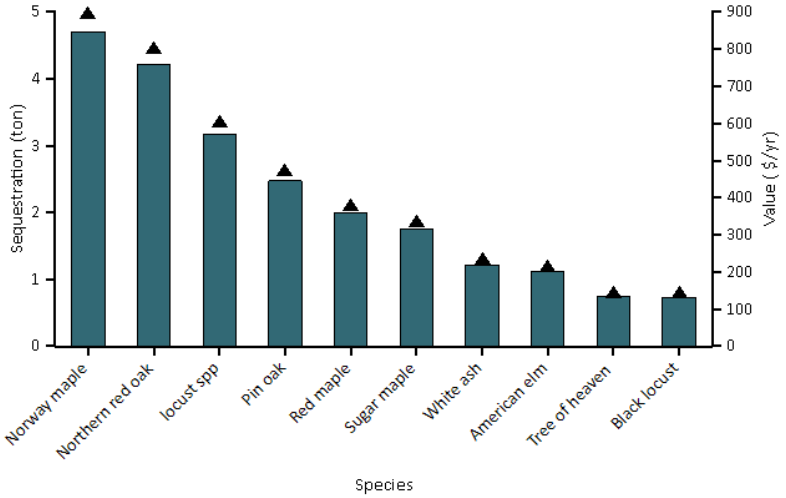


Figure 8. Estimated annual gross carbon sequestration (points) and value (bars) for urban tree species with the greatest sequestration, Cambridge

Carbon storage is another way trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases much of the stored carbon back into the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining healthy trees will keep the carbon stored in trees, but tree maintenance can contribute to carbon emissions (Nowak et al 2002c). When a tree dies, using the wood in long-term wood products, to heat buildings, or to produce energy will help reduce carbon emissions from wood decomposition or from fossil-fuel or wood-based power plants.

Trees in Cambridge are estimated to store 1440 tons of carbon ($246 thousand). Of the species sampled, Northern red oak stores the most carbon (approximately 14.5% of the total carbon stored) and Norway maple sequesters the most (approximately 12.8% of all sequestered carbon.)

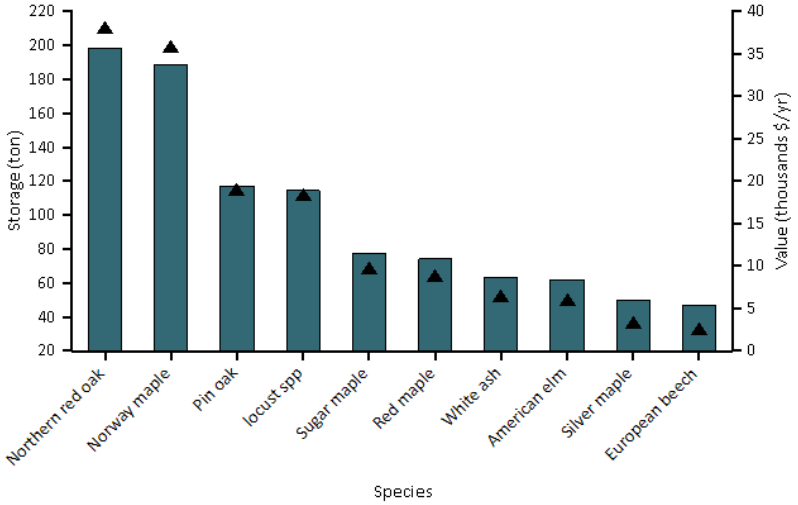


Figure 9. Estimated carbon storage (points) and values (bars) for urban tree species with the greatest storage, Cambridge

V. Oxygen Production

Oxygen production is one of the most commonly cited benefits of urban trees. The annual oxygen production of a tree is directly related to the amount of carbon sequestered by the tree, which is tied to the accumulation of tree biomass.

Trees in Cambridge are estimated to produce 103.7 tons of oxygen per year.[4] However, this tree benefit is relatively insignificant because of the large and relatively stable amount of oxygen in the atmosphere and extensive production by aquatic systems. Our atmosphere has an enormous reserve of oxygen. If all fossil fuel reserves, all trees, and all organic matter in soils were burned, atmospheric oxygen would only drop a few percent (Broecker 1970).

Table 2. The top 20 oxygen production species.

Species	*Oxygen (ton)*	*Gross Carbon Sequestration (ton/yr)*	*Number of Trees*	*Leaf Area (acre)*
Norway maple	13.25	4.97	450	22.87
Northern red oak	11.85	4.44	196	12.41
locust spp	8.93	3.35	226	5.37
Pin oak	6.97	2.61	110	5.73
Red maple	5.59	2.10	216	8.11
Sugar maple	4.93	1.85	209	6.09
White ash	3.41	1.28	128	3.54
American elm	3.14	1.18	127	6.08
Tree of heaven	2.11	0.79	122	2.72
Black locust	2.07	0.78	72	2.49
apple spp	1.97	0.74	143	2.01
River birch	1.73	0.65	83	1.95
Littleleaf linden	1.70	0.64	75	3.40
Black cherry	1.70	0.64	74	1.52
Silver maple	1.51	0.57	33	2.54
European beech	1.39	0.52	24	2.17
Green ash	1.36	0.51	99	3.19
Japanese cherry	1.35	0.51	80	1.31
Callery pear	1.30	0.49	53	1.06
Black walnut	1.19	0.45	29	2.35

VI. Avoided Runoff

Surface runoff can be a cause for concern in many urban areas as it can contribute pollution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff (Hirabayashi 2012). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees and shrubs, however, are beneficial in reducing surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees and shrubs of Cambridge help to reduce runoff by an estimated 45.3 thousand cubic feet a year with an associated value of $3 thousand (see Appendix I for more details). Avoided runoff is estimated based on local weather from the user-designated weather station. In Cambridge, the total annual precipitation in 2015 was 35.6 inches.

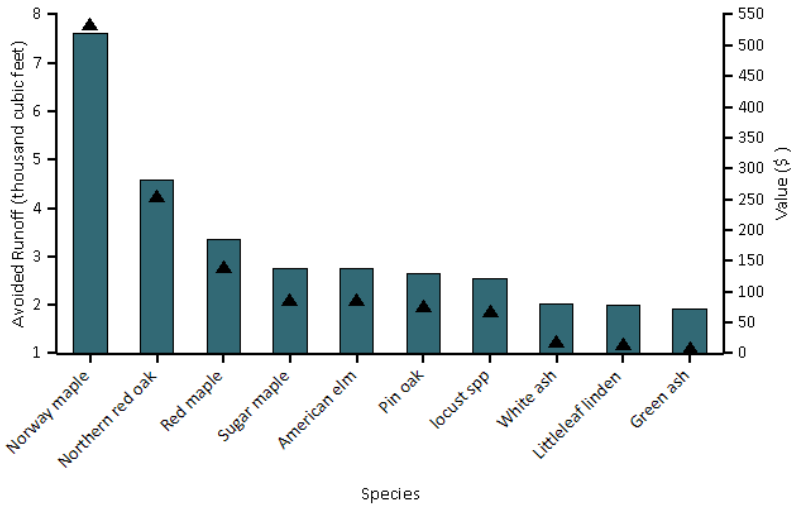


Figure 10. Avoided runoff (points) and value (bars) for species with greatest overall impact on runoff, Cambridge

VII. Trees and Building Energy Use

Trees affect energy consumption by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings (McPherson and Simpson 1999).

Because energy-related data were not collected, energy savings and carbon avoided cannot be calculated.

Table 3. Annual energy savings due to trees near residential buildings, Cambridge

	Heating	*Cooling*	*Total*
MBTU[a]	0	N/A	0
MWH[b]	0	0	0
Carbon Avoided (pounds)	0	0	0

[a]MBTU - one million British Thermal Units

[b]MWH - megawatt-hour

Table 4. Annual savings [a]($) in residential energy expenditure during heating and cooling seasons, Cambridge

	Heating	*Cooling*	*Total*
MBTU[b]	0	N/A	0
MWH[c]	0	0	0
Carbon Avoided	0	0	0

[b]Based on the prices of $149.475 per MWH and $15.6414655508253 per MBTU (see Appendix I for more details)

[c]MBTU - one million British Thermal Units

[c]MWH - megawatt-hour

[5] Trees modify climate, produce shade, and reduce wind speeds. Increased energy use or costs are likely due to these tree-building interactions creating a cooling effect during the winter season. For example, a tree (particularly evergreen species) located on the southern side of a residential building may produce a shading effect that causes increases in heating requirements.

VIII. Structural and Functional Values

Urban forests have a structural value based on the trees themselves (e.g., the cost of having to replace a tree with a similar tree); they also have functional values (either positive or negative) based on the functions the trees perform.

The structural value of an urban forest tends to increase with a rise in the number and size of healthy trees (Nowak et al 2002a). Annual functional values also tend to increase with increased number and size of healthy trees. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

Urban trees in Cambridge have the following structural values:

- Structural value: $4.67 million
- Carbon storage: $246 thousand

Urban trees in Cambridge have the following annual functional values:

- Carbon sequestration: $6.63 thousand
- Avoided runoff: $3.03 thousand
- Pollution removal: $35.2 thousand
- Energy costs and carbon emission values: $0

(Note: negative value indicates increased energy cost and carbon emission value)

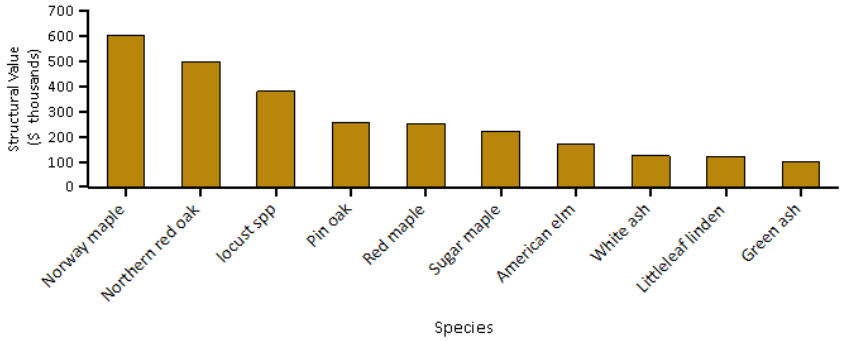


Figure 11. Tree species with the greatest structural value, Cambridge

IX. Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, structural value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ among cities.Thirty-six pests were analyzed for their potential impact and compared with pest range maps (Forest Health Technology Enterprise Team 2014) for the conterminous United States to determine their proximity to Middlesex County. Eleven of the thirty-six pests analyzed are located within the county. For a complete analysis of all pests, see Appendix VII.

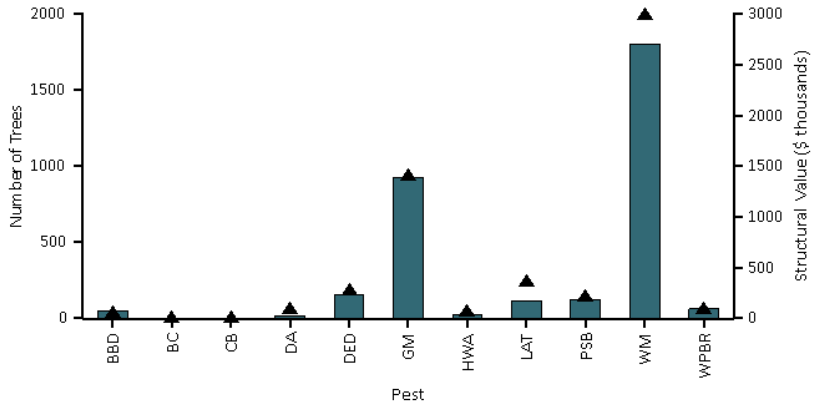


Figure 12. Number of trees at risk (points) and associated compensatory value (bars) for most threatening pests located in the county, Cambridge

Beech bark disease (BBD) (Houston and O'Brien 1983) is an insect-disease complex that primarily impacts American beech. This disease threatens 0.8 percent of the population, which represents a potential loss of $73.4 thousand in structural value.

Butternut canker (BC) (Ostry et al 1996) is caused by a fungus that infects butternut trees. The disease has since caused significant declines in butternut populations in the United States. Potential loss of trees from BC is 0.0 percent ($0 in structural value).

The most common hosts of the fungus that cause chestnut blight (CB) (Diller 1965) are American and European chestnut. CB has the potential to affect 0.0 percent of the population ($0 in structural value).

Dogwood anthracnose (DA) (Mielke and Daughtrey) is a disease that affects dogwood species, specifically flowering and Pacific dogwood. This disease threatens 1.5 percent of the population, which represents a potential loss of $24.2 thousand in structural value.

American elm, one of the most important street trees in the twentieth century, has been devastated by the Dutch

elm disease (DED) (Northeastern Area State and Private Forestry 1998). Since first reported in the 1930s, it has killed over 50 percent of the native elm population in the United States. Although some elm species have shown varying degrees of resistance, Cambridge could possibly lose 4.3 percent of its trees to this pest ($237 thousand in structural value).

The gypsy moth (GM) (Northeastern Area State and Private Forestry 2005) is a defoliator that feeds on many species causing widespread defoliation and tree death if outbreak conditions last several years. This pest threatens 22.6 percent of the population, which represents a potential loss of $1.39 million in structural value.

As one of the most damaging pests to eastern hemlock and Carolina hemlock, hemlock woolly adelgid (HWA) (U.S. Forest Service 2005) has played a large role in hemlock mortality in the United States. HWA has the potential to affect 1.0 percent of the population ($37.7 thousand in structural value).

Quaking aspen is a principal host for the defoliator, large aspen tortrix (LAT) (Ciesla and Kruse 2009). LAT poses a threat to 5.7 percent of the Cambridge urban forest, which represents a potential loss of $175 thousand in structural value.

The pine shoot beetle (PSB) (Ciesla 2001) is a wood borer that attacks various pine species, though Scotch pine is the preferred host in North America. PSB has the potential to affect 3.4 percent of the population ($186 thousand in structural value).

Winter moth (WM) (Childs 2011) is a pest with a wide range of host species. WM causes the highest levels of injury to its hosts when it is in its caterpillar stage. Cambridge could possibly lose 48.3 percent of its trees to this pest ($2.71 million in structural value).

Since its introduction to the United States in 1900, white pine blister rust (Eastern U.S.) (WPBR) (Nicholls and Anderson 1977) has had a detrimental effect on white pines, particularly in the Lake States. WPBR has the potential to affect 1.5 percent of the population ($93.5 thousand in structural value).

Appendix I. i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardized field data and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects (Nowak and Crane 2000), including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power sources.
- Structural value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian longhorned beetle, emerald ash borer, gypsy moth, and Dutch elm disease.

Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings (Nowak et al 2005; Nowak et al 2008).

During data collection, trees are identified to the most specific taxonomic classification possible. Trees that are not classified to the species level may be classified by genus (e.g., ash) or species groups (e.g., hardwood). In this report, tree species, genera, or species groups are collectively referred to as tree species.

Tree Characteristics:

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing. In the event that these data variables were not collected, they are estimated by the model.

An analysis of invasive species is not available for studies outside of the United States. For the U.S., invasive species are identified using an invasive species list (Massachusetts Invasive Plant Advisory Group 2005)for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

Air Pollution Removal:

Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 2.5 microns. Particulate matter less than 10 microns (PM10) is another significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models (Baldocchi 1988; Baldocchi et al 1987). As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature (Bidwell and Fraser 1972; Lovett 1994) that were adjusted depending on leaf phenology and leaf area.

Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere (Zinke 1967). Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values (Hirabayashi et al 2011; Hirabayashi et al 2012; Hirabayashi 2011).

Trees remove PM2.5 when particulate matter is deposited on leaf surfaces (Nowak et al 2013). This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors. Generally, PM2.5 removal is positive with positive benefits. However, there are some cases when net removal is negative or resuspended particles lead to increased pollution concentrations and negative values. During some months (e.g., with no rain), trees resuspend more particles than they remove. Resuspension can also lead to increased overall PM2.5 concentrations if the boundary layer conditions are lower during net resuspension periods than during net removal periods. Since the pollution removal value is based on the change in pollution concentration, it is possible to have situations when trees remove PM2.5 but increase concentrations and thus have negative values during periods of positive overall removal. These events are not common, but can happen.

For reports in the United States, default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter less than 2.5 microns using data from the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP) (Nowak et al 2014). The model uses a damage-function approach that is based on the local change in pollution concentration and population. National median externality costs were used to calculate the value of carbon monoxide removal (Murray et al 1994).

For international reports, user-defined local pollution values are used. For international reports that do not have local values, estimates are based on either European median externality values (van Essen et al 2011) or BenMAP regression equations (Nowak et al 2014) that incorporate user-defined population estimates. Values are then converted to local currency with user-defined exchange rates.

For this analysis, pollution removal value is calculated based on the prices of $1,380 per ton (carbon monoxide), $25,087 per ton (ozone), $2,069 per ton (nitrogen dioxide), $826 per ton (sulfur dioxide), $1,519,374 per ton (particulate matter less than 2.5 microns).

Carbon Storage and Sequestration:

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak 1994). To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

Carbon sequestration is the removal of carbon dioxide from the air by plants. To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1.

Carbon storage and carbon sequestration values are based on estimated or customized local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States (U.S. Environmental Protection Agency 2015, Interagency Working Group on Social Cost of Carbon 2015) and converted to local currency with user-defined exchange rates.

For this analysis, carbon storage and carbon sequestration values are calculated based on $171 per ton.

Oxygen Production:

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net O2 release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition (Nowak et al 2007). For complete inventory projects, oxygen production is estimated from gross carbon sequestration and does not account for decomposition.

Avoided Runoff:

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis.

The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilized and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series (McPherson et al 1999; 2000; 2001; 2002; 2003; 2004; 2006a; 2006b; 2006c; 2007; 2010; Peper et al 2009; 2010; Vargas et al 2007a; 2007b; 2008).

For this analysis, avoided runoff value is calculated based on the price of $0.07 per ft^3.

Building Energy Use:

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature (McPherson and Simpson 1999) using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU are utilized.

For this analysis, energy saving value is calculated based on the prices of $149.48 per MWH and $15.64 per MBTU.

Structural Values:

Structural value is the value of a tree based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree). Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak et al 2002a; 2002b). Structural value may not be included for international projects if there is insufficient local data to complete the valuation procedures.

Potential Pest Impacts:

The complete potential pest risk analysis is not available for studies outside of the United States. The number of trees at risk to the pests analyzed is reported, though the list of pests is based on known insects and disease in the United States.

For the U.S., potential pest risk is based on pest range maps and the known pest host species that are likely to

experience mortality. Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team 2014) were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007).

Relative Tree Effects:

The relative value of tree benefits reported in Appendix II is calculated to show what carbon storage and sequestration, and air pollutant removal equate to in amounts of municipal carbon emissions, passenger automobile emissions, and house emissions.

Municipal carbon emissions are based on 2010 U.S. per capita carbon emissions (Carbon Dioxide Information Analysis Center 2010). Per capita emissions were multiplied by city population to estimate total city carbon emissions.

Light duty vehicle emission rates (g/mi) for CO, NOx, VOCs, PM10, SO2 for 2010 (Bureau of Transportation Statistics 2010; Heirigs et al 2004), PM2.5 for 2011-2015 (California Air Resources Board 2013), and CO2 for 2011 (U.S. Environmental Protection Agency 2010) were multiplied by average miles driven per vehicle in 2011 (Federal Highway Administration 2013) to determine average emissions per vehicle.

Household emissions are based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (Energy Information Administration 2013; Energy Information Administration 2014)

- CO2, SO2, and NOx power plant emission per KWh are from Leonardo Academy 2011. CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information Administration 1994. PM10 emission per kWh from Layton 2004.
- CO2, NOx, SO2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) from Leonardo Academy 2011.
- CO2 emissions per Btu of wood from Energy Information Administration 2014.
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from (British Columbia Ministry 2005; Georgia Forestry Commission 2009).

Appendix II. Relative Tree Effects

The urban forest in Cambridge provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions, average passenger automobile emissions, and average household emissions. See Appendix I for methodology.

Carbon storage is equivalent to:

- Amount of carbon emitted in Cambridge in 1 days
- Annual carbon (C) emissions from 1,020 automobiles
- Annual C emissions from 418 single-family houses

Carbon monoxide removal is equivalent to:

- Annual carbon monoxide emissions from 0 automobiles
- Annual carbon monoxide emissions from 0 single-family houses

Nitrogen dioxide removal is equivalent to:

- Annual nitrogen dioxide emissions from 25 automobiles
- Annual nitrogen dioxide emissions from 11 single-family houses

Sulfur dioxide removal is equivalent to:

- Annual sulfur dioxide emissions from 103 automobiles
- Annual sulfur dioxide emissions from 0 single-family houses

Annual carbon sequestration is equivalent to:

- Amount of carbon emitted in Cambridge in 0.0 days
- Annual C emissions from 0 automobiles
- Annual C emissions from 0 single-family houses

Appendix III. Comparison of Urban Forests

A common question asked is, "How does this city compare to other cities?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the i-Tree Eco model.

I. City totals for trees

City	*% Tree Cover*	*Number of Trees*	*Carbon Storage (tons)*	*Carbon Sequestration (tons/yr)*	*Pollution Removal (tons/yr)*
Toronto, ON, Canada	26.6	10,220,000	1,221,000	51,500	2,099
Atlanta, GA	36.7	9,415,000	1,344,000	46,400	1,663
Los Angeles, CA	11.1	5,993,000	1,269,000	77,000	1,975
New York, NY	20.9	5,212,000	1,350,000	42,300	1,676
London, ON, Canada	24.7	4,376,000	396,000	13,700	408
Chicago, IL	17.2	3,585,000	716,000	25,200	888
Baltimore, MD	21.0	2,479,000	570,000	18,400	430
Philadelphia, PA	15.7	2,113,000	530,000	16,100	575
Washington, DC	28.6	1,928,000	525,000	16,200	418
Oakville, ON , Canada	29.1	1,908,000	147,000	6,600	190
Boston, MA	22.3	1,183,000	319,000	10,500	283
Syracuse, NY	26.9	1,088,000	183,000	5,900	109
Woodbridge, NJ	29.5	986,000	160,000	5,600	210
Minneapolis, MN	26.4	979,000	250,000	8,900	305
San Francisco, CA	11.9	668,000	194,000	5,100	141
Morgantown, WV	35.5	658,000	93,000	2,900	72
Moorestown, NJ	28.0	583,000	117,000	3,800	118
Hartford, CT	25.9	568,000	143,000	4,300	58
Jersey City, NJ	11.5	136,000	21,000	890	41
Casper, WY	8.9	123,000	37,000	1,200	37
Freehold, NJ	34.4	48,000	20,000	540	22

II. Totals per acre of land area

City	*Number of Trees/ac*	*Carbon Storage (tons/ac)*	*Carbon Sequestration (tons/ac/yr)*	*Pollution Removal (lb/ac/yr)*
Toronto, ON, Canada	64.9	7.8	0.33	26.7
Atlanta, GA	111.6	15.9	0.55	39.4
Los Angeles, CA	19.6	4.2	0.16	13.1
New York, NY	26.4	6.8	0.21	17.0
London, ON, Canada	75.1	6.8	0.24	14.0
Chicago, IL	24.2	4.8	0.17	12.0
Baltimore, MD	48.0	11.1	0.36	16.6
Philadelphia, PA	25.1	6.3	0.19	13.6
Washington, DC	49.0	13.3	0.41	21.2
Oakville, ON , Canada	78.1	6.0	0.27	11.0
Boston, MA	33.5	9.1	0.30	16.1
Syracuse, NY	67.7	10.3	0.34	13.6
Woodbridge, NJ	66.5	10.8	0.38	28.4
Minneapolis, MN	26.2	6.7	0.24	16.3
San Francisco, CA	22.5	6.6	0.17	9.5
Morgantown, WV	119.2	16.8	0.52	26.0
Moorestown, NJ	62.1	12.4	0.40	25.1
Hartford, CT	50.4	12.7	0.38	10.2
Jersey City, NJ	14.4	2.2	0.09	8.6
Casper, WY	9.1	2.8	0.09	5.5
Freehold, NJ	38.3	16.0	0.44	35.3

Appendix IV. General Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are (Nowak 1995):

- Temperature reduction and other microclimate effects
- Removal of air pollutants
- Emission of volatile organic compounds (VOC) and tree maintenance emissions
- Energy effects on buildings

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities (Nowak 2000). Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include (Nowak 2000):

Strategy	*Result*
Increase the number of healthy trees	Increase pollution removal
Sustain existing tree cover	Maintain pollution removal levels
Maximize use of low VOC-emitting trees	Reduces ozone and carbon monoxide formation
Sustain large, healthy trees	Large trees have greatest per-tree effects
Use long-lived trees	Reduce long-term pollutant emissions from planting and removal
Use low maintenance trees	Reduce pollutants emissions from maintenance activities
Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
Plant trees in energy conserving locations	Reduce pollutant emissions from power plants
Plant trees to shade parked cars	Reduce vehicular VOC emissions
Supply ample water to vegetation	Enhance pollution removal and temperature reduction
Plant trees in polluted or heavily populated areas	Maximizes tree air quality benefits
Avoid pollutant-sensitive species	Improve tree health
Utilize evergreen trees for particulate matter	Year-round removal of particles

Appendix V. Invasive Species of the Urban Forest

The following inventoried tree species were listed as invasive on the Massachusetts invasive species list (Massachusetts Invasive Plant Advisory Group 2005):

Species Name[a]	*Number of Trees*	*% of Trees*	*Leaf Area (ac)*	*Percent Leaf Area*
Norway maple	450	10.9	22.9	17.2
Tree of heaven	122	3.0	2.7	2.0
Black locust	72	1.7	2.5	1.9
European buckthorn	58	1.4	0.2	0.1
Sycamore maple	26	0.6	1.0	0.8
Total	**728**	**17.68**	**29.25**	**21.94**

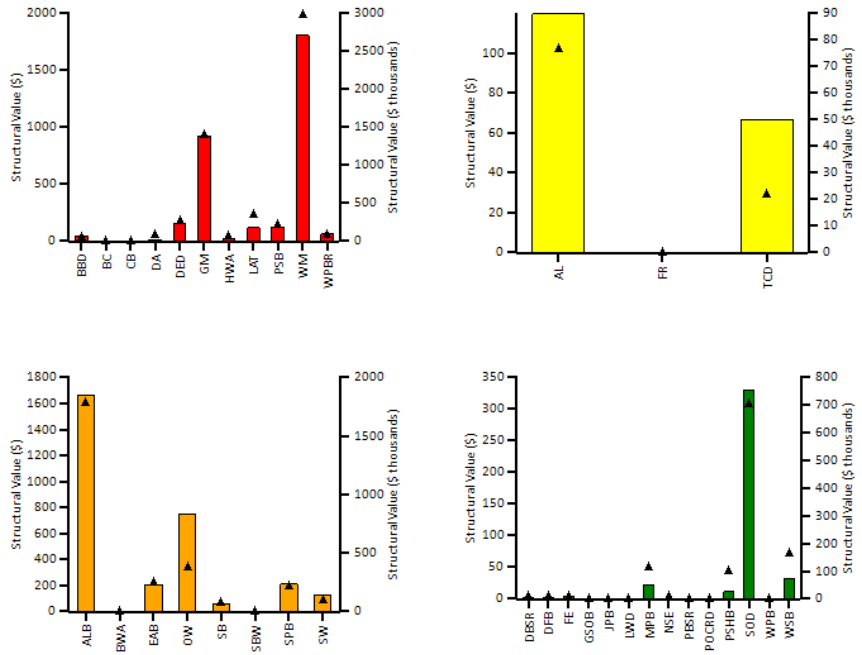
[a]Species are determined to be invasive if they are listed on the state's invasive species list

Appendix VI. Potential Risk of Pests

Thirty-six insects and diseases were analyzed to quantify their potential impact on the urban forest. As each insect/ disease is likely to attack different host tree species, the implications for {0} will vary. The number of trees at risk reflects only the known host species that are likely to experience mortality.

Code	Scientific Name	Common Name	Trees at Risk (#)	Value ($ thousands)
AL	Phyllocnistis populiella	Aspen Leafminer	102	89.86
ALB	Anoplophora glabripennis	Asian Longhorned Beetle	1,601	1,853.41
BBD	Neonectria faginata	Beech Bark Disease	31	73.40
BC	Sirococcus clavigignenti juglandacearum	Butternut Canker	0	0.00
BWA	Adelges piceae	Balsam Woolly Adelgid	3	3.83
CB	Cryphonectria parasitica	Chestnut Blight	0	0.00
DA	Discula destructiva	Dogwood Anthracnose	61	24.18
DBSR	Leptographium wageneri var. pseudotsugae	Douglas-fir Black Stain Root Disease	3	5.67
DED	Ophiostoma novo-ulmi	Dutch Elm Disease	177	236.53
DFB	Dendroctonus pseudotsugae	Douglas-Fir Beetle	3	5.67
EAB	Agrilus planipennis	Emerald Ash Borer	228	227.21
FE	Scolytus ventralis	Fir Engraver	5	8.98
FR	Cronartium quercuum f. sp. Fusiforme	Fusiform Rust	0	0.00
GM	Lymantria dispar	Gypsy Moth	931	1,388.38
GSOB	Agrilus auroguttatus	Goldspotted Oak Borer	0	0.00
HWA	Adelges tsugae	Hemlock Woolly Adelgid	40	37.71
JPB	Dendroctonus jeffreyi	Jeffrey Pine Beetle	0	0.00
LAT	Choristoneura conflictana	Large Aspen Tortrix	235	175.15
LWD	Raffaelea lauricola	Laurel Wilt	0	0.00
MPB	Dendroctonus ponderosae	Mountain Pine Beetle	50	50.93
NSE	Ips perturbatus	Northern Spruce Engraver	4	0.72
OW	Ceratocystis fagacearum	Oak Wilt	339	833.03
PBSR	Leptographium wageneri var. ponderosum	Pine Black Stain Root Disease	0	0.00
POCRD	Phytophthora lateralis	Port-Orford-Cedar Root Disease	0	0.00
PSB	Tomicus piniperda	Pine Shoot Beetle	139	186.24
PSHB	Euwallacea nov. sp.	Polyphagous Shot Hole Borer	44	26.32
SB	Dendroctonus rufipennis	Spruce Beetle	68	60.67
SBW	Choristoneura fumiferana	Spruce Budworm	0	0.00
SOD	Phytophthora ramorum	Sudden Oak Death	307	755.26
SPB	Dendroctonus frontalis	Southern Pine Beetle	197	233.94
SW	Sirex noctilio	Sirex Wood Wasp	90	135.64
TCD	Geosmithia morbida	Thousand Canker Disease	29	50.07
WM	Operophtera brumata	Winter Moth	1,989	2,709.29
WPB	Dendroctonus brevicomis	Western Pine Beetle	0	0.00
WPBR	Cronartium ribicola	White Pine Blister Rust	60	93.54
WSB	Choristoneura occidentalis	Western Spruce Budworm	72	74.06

In the following graph, the pests are color coded according to the county's proximity to the pest occurrence in the United States. Red indicates that the pest is within the county; orange indicates that the pest is within 250 miles of the county; yellow indicates that the pest is within 750 miles of the county; and green indicates that the pest is outside of these ranges.



Note: points - Number of trees, bars - Structural value

Based on the host tree species for each pest and the current range of the pest (Forest Health Technology Enterprise Team 2014), it is possible to determine what the risk is that each tree species in the urban forest could be attacked by an insect or disease.

Spp. Risk	Risk Weight	Species Name	AL	ALB	BBD	BC	BWA	CB	DA	DBSR	DED	DFB	EAB	FE	FR	GM	GSOB	HWA	JPB	LAT	LWD	MPB	NSE	OW	PBSR	POCRD	PSB	PSHB	SB	SBW	SOD	SPB	SW	TCD	WM	WPB	WPBR	WSB
	17	Quaking aspen																																				
	17	White willow																																				
	15	River birch																																				
	15	Paper birch																																				
	15	Gray birch																																				
	14	Eastern white pine																																				
	13	willow spp																																				
	13	Pussy willow																																				
	12	Northern red oak																																				
	12	Pin oak																																				
	12	Norway spruce																																				
	12	Scotch pine																																				
	11	American elm																																				
	11	Swamp white oak																																				
	11	Slippery elm																																				
	11	Siberian elm																																				
	11	White oak																																				
	11	Chestnut oak																																				
	11	Black oak																																				
	11	Scarlet oak																																				
	11	Willow oak																																				
	11	European white birch																																				
	10	Green ash																																				
	10	Austrian pine																																				
	10	Jack pine																																				
	10	Sweet mountain pine																																				
	8	Boxelder																																				
	8	American basswood																																				
	8	White spruce																																				
	8	Douglas fir																																				
	8	English oak																																				
	7	Norway maple																																				
	7	Red maple																																				
	7	Sugar maple																																				
	7	White ash																																				

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structural value calculation assumptions

average tree per Bartlett survey is 9.68 dbh

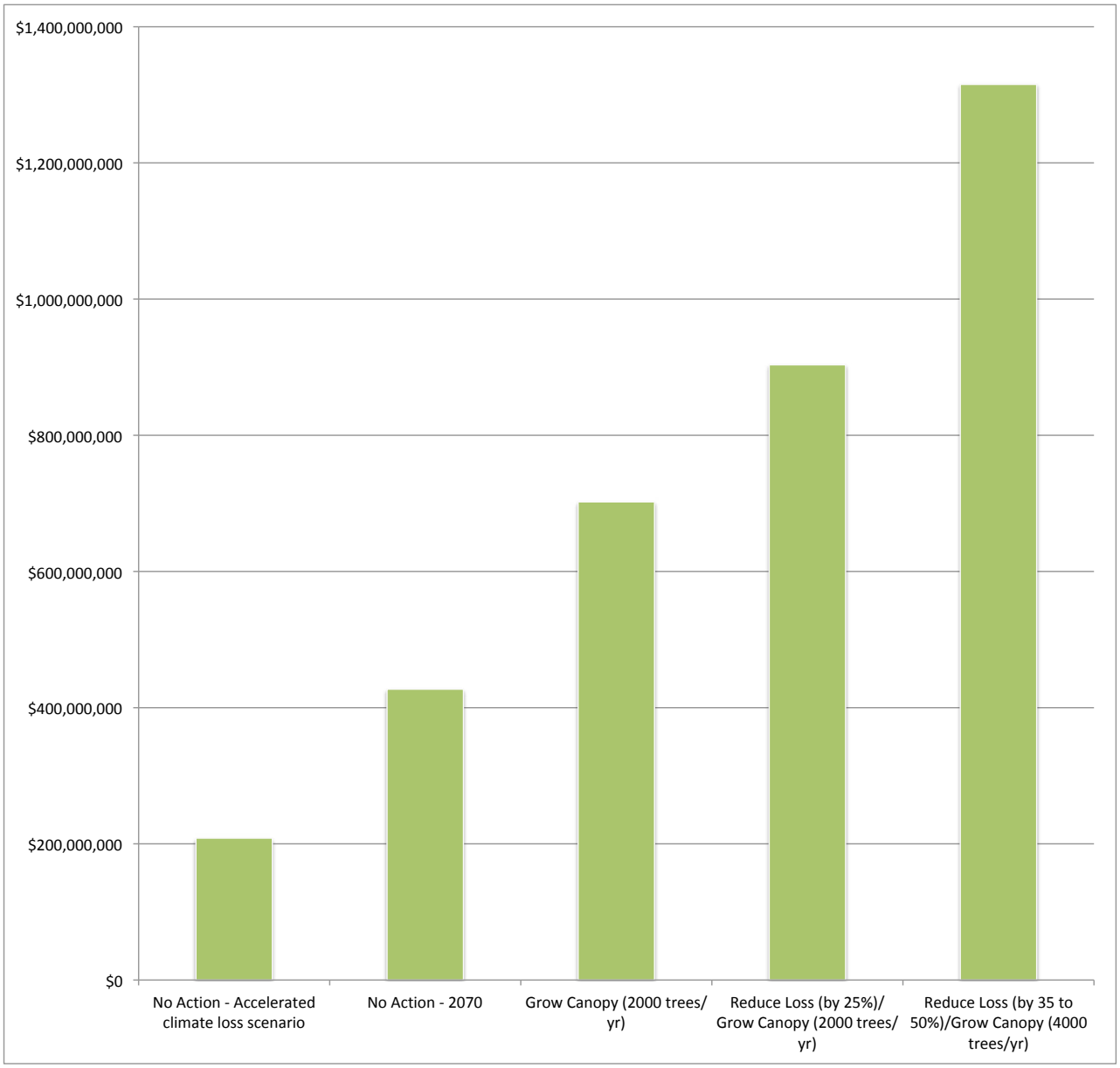
using trunk area formula, average tree, (red oak) with 0.7 condition and 0.7 location rating would be worth $7100

Assume 80,000 trees in Cambridge currently, so total structural value of the forest is 7100*80000

	canopy acres	monetary value			
Current Canopy 2018	1056	$1,309,440		5,567,870	289529240
No Action - 2070	469	$581,560		2472851.354	128588270
Grow Canopy - 2070	797	$988,280		4202265.521	218517807
Reduce Loss/Grow Canopy - 2070	1040	$1,289,600		$5,483,508	285142433
Reduce Loss (by 35 to 50%)/Grow Canopy (4000 trees/y	1520	$1,884,800		$8,014,358	416746633
No Action - Accelerated climate loss scenario	433	$536,920		$1,132,817	58906465

		total benefit	benefit by acres
heat island benefit - annually	5,567,870	$289,529,240	
annual value	1227000		
annual value per acre	1161.931818		
one time value - carbon	6700000		
one time structural value per trunk area formula	568000000		
total one time value	574700000		544223

	monetary value	cumulative acres	one time value	total value
No Action - Accelerated climate loss scenario	$90,439,435	27138.4	$117,933,229	$208,372,664
No Action - 2070	$171,932,920	37304.0	$255,240,814	$427,173,735
Grow Canopy (2000 trees/yr)	$268,484,485	43003.1	$433,746,117	$702,230,602
Reduce Loss (by 25%)/Grow Canopy (2000 trees/yr)	$337,531,352	45087.8	$565,992,424	$903,523,777
Reduce Loss (by 35 to 50%)/Grow Canopy (4000 trees/y	$488,121,781	61428.0	$827,219,697	$1,315,341,478


$1,400,000,000
$1,200,000,000
$1,000,000,000
$800,000,000
$600,000,000
$400,000,000
$200,000,000
$0
No Action - Accelerated climate loss scenario
No Action - 2070
Grow Canopy (2000 trees/ yr)
Reduce Loss (by 25%)/ Grow Canopy (2000 trees/ yr)
Reduce Loss (by 35 to 50%)/Grow Canopy (4000 trees/yr)

APPENDIX F: ARBORICULTURAL RECOMMENDATIONS

PROPOSED MANAGEMENT CHANGES

Recommended Prioritization (to-date) (1= now, 2=short-term, 3=long-term)	Management Practices that Could Be Improved	What's deficient about current practice?	What are benefits of this improvement?	What specific activities are proposed?
1	Tree Inventory	Could Improve: Currently, there is a tree inventory in place that was conducted in 2011 and updated in 2014 and the City is moving toward having contractors that plant new trees inventory them with the Cartegraph system. Inventories, depending on how intensively they are managed, need to be conducted again about every 3 to 5 years and should include existing trees, newly planted trees, and planting opportunities. There is no formal/regular system for updating the inventory, for when and how the inventory will be conducted again, or for training of individuals that will be responsbile for inventorying trees.	A formalized tree inventory policy can help ensure that the city-owned tree inventory is kept up-to-date, remains complete, and help ensure that accurate and consistent tree attribute information is documented. A new 100% tree inventory with consistent data collection and trained personnel will generete a complete baseline to start off with for future management.	Develop and implement a robust tree inventory policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with the existing tree inventory procedures including a complete and up-to-date inventory of all City managed trees, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree inventory procedures; tree inventory program, software, and equipment to be used; specifications on type of inventory to be conducted and what trees would be included; specifications on required features to be collected including trees and potentially shrubs, stumps, and new tree planting opportunities; specifications on required attributes including tree identification, size, condition, management needs, tree work prioritzation, tree risk assessment, and possibly measurements to help quantify environmental benefits; data quality and integrity procedures; monitoring and sampling of documented tree inventory information for oversight purposes; required qualifications of any individual involved in the tree inventory process; descriptions of each attribute field and options if applicable; and proper documentation, 4) determination of if/when volunteers or citizens would be used including specifcations on experience and knowledge and level of training that will be needed, 5) creation of a re-inventory process including: individual(s) responsible for carrying out the re-inventory; required qualifications for any individual involved in the re-inventory process; determination of a re-inventory schedule; specifications on requirements of the re-inventory process; specifications on proper documentation of the re-inventory process, 6) determination of documentation procedures including how the specified program is to be utilized in the field to collect information and how that information will be entered or transferred into the main tree management program, and specifications on information requried to be captured during all phases and aspects of the tree inventory process, 7) annual review of current version of the International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Inventories document to incorporate recent changes or modifications, and 8) annual review of existing tree inventory policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
1	Tree Risk Assessment	Could Improve: Currently, tree risk assessments are conducted in an informal manner on an as-needed basis, with residents reporting the issues some of the times. There is no formal/regular system for assessing trees for risk, including guidelines on the qualifications of the assessor, when to assess, how often to assess, and what level of assessment is.	Formal tree risk assessment procedures would provide increased efficiency, effectiveness, thoroughness, and better demonstrated due-diligence of managing the risks trees pose to the urban environment. The procedures would demonstrate a detailed plan of how Cambridge addresses the risks associated with trees.	Develop and implement a robust tree risk assessment policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with existing tree risk assessment practices, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; industry standard or practice being employeed for tree risk assessment; level of assessment; assessment techniques; assessment tools; risk mitigation recommendations and options; required qualifications of any individual involved in the tree risk assessment process; descriptions of different types and levels of tree risk assessment and when each would be employeed; and guidelines for prioritization of tree risk assessment and mitigation recommendations; and proper documentation, 4) creation of a tree risk assessment inspection process, in conjunction with the existing See Click Fix process, including: individual(s) responsible for carrying out the inspections; required qualifications for any individual involved in the inspection process; determination of re-inspection intervals and site conditions that may require additional re-inspections; specifications on requirements of the inspection process; and specifications on proper documentation of the inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree risk assessment process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Tree Risk Assessment a. Tree Structure Assessment – Part 9 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Risk Assessment documents to incorporate recent changes or modifications, and 7) annual review of existing tree risk assessment policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
2	Irrigation	Could Improve: Currently, the City has several programs, including contract language, in place that provide information on irrigation/watering for newly planted trees. Outside of the contract language, the current documentation does not provide a complete picture of tree and shrub irrigation including written internal documentation and procedures.	A more complete and documented tree and shrub irrigation policy will provide better clarification for City staff on the irrigation process which will help increase survivability of new plantings and existing trees and shrubs.	Develop and implement a robust tree and shrub irrigation policy, which should be in conjunction with the existing new tree planting contracts and irrigation and watering programs and practices, including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree and shrub assessment procedures including plant and soil sampling and anlaysis; specifications on appropriate soil moisture levels for different specimens, locations, and during or after establishment periods; action thresholds; specifications on soil moisture monitoring equipment; specifications on irrigation equipment and systems; timing of irrigation acitivities; application procedures and areas; required qualifications of any individual involved in the tree and shrub irrigation process; descriptions of each tree and shrub irrigation option and procedure and when each would be applied or employeed; guidelines for prioritization of, evaluation of, and additional applications of tree and shrub irrigation options and procedures; specifications on proper documentation of irrigation procedures; and proper documentation, 4) creation of a tree and shrub irrigation needs assessment process including: individual(s) responsible for carrying out the needs assessment process; required qualifications for any individual involved in the needs assessment process; determination of a needs assessment schedule; specifications on requirements of the needs assessment process; and specifications on proper documentation of the needs assessment process, 5) creation of a tree and shrub irrigation monitoring process including: individual(s) responsible for carrying out the monitoring process; required qualifications for any individual involved in the monitoring process; determination of a monitoring schedule; specifications on requirements of the monitoring process; and specifications on proper documentation of the monitoring process, 6) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree and shrub irrigation process, 7) annual review of current versions of: American National Standards Institute (ANSI) A300 Soil Management a. Modification, b. Fertilization, and c. Drainage – Part 2 and Transplanting – Part 6; and International Society of Arboriculture (ISA) Best Management Practices (BMP): Soil Management for Urban Trees and Tree Planting documents to incorporate recent changes or modifications, and 8) annual review of existing tree and shrub irrigation policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	Tree Planting Contract	Could Improve: Currently, the City has a very detailed planting contract. The contract does not account for additional industry specifications and best management practices.	The inclusion of additional specifications for industry standards and best management practices would lead to a higher quality contract resulting in more effective tree planting and higher rates of survivability.	Implement additional requirements or standards into existing tree planting contract including: 1) determination of City goals and objectives for the contract, 2) determination of individual(s) responsible for oversight, enforcement, and modification of the contract, 3) contract specifications including: goals and objectives; updating Applicable Standards section to reflect current editions and inclusion of American National Standards Institute (ANSI) A300 Transplanting – Part 6 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Planting; specification that fertilizer selection will be based off of soil samples; specifications on additional soil management practices outside of the planting hole/pit when applicable, including deceompaction measures; inclusion of new root ball manipulation techniques in the Plant Root Ball section; include specifications on appropriate drainage, evaluation techniques, and modification techniques; specifications on what information is required to be recorded in the main tree management system during the watering process; evaluation procedures for the need of staking all newly planted trees; and evaluation process for the need of trunk wrapping during installation and establishment period, 4) annual review of current version of American National Standards Institute (ANSI) A300 Transplanting – Part 6 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Planting documents to incorporate recent changes or modifications,and 5) annual review of existing tree planting contract and policy goals and objectives to determine if any changes, modifications, or additions are needed.

Recommended Prioritization (to-date) (1= now, 2=short-term, 3=long-term)	Management Practices that Could Be Improved	What's deficient about current practice?	What are benefits of this improvement?	What specific activities are proposed?
	Planting	Could Improve: Currently, specifications on planting is in existing tree planting contracts for external contractors, while there is also some details on planting on the Public Works website. Outside of the contract language, the current documentation does not provide a complete picture of the planting process including written internal documentation and procedures.	A more complete and documented tree and shrub planting policy will provide better clarification for City staff on the planting process which will help increase survivability of new plantings.	Develop and implement a tree and shrub planting policy, which should be in conjuction with existing tree planting contract specifications, including: 1) determination of City goals and objectives for the policy, which should include determination of number of trees to be planted every year that is in line with canopy cover goals, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) documentation of the specifications provided in the existing tree planting contract specifications with the exception of bare root planting practices, 4) creation of a tree and shrub planting opportunity identification process, which should be done in conjunction with tree inventory activities, including: individual(s) responsible for carrying out the identification process; required qualifications for any individual involved in the identification process; determination of an identification process schedule; specifications on requirements of the identification process; and specifications on proper documentation of the identification process, 5) creation of a tree and shrub planting inspection process, in conjunction with the existing See Click Fix process, including: individual(s) responsible for carrying out the tree and shrub planting inspections; required qualifications for any individual involved in the tree and shrub planting inspections; determination of a tree and shrub planting inspection schedule; specifications on requirements of the tree and shrub planting inspections; and specifications on proper documentation of the tree and shrub planting inspections, 6) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree and shrub planting process, 7) annual review of current versions of American National Standards Institute (ANSI) A300 Transplanting – Part 6 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Planting documents to incorporate recent changes or modifications, and 8) annual review of existing planting policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
2	Tree Injection Contracts	Could Improve: Currently, the City has an individual detailed contract for Emerald Ash Borer injections and Dutch Elm Disease specifications included in external pruning contracts for City trees in the rights-of-way and for the parks, cemetery, and water department locations. The written information specific to injection activities and requirements is not as detailed as it could be as inclusion of additional industry certifications and qualifications, and safety requirements are not present and there is not an individual contract for Dutch Elm Disease.	The inclusion of additional specifications for industry standards, qualifications, certifications, safety requirements, and process details would lead to a higher standard of contractor selection, treatment success, and overall tree care.	Implement additional requirements or standards into existing injection contracts for Emerald Ash Borer and Dutch Elm Disease, including creation on an individual Dutch Elm Disease contract, for City trees in the rights-of-way and for parks, cemetery, and water department locations including: 1) determination of City goals and objectives for the contracts, 2) determination of individual(s) responsible for oversight, enforcement, creation, and modification of injection contracts, 3) contract specifications including: goals and objectives; specification that all individuals involved in injection activities be certified arborists through the International Society of Arboriculture (ISA) or Massachusetts Arborist Association (MAA); specification that at least one individual with the International Society of Arboriculture (ISA) Tree Risk Assessment Qualification be on-site at all times; specifications that maintenance sheets, trainings, schedules, and insurance documentation is required to be provided for all equipment; specifically list out all American National Standards Institute (ANSI), International Society of Arboriculture (ISA), and other local, state, and federal regulations and laws that must be adhered to; written documentation or entering into main tree management program of additional tree management needs, justification, prioritization, and tree risk assessment if applicable; removal of tree and branch removal language from injection contracts; review and comparison of injection contract language to pruning contract language to determine consistency in like sections; specifications on how on-site inspections will be conducted including documentation procedures; and specifications on which trees will recieve injection in the current contract; 4) annual review of current versions of: American National Standards Institute (ANSI) Z133 - Safety Requirements and federal, state, and local safety regulations; American National Standards Institute (ANSI) A300 Integrated Vegetation Management a. Electric Utility Rights-of-Way – Part 7, Tree Risk Assessment – Part 9, Integrated Pest Management – 10; and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Injection, Tree Risk Assessment, and Integrated Vegetation Management documents to incorporate recent changes or modifications, and 5) annual review of existing tree injection contracts, policy goals and objectives, and chemical and treatment documentation to determine if any changes, modifications, or additions are needed.
2	Recommended Tree Species Planting List	Could Improve: The current recommended tree species planting list is not reviewed and revised on a regular or consistent basis. There is no documented evalution process of the existing list, existing tree species in the urban forest, and updated invasive and potentially invasive species lists.	A formalized recommended tree species planting list process will create a healthier and more sustainable urban forest with a good balance of native and non-native species to maintain diversity in a changing urban environment.	Develop a robust recommended tree species planting list program including: 1) determination of City goals and objectives for the program, which should include recommended tree species as well as prohibited species, 2) determination of individual(s) responsible for oversight, implementation, modification, and potential enforcement of program specifications, 3) creation of a tree species review process that would include: review of current species diversity in the urban forest; review of current recommended tree species planting list including review of literature on species tendancies; review of existing and potential invasive tree species lists for the Cambridge and Massachusetts area; and review of performance of existing trees and recommended tree species that have been recently planted to evaluate success and failure, 4) creation of a community-wide education system built off of the existing recommended tree species list but should be expanded to include invasive and prohibited species and could also include the benefits each species provides, 5) creation of a monitoring process including: individual(s) responsible for carrying out the monitoring; determination of a monitoring schedule; specifications on requirements of the monitoring process including when and how the monitoring will be conducted; specifications on proper documentation of the monitoring process, 6) determination of documentation procedures including how information will be documented in the field; how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all the monitoring visits, and 7) annual review of existing recommended tree species planting list program to determine if there should be any changes, modifications, or additions.
2	Tree Pruning Contracts	Could Improve: Currently, the City has detailed contracts for cyclic pruning of City trees in the rights-of-way and for the parks, cemetery, and water department locations. The written information specific to tree pruning activities and requirements is not as detailed as it could be as inclusion of additional industry certifications and qualifications, and safety requirements are not present.	The inclusion of additional specifications for industry standards, qualifications, certifications, safety requirements, and process details would lead to a higher standard of contractor selection and overall tree care.	Implement additional requirements or standards into existing pruning contracts for City trees in the rights-of-way and for parks, cemetery, and water department locations including: 1) determination of City goals and objectives for the contracts, including potentially evaluating the inclusion of designation of trees to be pruned in a year based off tree needs, age, and pruning type in conjuction with current determination procedures, 2) determination of individual(s) responsible for oversight, enforcement, and modification of pruning contracts, 3) contract specifications including: goals and objectives; specification that all individuals involved in pruning activities be certified arborists through the International Society of Arboriculture (ISA) or Massachusetts Arborist Association (MAA); specification that at least one individual with the International Society of Arboriculture (ISA) Tree Risk Assessment Qualification be on-site at all times; specifications that maintenance sheets, trainings, schedules, and insurance documentation is required to be provided for all equipment; specifically list out all American National Standards Institute (ANSI), International Society of Arboriculture (ISA), and other local, state, and federal regulations and laws that must be adhered to; written documentation or entering into main tree management program of additional tree management needs, justification, prioritization, and tree risk assessment if applicable; removal of Dutch Elm Disease injection specifications from pruning contract; review and comparison of injection contract language to pruning contract language to determine consistency in like sections; descripctions of additional City tree removal and storm response policies that should be adhered to besides language in the pruning contract; specifications on how on-site inspections will be conducted including documentation procedures; specifications on what types of trees will recieve what type of pruning including descriptions of goals and objectives; and provide clarification on tree removal for if/when the Contractor will conduct removals and what the decision process is, 4) annual review of current versions of: American National Standards Institute (ANSI) Z133 - Safety Requirements and federal, state, and local safety regulations; American National Standards Institute (ANSI) A300 Pruning – Part 1, Integrated Vegetation Management a. Electric Utility Rights-of-Way – Part 7, Tree Risk Assessment – Part 9; and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Pruning, Utility Pruning of Trees, Tree Risk Assessment, and Integrated Vegetation Management documents to incorporate recent changes or modifications, and 5) annual review of existing pruning contracts and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	Pruning	Could Improve: Currently, the only documentation on tree pruning is in existing cyclic pruning contracts for external contractors, laws and regulations on who can prune City trees, and some basic explanations of pruning for public consumption. The current documentation does not provide a complete picture of the pruning process including written internal documentation and procedures, not going into depth on what the evaluation process is and who is involved, and does not state what standard or best management practices followed.	A more complete and documented tree and shrub pruning policy will provide better clarification for City staff and the public on all aspects of pruning of city-owned trees and shrubs and better demonstrate due-diligence and due-process.	Develop and implement tree and shrub pruning policies in addition to existing external pruning contracts and existing practices including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree and shrub evaluation procedures; action thresholds; specifications on types of pruning methods and cuts; determining amount of pruning; timing of pruning activities; required qualifications of any individual involved in the tree and shrub pruning process; descriptions of each pruning method and when each would be employeed; guidelines for prioritization of pruning including tree risk assessment; establishment of pruning crews responsible for different pruning types, locations, and/or in response to storms; and proper documentation, 4) creation of a tree and shrub pruning evaluation process, in conjunction with the existing See Click Fix process, including: individual(s) responsible for carrying out the pruning evaluations; required qualifications for any individual involved in the pruning evaluations; determination of a pruning evaluation schedule; and specifications on requirements of the pruning evaluations; specifications on proper documentation of the pruning evaluations, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree and shrub pruning process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Pruning – Part 1 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Pruning documents to incorporate recent changes or modifications, and 7) annual review of existing pruning policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.

Recommended Prioritization (to-date) (1= now, 2=short-term, 3=long-term)	Management Practices that Could Be Improved	What's deficient about current practice?	What are benefits of this improvement?	What specific activities are proposed?
1	Tree and Shrub Preservation (outside of construction/development projects)	Could Improve: The City has some documentation on tree preservation, but mainly as it is related to construction/development projects. There is no formal independent tree preservation policy or guidelines to help guide the City and Citizens on maintaining trees including the potential for creating a historic tree definition and enforcement, damages, and specific tree protection activities and monitoring outside of construction/development projects.	A more expansive, detailed, and formalized tree and shrub preservation policy will make preservation more important for the City and citizens throughout the urban forest at all times and not just during construction/development projects. A preservation policy will help maintain and/or improve the existing urban forest, canopy cover, tree and shrub health, and treesand shrubs including potentially historic specimens.	Develop and implement tree and shrub preservation policies in addition to existing regulations, laws, and practices including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of additional policy specifications including: goals and objectives; establishment of criteria for different levels of tree and shrub classification and potential impacts on level of preservation activities, monitoring, and damages; tree and shrub evaluation procedures based off of up-to-date inventory information; specifications on preservation activities and methods including activities not allowed; specifications on required preservation signage and information required; required qualifications of any individual involved in the preservation of trees and shrubs; descriptions of each preservation activitiy or method and when each would be applied or employeed; guidelines for prioritization of, evaluation of, and additional need of preservation activities; and proper documentation, 4) creation of additional tree and shrub preservation materials for for internal, contractor, citizen, and neighborhood education, 5) creation of a tree and shrub preservation monitoring process including: specimens that would be included in monitoring activities; individual(s) responsible for carrying out the monitoring; required qualifications for any individual involved in the preservation process; determination of a monitoring and inspection schedule in general and on an individual project basis; specifications on requirements of the monitoring and inspection process; and specifications on proper documentation and reporting of the monitoring and inspection process, 6) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree preservation policy, 7) annual review of current versions of American National Standards Institute (ANSI) A300 and International Society of Arboriculture (ISA) Best Management Practices (BMP) documents to incorporate recent changes or modifications, and 8) annual review of existing tree and shrub preservation policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
1	Tree Information Documentation/Management Software	Could Improve: The new program Cartegraph is still being implemented. Cartegraph will need to be a requirement for all parties involved with tree management to utilize and maintain. Review of existing tree information demonstrated inconsistencies in attribute fields and how, when, and who documented tree information.	Having one system for documenting tree information creates the most effective way to maintain, update, and manage tree information. Requiring all parties involved with tree management to utilize the system will help keep all tree related information up-to-date and accurate and help share the responsibility for managing the large amount of information. Having one system, with a standard list of attributes and how to measure and record that information will create efficiency and accuracy and lead to a larger trained force to document tree information.	Continue to implement, review, and train staff on the Cartegraph system, including contractors, with very specific and streamlined information to be documented on a regular basis
3	Tree and Shrub Infrastructure Interaction	Could Improve: Currently, the only documented infrastructure interactions are tree grates and that process is conducted by numerous individuals. There are numerous infrastructure interactions that don't seem to be accounted for, there is no formalized inspection and monitoring process, and there is no standarized documentation.	The ability to have up-to-date and accurate accounting of all current and potential tree and shrub infrastructure interactions can help provide increased efficiency and effectiveness when planning mitigation efforts, help prevent damage to trees increasing health and longevity, help reduce infrastructure damage and their associated repair costs, and help reduce the risks associated with tree and infrastructure interactions.	Develop and implement a robust tree and shrub infrastructure interaction program including: 1) determination of City goals and objectives for the program, which should be in conjunction with current grate monitoring and root management activities, 2) determination of individual(s) responsible for oversight and enforcement of the program, 3) determination of program specifications including: goals and objectives; a tree and shrub evaluation process; tree or shrub species and size; type of infrastructure interaction; action threshold and tree risk assessment procedures; management specifications; required qualifications of any individual involved in the tree and shrub infrastructure interaction program; description of tree and shrub infrastructure interaction including when different types of management would be employeed; guidelines for prioritization of work including tree risk assessment results and level of or damage to infrastructure; and proper documentation, 4) creation of a tree and shrub infrastructure interaction monitoring process including: individual(s) responsible for carrying out the monitoring; required qualifications for any individual involved in the monitoring process; determination of monitoring intervals and site conditions that may require additional monitoring visits; specifications on requirements of the monitoring process including recommendations and tree risk assessment; and specifications on proper documentation of the monitoring process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during the tree and shrub infrastructure interaction monitoring process, and 6) annual review of existing tree and shrub infrastructure interaction program, progess over the past year, and program goals and objectives to determine if any aspect of the program needs any changes, modifications, or additions.
	Stump Removal/Grinding	Could Improve: Stump removal/grinding is currently conducted in-house and are generally handled at one time or in a large group. Stump grinding could be conducted on a more regular basis and with a dedicated crew to create efficiences.	A more formalized stump removal/grinding program would create efficiences in handling stump removal/grinding by having regularly scheduled days and a consistent crew. Having stumps addressed more regularly would also help eliminate the risk that stumps pose to pedestrians and provide opportunities to use those locations in a quicker fashion.	Develop a more robust stump removal/grinding program including: 1) determination of City goals and objectives for the program, 2) determination of individual(s) responsible for oversight and enforcement of the program, 3) determination of program specifications including: goals and objectives; an evaluation process to determine the need for removal including tree risk assessment; location and infrastruture details; details on the species and size of the stump; specifications on equipment needed; required qualifications of any individual involved in the stump removal/grinding process; and guidelines for prioritization of work including tree risk assessment results; and proper documentation, 4) creation of a monitoring process, in conjunction with the existing See Click Fix process, including: individual(s) responsible for the monitoring process; monitoring intervals; specifications on requirements of the monitoring process; and specifications on proper documentation of the monitoring process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during the all phases and aspects of the stump removal/grinding program, and 6) annual review of existing stump removal/grinding program, progess over the past year, and program goals and objectives to determine if any aspect of the program needs any changes, modifications, or additions.
3	Tree Removal	Could Improve: A partial tree removal policy is in place with brief explanations of when public trees can be removed and tree hearing notices. The current documentation does not provide a complete picture of the tree removal process including not going into depth on what the tree removal evaluation process is and who is involved, does not state what standard or best management practice is used to determine a hazard tree, and does not state what happens if a tree removal request is not approved.	A more complete and documented tree removal policy will provide better clarification for City staff and the public on all aspects of removal of city-owned trees and better demonstrate due-diligence and due-process.	Develop and implement a robust tree removal policy including: 1) determination of City goals and objectives for the policy, which should be in conjuction with existing tree removal procedures, tree hearing notice procedures, and state laws, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree evaluation process for determination of the need for tree removal including tree risk assessment; type of management recommended; potential quantification of environmental benefits provided; evaluation of number of requests for removal and past work conducted on the tree; required qualifications of any individual involved in the tree removal process; description of the tree removal process including when different techniques or equipment should be used; and guidelines for prioritization of work including tree risk assessment results; and proper documentation, 4) creation of a more robust and detailed tree removal evaluation process, in conjunction with the existing See Click Fix process, including: individual(s) responsible for carrying out the evaluation; required qualifications for any individual involved in the evaluation process; specifications on requirements of the evaluation process; tree risk assessment and standards or practices used; management recommendations and specifications; specifications on the re-evaluation process if removal is not recommended; and specifications on proper documentation of the inspection process, 5) determination of level/type of information or report to be provided to citizen, neighborhood, company, or institution requesting removal, if applicable, 6) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree removal process, 7) more detailed information on the entire tree removal process incorporated into the Public Works website including: process steps; tree risk assessment standards or practices used; and alternatives to tree removal, and 8) annual review of existing tree removal policy including changes to state laws, progess over the past year, and policy goals and objectives to determine if any aspect of the policy needs any changes, modifications, or additions.

Recommended Prioritization (to-date) (1= now, 2=short-term, 3=long-term)	Management Practices that Could Be Improved	What's deficient about current practice?	What are benefits of this improvement?	What specific activities are proposed?
	Soil Management for Urban Trees and Shrubs	Could Improve: Soil management currently only consists of incorporation of Biochar and soil specifications for new plantings. Soil management for established trees and additional aspects of soil management have not been implemented.	Propert soil management can help increase tree and shrub longevity, establishment, growth, and health in urban soils that are often times not ideal for tree and shrub growth.	Develop and implement a robust soil management for urban trees and shrubs policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with the existing new planting and management during construction projects practices, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; soil assessment procedures including sampling and anlaysis; specifications on appropriate soil conditions including pH and compaction; action thresholds; specifications on modification options and procedures including mulching, timing of modification options and procedures; application procedures and areas; specifications on how fertilizer and biological agents should be handled and stored; required qualifications of any individual involved in the soil management for urban trees process; descriptions of each mitigation option and procedure and when each would be applied or employeed; guidelines for prioritization of, evaluation of, and additional applications of modification options and procedures; and guidelines on soil conservation; and proper documentation, 4) creation of a tree and soil monitoring and inspection process including: individual(s) responsible for carrying out the monitoring and inspections; required qualifications for any individual involved in the monitoring and inspection process; determination of a monitoring and inspection schedule; specifications on requirements of the monitoring and inspection process; and specifications on proper documentation of the monitoring and inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the soil management for urban trees process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Soil Management a. Modification, b. Fertilization, and c. Drainage – Part 2 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Soil Management for Urban Trees documents to incorporate recent changes or modifications, and 7) annual review of existing soil management for urban trees policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
3	Integrated Pest Management	Could Improve: Pest management currently only consists of City contracts for tree injections for Emerald Ash Borer and Dutch Elm Disease for specific trees. Additional aspects of integrated pest management, including additional species for management, have not been implemented.	Integrated pest management can help increase the survivability, appearance, value, structure, and health of trees and shrubs in the landscape. Proper management can help reduce stress to the plants leading to better health and longevity. Integrated pest management can also lead to less tree and shrub loss due to pests and diseases and could increase the number of species available to Cambridge to plant if they would have pest management provided.	Develop and implement a robust integrated pest management policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with the existing external contacts for Emerald Ash Borer and Dutch Elm Disease injections, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; action thresholds; specifications on control tactics and options; timing of control applications and rates; application procedures and areas; specifications on how chemical and biological agents should be handled and stored; required qualifications of any individual involved in the integrated pest management process; descriptions of each control tactic and when each would be applied or employeed; guidelines for prioritization of, evaluation of, and additional applications of control measures; and proper documentation, 4) creation of a tree and shrub monitoring and inspection process including: individual(s) responsible for carrying out the monitoring and inspections; required qualifications for any individual involved in the monitoring and inspection process; determination of a monitoring and inspection schedule; specifications on requirements of the monitoring and inspection process; and specifications on proper documentation of the monitoring and inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the integrated pest management process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Integrated Pest Management – Part 10 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Integrated Pest Management documents to incorporate recent changes or modifications, and 7) annual review of existing integrated pest management prolicy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	Tree Tourism	Could Improve: Currently, there are several tours and events, including for the Tree City USA program, in Cambridge where trees are a part of the program. There is no formal tree tourism program specific to trees or the urban forest.	A more robust tree tourism program will lead to more community awareness of the exisitng tree population, history as it relates to the trees, and provide avenues for visitors to learn more about the trees in Cambridge and specifically draw tourists for the trees. These activities could also provide avenues for more funding for the urban forestry program and public awareness.	Develop a tree tourism program including: 1) determination of City goals and objectives for the program, which should be done in conjuction with the existing Tree City USA program and tours and events, 2) determination of individual(s) responsible for oversight and operation of the program, 3) determination of individual(s) responsible for outreach and working directly with City, state, and regional tourism officials, 4) identification and analysis of additional local, state, regional, national, and potentially international tourism events and activities that the City could be involved with including Earth Day and Arbor Day, 5) determination of program specifications including: goals and objectives; continual evaluation of the Cambridge tourism website and calendar for events where the trees and urban forest could be involved and highlighted; potential creation of a community calendar on the Public Works webiste dedicated to upcoming tree and urban forest events; determination of trees in the urban forest that could be used for tourism activities including historic trees, trees on historic properties, unique specimens, and state champion trees; identification of external partners and relationships that could assist with tourism acitivites and promotions including international tree and plant society organizations; specifications on how trees and urban forest would be promoted as tourism articles including: signage, interactive webiste, and dedicated tree tours; and creation of tree tourism promotional materials which may include flyers, websites, social media, software applications, and television and radio outlets, and 6) annual review of existing tree tourism program, progess over the past year, and program goals and objectives to determine if any changes, modifications, or additions are needed.
	Staffing	Could Improve: Currently, the City feels they need more staff to create an additional in-house crew because it can take several weeks to months to close our work orders. There is also not enough staff t to properly oversee existing external contractor contracts and oversee the new planting program adequately. As new programs or policies are put in place, the existing staff will not be large enough to properly oversee and implement them.	An increase in the size of the forestry staff would decrease the time it takes to close out work-orders and increasing Citizen, neighborhood, and City satisfaction with the forestry department and overall urban forestry program. Increasing staff will also increase efficiency in existing programs and operations and provide the ability to create and implement new programs to improve the overall urban forest.	Develop and implement a robust staffing policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with the existing staff and staffign procedures, 2) determination of individual(s) responsible for oversight and implementation of the policy, 4) determination of individual(s) responsible for determining need of additional staff members in specific areas, 5) determination of policy specifications including: goals and objectives; written staff descriptions, job responsibilities, and flow chart, including in all necessary languages and forms; regularly scheduled urban forest program evaluations and meetings, including assessment of See Click Fix request close out times, to determine the need for hiring additional staff which should include supervisor to crew member ratios; specifications on determining what activities will required external contractors and when those determinations will be made; determination of programs that require individual supervisors including one for all tree and shrub planting programs, external contract oversight and evaluation, citizen and neighborhood involvement and acitivies, and safety requirements and standards; formalized training programs; determination of trainings to be conducted by external consultants; determination of external trainings required for staff; specifications on support that will be provided to staff for obtaining and maintaining required professional qualifications and credentials; and proper documentation and reporting procedures; and required qualifications of any individual involved in any aspect of tree and urban forest management including internal staff and external contractors, 6) creation of a performance review process including: individual(s) responsible for carrying out the performance reviews; required qualifications for any individual involved in the performance review process; determination of a performance review schedule; specifications on requirements of the performance review process including specific tasks and operations to be reviewed; and specifications on proper documentation of the performance review process, 7) determination of documentation procedures including: justification for additional staff; job descriptions and required qualifications;cperformance reviews; and specfications on information requried to be captured during all phases and aspects of the staffing process, and 8) annual review of existing staffing policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.

Recommended Prioritization (to-date) (1= now, 2=short-term, 3=long-term)	Management Practices that Could Be Improved	What's deficient about current practice?	What are benefits of this improvement?	What specific activities are proposed?
1	Safety Standards and Requirements	Could Improve: Safety standards, requirements, and policies are not described or explained in a manual, handbook, or guideline book for staff members.	Documented safety standards, requirements, and policies help to create a safe working environment. Internal standards provide a plan to follow that can assist with up-to-date training, retraining, and formal documentation of all aspects of the safety program creating a safer work environment and help reduce accidents.	Develop and implement a robust safety standards and requirements policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with the existing safety standard and requirement policies including existing language in external contracts, 2) identification and analysis of all applicable safety standards and requirements with all aspects of managing trees and an urban forest, 3) determination of individual(s) responsible for oversight and enforcement of the policy, 4) determination of individual(s) responsible for individual portions of the policy including: training personnel; conducting safety meetings; and conducting safety audits, 5) determination of policy specifications including: goals and objectives; written safety procedures, in all necessary languages and forms, for all aspects of tree and urban forest management including appropriate personal protection equipment; display of written safety goals, objectives, standards, requirements, and benefits where all staff can see and/or read; formalized training programs including: regularly scheduled safety meetings, job briefings, trainings and re-trainings on all equipment and procedures; determination of trainings to be conducted by external consultants; determination of external safety trainings required for staff; specifications on support that will be provided to staff for obtaining and maintaining required safety and professional qualifications and credentials; and proper documentation and reporting procedures; and required qualifications of any individual involved in any aspect of tree and urban forest management including internal staff and external contractors, 6) creation of a safety audit process including: individual(s) responsible for carrying out the safety audit; required qualifications for any individual involved in the safety audit process; determination of a safety audit schedule; specifications on requirements of the safety audit process inclduing details on auditing indivduals, contractors, work sites, equipment, and vehicles; specifications on proper documentation of the safety audit process, 7) determination of documentation procedures including how information will be documented during safety meetings, inspections of equipment, field safety audits, safety trainings, and safety violations; and specficiations on information requried to be captured during all phases and aspects of the safety standards and requirements process, 8) annual review of current versions of the American National Standards Institute (ANSI) Z133 - Safety Requirements and federal, state, and local safety regulations documents to incorporate recent changes or modifications, and 9) annual review of existing safety standards and requirements policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	Managing Trees During Construction	Could Improve: The City does have a written Tree Protection during Construction document and David Leftcourt does present on this topic to all contractors in the spring. The written document could be improved by providing more detail and specifications on the entire tree preservation process including more information on tree protection plan and work schedule specifications, proper signage, details on the size of the tree protection area and how to calculate it, etc.	Management of trees during all phases of consturction/development projects can assist with proper selection of trees to protect and preserve, increase likelihood of tree survival during and after the project through proper protection techniques, reduce tree loss from projects or project related loss after the project, and help preserve design intent.	Develop and implement managing trees during construction policies in addition to existing regulations, laws, and practices including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of additional policy specifications including: goals and objectives; inclusion of City staff in the planning, design, pre-construction, construction, and post-construction phases; site assessment procedures including review of plans, impacts, and tree protection measures and materials; specifications on requirements of ridged fence materials and construction; tree protection and critical root zone calculations based on tree species, condition, and age; additional pre-construction management including for soils and soil protection, pests, diseases, and irrigation; specifications on required tree protection signage including size, locations, and information required; required qualifications of any individual involved in the management of trees and shrubs during the construction process; descriptions of each construction management option and procedure and when each would be applied or employeed; guidelines for prioritization of, evaluation of, and additional applications of construction management procedures and operations; and proper documentation and reporting procedures, 4) creation of a tree and shrub monitoring and inspection process including: individual(s) responsible for carrying out the monitoring and inspections; required qualifications for any individual involved in the monitoring and inspection process; determination of a monitoring and inspection schedule in general and on an individual project basis; specifications on requirements of the monitoring and inspection process; specifications on proper documentation and reporting of the monitoring and inspection process, 5) determination of documentation procedures including: how information will be documented in the field and how that information will be entered or transferred into the main tree management program; specifications on information requried to be captured during all phases and aspects of the managing trees during construction process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Management of Trees and Shrubs During Site Planning, Site Development, and Construction – Part 5 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Managing Trees During Construction documents to incorporate recent changes or modifications, and 7) annual review of existing soil management for urban trees policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	Citizen and Neighborhood Involvement	Could Improve: Currently, the City has a See Click Fix program, Adopt-A-Tree program, Tree Planting programs, Forestry programs, and the Public Works website in place to provide ways for citizens and neighborhoods to get and stay involved. There are numerous additional ways that citizens and neighborhoods could be more involved outside of requesting work, requesting new trees, establishing a commerative tree, or aiding in the watering of trees.	Citizen and neighborhood level involvement with the urban forest can help create community level support for the care and preservation of the entire urban forest. Involving citizens and entire neighborhoods in certain aspects of the decision-making process, goal setting, responsibility and work, and future of the trees and urban forest can help create buy-in and a feeling of ownership which can help strengthen the urban forest and entire urban forest program.	Develop a more robust citizen and neighborhood involvement program including: 1) determination of City, citizen, and neighborhood goals and objectives for the program, which should be done in conjuction with existing programs, 2) determination of individual(s) responsible for oversight and operation of the program, which should include citizen and neighborhood representatives as well as City staff, 3) creation of a citizen and neighborhood involvement community calendar including scheduled meetings and programs, 4) creation of a community educational component and specifications which may include: social applications; tree information pages or documents; and promotional materials covering benefits of trees or possibly a newsletter, 5) citzen and neighborhood involvement and responsibilities in the areas of: updating tree information; managing new tree plantings; continutation of existing established programs; and monitoring of trees, 6) specifications on potential incentives for citizen and neighborhood involvement in tree management related activities, and 7) annual review of existing citizen and neighborhood involvement program, progess over the past year, and program goals and objectives to determine if any changes, modifications, or additions are needed.
	Tree Donations and Commerative Trees	Could Improve: Currently, the City has a Commerative Tree program where you can have a tree planted to mark a significant event. The existing program does not take into account existing trees or provide very much information on the program.	Tree donation and commerative tree programs can be further developed and implemented to provide funding for planting new trees or to provide funding for care for existing trees. These programs can calso provide an avenue for citizens, companies, etc. to be more involved with the trees in the urban forest and increase overall management and sustainability.	Develop a more robust tree donation and commerative tree program including: 1) determination of City goals and objectives for the program, which should be done in conjuntion with the existing commerative tree program, 2) determination of individual(s) responsible for oversight, administration, and operation of the program, 3) determination of program specifications including: goals and objectives; review of existing commerative tree program; determination of existing trees that are eligible for the tree donation program and how/if new plantings would be accommodated; the existing monetary level of donation required and if monetary levels will be different based on if it is an existing tree or new planting, or based on tree species, size, or location; determination of where the monetary donations will go and what types of tree related activities it can be spent on; level of public notification and involvement; creation of a tree donation website, form, or flyer and system to track all information and requests; specifications on what/how much information can be be conveyed with the donation and how the donor, City, and citizens can interact with that information; specifications on whether the usage of tree plaques, stakes, or signs will be used and their specifications; and guidelines for timing and prioritizaton of donations, 4) creation of a monitoring process including: individual(s) responsible for carrying out the monitoring and inspections; determination of a monitoring schedule; specifications on requirements of the monitoring process; specifications on proper documentation of the monitoring process; and specifications on the level of information, if any, to be provided back to the tree donor following monitoring visits and how the information will be conveyed, 5) determination of documentation procedures including how information will be documented in the field and how/if that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during monitoring visits, and 6) annual review of existing tree donation and commerative tree program, progess over the past year, and program goals and objectives to determine if any changes, modifications, or additions are needed.
	Storm Response	Could Improve: Currently, the City has some detail on storm response on the Public Works website and is also covered to a limited degree in the existing external pruning contracts. The current documentation does not provide a complete picture of the storm response process including not going into depth on what the evaluation process is and who is involved.	A more complete and documented storm response policy will provide better clarification for City staff and the public on all aspects of storm response and better demonstrate due-diligence and due-process.	Develop and implement a more robust storm response program, which should be done in conjuction with existing storm response language in external pruning contracts, including: 1) determination of City goals and objectives for the program, 2) determination of individual(s) responsible for oversight and enforcement of the program, 3) determination of program specifications including: goals and objectives; inspection procedures; action thresholds including thresholds for when City staff or external contractors would be used; specifications on types of recommendations and mitigation following existing City tree management policies; required qualifications of any individual involved in the storm response process; descriptions of each work or mitigation type and when each would be employeed; guidelines for prioritization of work including tree risk assessment; establishment of City crews responsible for response to storms and their responsibilities; and proper documentation, 4) creation of a storm response inspection process, in conjunction with the existing See Click Fix process, including: individual(s) responsible for carrying out the storm response inspections; required qualifications for any individual involved in the storm response inspections; determination of a storm response inspection schedule and route; specifications on requirements of the storm response inspections; and specifications on proper documentation of the storm response inspections, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the storm response process, and 6) annual review of existing storm response program, contract language, and program goals and objectives to determine if any changes, modifications, or additions are needed.
	Green and Sustainability Initiative Program	Could Improve: Currently, the City has green and sustainability initiatives, like the Green Fleet inititative and an ordinance for leaf blowers, that have to do with becoming more green and sustainable as far as emissions. These initiatives could be expanded to more oeprating areas of the urban forest program.	A more robust green and sustainability initiatve program could provide benchmarks for the City and its external contractors to meet that can help guide and influence city-wide tree management so that all practices become more sustainable and produce fewer emissions to help meet City goals.	Implement a more robust green and sustainability initiative program including: 1) determination of City goals and objectives for the program, which should include the existing initiatives, ordinances, and quantification of the environmental benefits provided by the canopy cover, 2) determination of individual(s) responsible for oversight, enforcement, identification, and implemention of green and sustainability initiative program, 3) determination of specifications including: goals and objectives; benchmarks and progess measurement protocols; and when and where new green and sustainability initiatives will be in effect, including when City staff and external contractors have to abide by program policies, 4) creation of promotional materials which may include: informative flyers; adding to existing Public Works websites; social media; and television and radio outlets, and 5) annual review of existing green and susttainability initiative program, progess over the past year, and program goals and objectives to determine if any changes, modifications, or additions are needed.

Recommended Prioritization (to-date) (1= now, 2=short-term, 3=long-term)	Management Practices that Could Be Improved	What's deficient about current practice?	What are benefits of this improvement?	What specific activities are proposed?
1	Documentation of Policies/Programs	Currently, the City has very few policies and programs documented in a written format.	Complete and thorough documentation of City management practices would provide a baseline for accounting and program evaluation, provide training materials for City staff, and provide clear and specific documenation for all parties involved with trees and tree management.	Create an internal management policies/programs operating manual including: 1) determination of City goals and objectives for the manual, 2) documentation of all appropriate operating policies/programs (i.e. human resources, safety procedures, best management practices including descriptive steps, and training documentation) for City staff and external contractors, 3) determination of the individual(s) and their qualifications, training, or experience that will be responsible for creation of, updating, and training City staff and external contractors on the appropriate aspects of the manual, 4) determination of the individual(s) responsible for oversight of policy/program adherence, 5) specifications on how and when documentation of City staff and external contractor adherence to policies/programs will be conducted, 6) annual policies/programs self-assessment to guage effectiveness of City staff and external contractor adherence to stated policies and programs, and 7) annual review of existing policies/procedures to evaluate their effectiveness and appropriateness, issues over the past year, and goals and objectives to determine if any changes, modifications, or additions are needed
	Management Practices that Could be Implemented			
3	Integrated Vegetation Management	Not a current practice	Integrated vegetation management can promote sustainable tree and plant communities and prevent invasive and other unwanted trees and plants from establishing in management areas, helping to reduce management costs and creating a more sustainable urban forest.	Develop and implement an integrated vegetation management policy including: 1) determination of City goals and objectives for the policy, which should be inconjuction with existing utility pruning specifications and require that the contractor have a utility vegetation manager be involved, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree and shrub evaluation process for determination of the need for integrated vegetation management including determined action thresholds and site evaluations; specifications on appropriate control methods and when each method would be employed; required qualifications of any individual involved in the integrated vegetation management process; guidelines for prioritization of management applications; and proper documentation, 4) creation of a monitoring and inspection process including: individual(s) responsible for carrying out the monitoring and inspections; required qualifications for any individual involved in the monitoring and inspection process; determination of a monitoring and inspection schedule; specifications on requirements of the monitoring and inspection process; and specifications on proper documentation of the monitoring and inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the integrated vegetation management process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Integrated Vegetation Management a. Electric Utility Rights-of-Way – Part 7 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Integrated Vegetation Management documents to incorporate recent changes or modifications, and 7) annual review of existing integrated vegetation management prolicy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
1	Private Tree Care and Oversight	Not a current practice	More City involvement with private tree care activities could lead to better overall success of City management practices, better preservation of trees throughout the entire City, the potential for larger-scale efforts to improve and protect the entire urban forest, and a potenital healthier and more sustainable urban forest.	Develop an initial private tree care and oversight policy including: 1) determination of City goals and objectives for the policy, which should include community programs or hearings for the citizens and neighborhoods, 2) determination of whether implemented activities will be guidelines or treated as City policy or regulations; what form enforcement will take; and damages/fines if guidelines, policies, or regulations are not adhered to, 3) determination of individual(s) responsible for oversight, implementation,and enforcement of policies or regulations and/or presentation of guidelines, 4) determination of areas of private tree care and oversight that the City would like to initially implement which may include: determination of tree species to have oversight over; tree locations to have oversight over; tree sizes to have oversight over; creation of new tree protection policies/guidelines or expansion of existing city policies to private property construction projects; and creation of new tree removal policies/guidelines or expansion of existing city policies to private property, 4) creation of a community-wide education and feedback system to cover all aspects of City oversight for private tree care including documentation, explanations, and specifications for activities that the City will provide oversight for on private property; and a feedback and evaluation program, 5) specifications on potential incentives for adhering to established guidelines, policies, or regulations, 6) determination of documentation procedures including how information will be documented in the field and how/if that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of private tree care that the City is providing oversight for, and 7) annual review of existing private tree care and oversight policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
3	Tree and Shrub Root Management	Not a current practice	Propert treeand shrub root management can assist with tree stability, maintain tree health, increase longevity, and help with managing root interaction with infrastructure.	Develop and implement a robust tree and shrub root management policy including: 1) determination of City goals and objectives for the policy, which should be in conjunction with established root management procedures for new plantings and management of trees on constuction/development sites, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree and shrub evaluation process; type of management needed; action threshold and tree risk assessment procedures; management specifications; required qualifications of any individual involved in the tree and shrub root management process; description of tree and shrub root management including when different types of management would be employeed; and guidelines for prioritization of work including tree risk assessment results and level of or damage to infrastructure, 4) creation of a tree and shrub root inspection process including: individual(s) responsible for carrying out the inspections; required qualifications for any individual involved in the inspection process; determination of re-inspection intervals and site conditions that may require additional re-inspections; specifications on requirements of the inspection process; and specifications on proper documentation of the inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree and shrub root management process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Root Management - Part 8 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Root Management documents to incorporate recent changes or modifications, and 7) annual review of existing tree root management policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
2	Tree Lightning Protection Systems	Not a current practice	Lightning protection systems can help protect vulnerable trees from damage or death from lightning strikes by providing a preferred path to the ground for lightning. Some protection can be provided to buildings that are close to tall trees with lightning protection systems installed.	Develop and implement a robust tree lightning protection system policy including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree evaluation process for determination of the need of a lightning protection system including tree risk assessment; type of system; system specifications; maintenance specification; required qualifications of any individual involved in the tree lightning protection process; description of tree lightning protection systems including when each system would be employeed; guidelines for prioritization of work including tree risk assessment results; and proper documentation, 4) creation of a lightning protection system inspection process including: individual(s) responsible for carrying out the inspections; required qualifications for any individual involved in the inspection process; determination of reinspection intervals and site conditions that may require additional reinspections; specifications on requirements of the inspection process; and specifications on proper documentation of the inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree lightning protection system process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Lightning Protection - Part 4 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Lightning Protection Systems documents to incorporate recent changes or modifications, and 7) annual review of existing tree lightning protection system policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.

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1	Tree Supplemental Support Systems	Not a current practice	Tree supplemental support systems can help reduce the risk of tree or tree part failure, lower the overall risk rating for a tree, increase the survivability of a tree, increase the longevity of a tree or tree part, and can provide options to help maintain an existing tree versus tree removal.	Develop and implement a robust tree supplemental support system policy including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree evaluation process for determination of the need of a supplemental support system including tree risk assessment, type of system; system specifications; maintenance specifications; required qualifications of any individual involved in the tree supplemental support system process; descriptions of cabling, bracing, guying, and propping systems including when each system would be employeed; guidelines for prioritization of work including tree risk assessment results; and proper documentaiton, 4) creation of a tree supplemental support system inspection process including: individual(s) responsible for carrying out the inspections; required qualifications for any individual involved in the inspection process; determination of reinspection intervals and site conditions that may require additional reinspections; specifications on requirements of the inspection process; specifications on proper documentation of the inspection process, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree supplemental support system process, 6) annual review of current versions of American National Standards Institute (ANSI) A300 Supplemental Support Systems – Part 3 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree Support Systems: Cabling, Bracing, Guying, and Propping documents to incorporate recent changes or modifications, and 7) annual review of existing tree supplemental support system policy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
3	Tree and Shrub Fertilization	Not a current practice	Proper fertilization can improve soil conditions and help provide essesntial elements that are lacking in urban soils. Trees and shrubs can have increased survivability, increased growth, possible improved fruiting and flowering, better health, better longevity, and an increased ability to resists pest and disease attack with proper fertilization.	Develop and implement a robust tree and shrub fertilization policy including: 1) determination of City goals and objectives for the policy, 2) determination of individual(s) responsible for oversight and enforcement of the policy, 3) determination of policy specifications including: goals and objectives; tree and shrub evaluation process for determination of the need of fertilization including soil testing and plant analysis; specifications on fertilizer selectio; timing of applications and fertilizer rates; application procedures and areas; specifications on how fertilizer should be handled and stored; and proper documentation; required qualifications of any individual involved in the tree and shrub fertilization process; descriptions of fertilizers and when each would be applied; guidelines for prioritization of applications; and proper documentation, 4) creation of a tree and shrub monitoring and inspection process including: individual(s) responsible for carrying out the monitoring and inspections; required qualifications for any individual involved in the monitoring and inspection process; determination of a monitoring and inspection schedule; specifications on requirements of the monitoring and inspection process; and specifications on proper documentation of the monitoring and inspection process, 5) determination of documentation procedures including: how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the tree and shrub fertilization process, 6) annual review of current version of the American National Standards Institute (ANSI) A300 Soil Management a. Modification, b. Fertilization, and c. Drainage – Part 2 and International Society of Arboriculture (ISA) Best Management Practices (BMP): Tree and Shrub Fertilization documents to incorporate recent changes or modifications, and 7) annual review of existing tree and shrub fertilization polivy, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	Recycled/Reclaimed Water Usage Program	Not a current practice	The use of recycled/reclaimed water can reduce the amount of potable water in the landscape. Reducing the amount of potable water used in the landscape makes more available for human consumption, can help reduce the amount needed in the landscape if water resources become limited, and could help reduce water costs.	
	Wildlife Management	Not a current practice	Taking into consideration the wildlife (i.e. birds) that may utilize the trees and urban forest in the goals, objectives, and work tree work that is conducted can lead to a more sustainable ecosystem. Wildlife is an important part of the urban forest and ecosystem and can provide additional benefits, a healthier entire ecosystem, and provide tourism opportunities when planned for.	
	Urban Wood Waste Utilization	Not a current practice	Urban forest wood waste utilization has been identified as an essential component of the sustainable urban forest management system. Utilizing this material as a valuable resource rather than treating it as a waste can have both environmental and economic benefits including; environmental sustainability, the avoidance of disposal or tipping fees, the opportunity to generate products for use elsewhere in the community, and avoidance of shipping or transportation costs.	
	Urban Forest Canopy Cover Goal	Not a current practice	An urban forest canopy cover goal provides a benchmark for the City to meet that can help guide and influence city-wide tree management so that the goal can be achieved.	Determine an urban forest canopy cover goal policy including: 1) determination of City goals and objectives for the policy, which may include the quantification of the environmental benefits provided by the canopy cover, 2) determination of the desired urban forest canopy cover percentage including cover on city-owned, private, commercial, and institutional property; and a total combined percentage, 3) determination of a year when the urban forest canopy cover goal is desired to be met, 4) specifications on how canopy cover will be determined including city boundaries land cover type time of year to be measured; and programs, software, equipment, or procedures to be followed to measure canopy cover, 5) determination of documentation procedures including how information will be documented in the field and how that information will be entered or transferred into the main tree management program; and specifications on information requried to be captured during all phases and aspects of the urban forest canopy cover process, and 6) annual review of existing canopy cover, progess over the past year, and policy goals and objectives to determine if any changes, modifications, or additions are needed.
	City-wide Tree and Shrub Management Plan	Not a current practice	An initial city-wide management plan conveys all information collected during a tree inventory including stand dynamics, risk related information, and tree work recommendations and priorities in an easy to understand document and in a format that provides a path for where tree management should begin. The management plan can also include environmental benefit quantification information, future planting opportunities, and budget information. The inital management plan can then become the baseline and can be updated and modified as information is provided.	Develop and implement a city-wide tree and shrub management plan including: 1) determination of City goals and objectives for the management plan which should take into account urban forest canopy cover goals, 2) determination of the management level and details each property type (city-owned, public, commercial, institutional) within the City boundaries will receive, 3) documentation of all aspects of tree and shrub management (i.e. pruning, removal, supplemental support systems, soil management,and tree risk assessment) including which trees require which type of management, tree location, tree identification, and prioritization, 4) determination of the individual(s) that will be responsible for creation of and updating the management plan, 5) determination of the individual(s) that will be responsible for tracking annual progress toward management plan goals and objectives, 6) specifications on how and when documentation of City staff and external contractor adherence to policies/procedures will be conducted, 7) annual self-assessment of progress toward management plan goals and objectives, and 8) annual review of the existing management plan to evaluate its effectiveness and appropriateness; progress towards goals and objectives; issues over the past year; and policy goals and objectives to determine if any changes, modifications, or additions are needed.

APPENDIX G: CLF CAMBRIDGE UFMP PUBLIC OPINION SURVEY RESULTS

Introduction & Methodology

A public opinion survey was conducted to collect information about Cambridge residents' opinions on the urban forest to help inform the development of the Urban Forest Master Plan. This report represents the results of the survey among 1,643 respondents between the dates of September 5, 2018 to December 6, 2018. The survey was completed by respondents primarily online using the SurveyHero platform. A screenshot of the online survey interface is included below.

Respondents were asked a series of questions related to the urban forest in Cambridge as well as optional demographic questions. Some respondents chose to exit the survey before completion and therefore not all questions have the same sample size.

Survey questions were designed to answer four key research questions:

What are Cambridge residents' perceptions of existing tree canopy condition?

What are Cambridge residents' awareness of existing programs and policies?

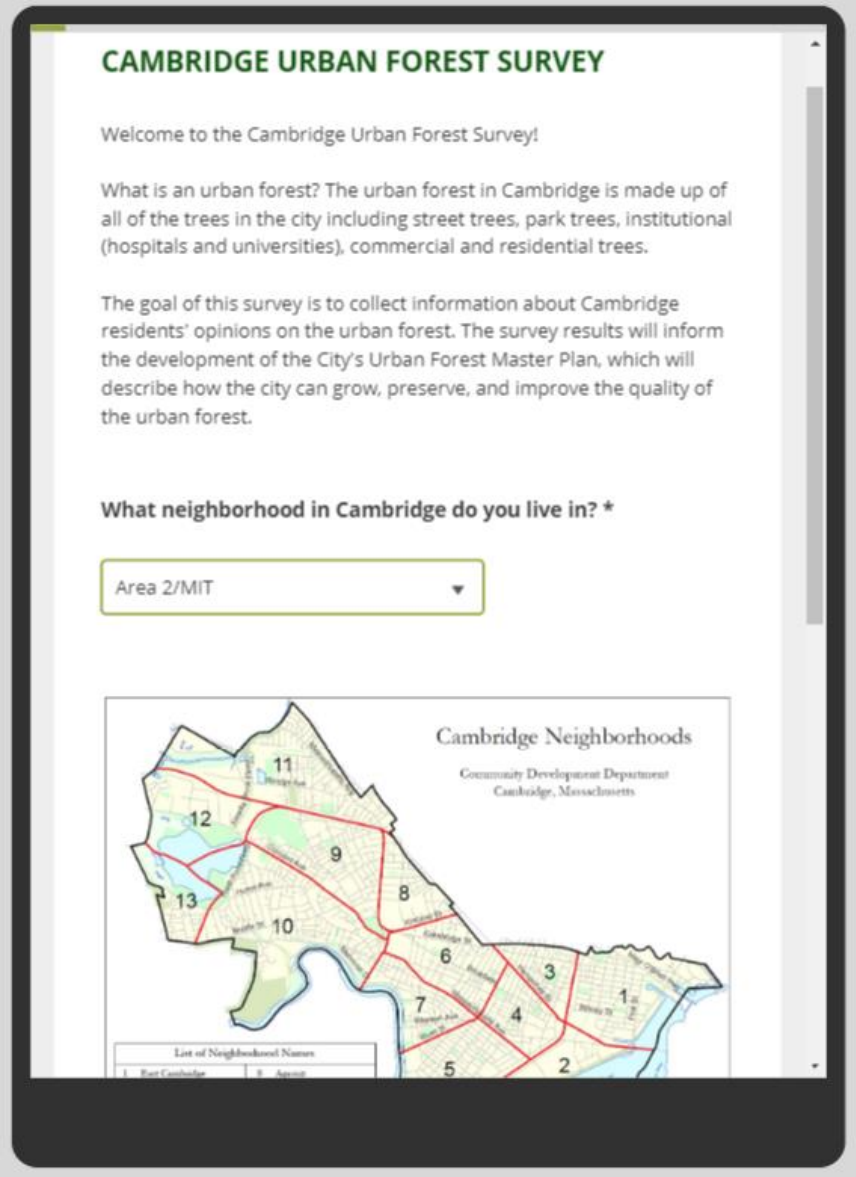
What are Cambridge residents' attitudes toward tree preservation and growth?

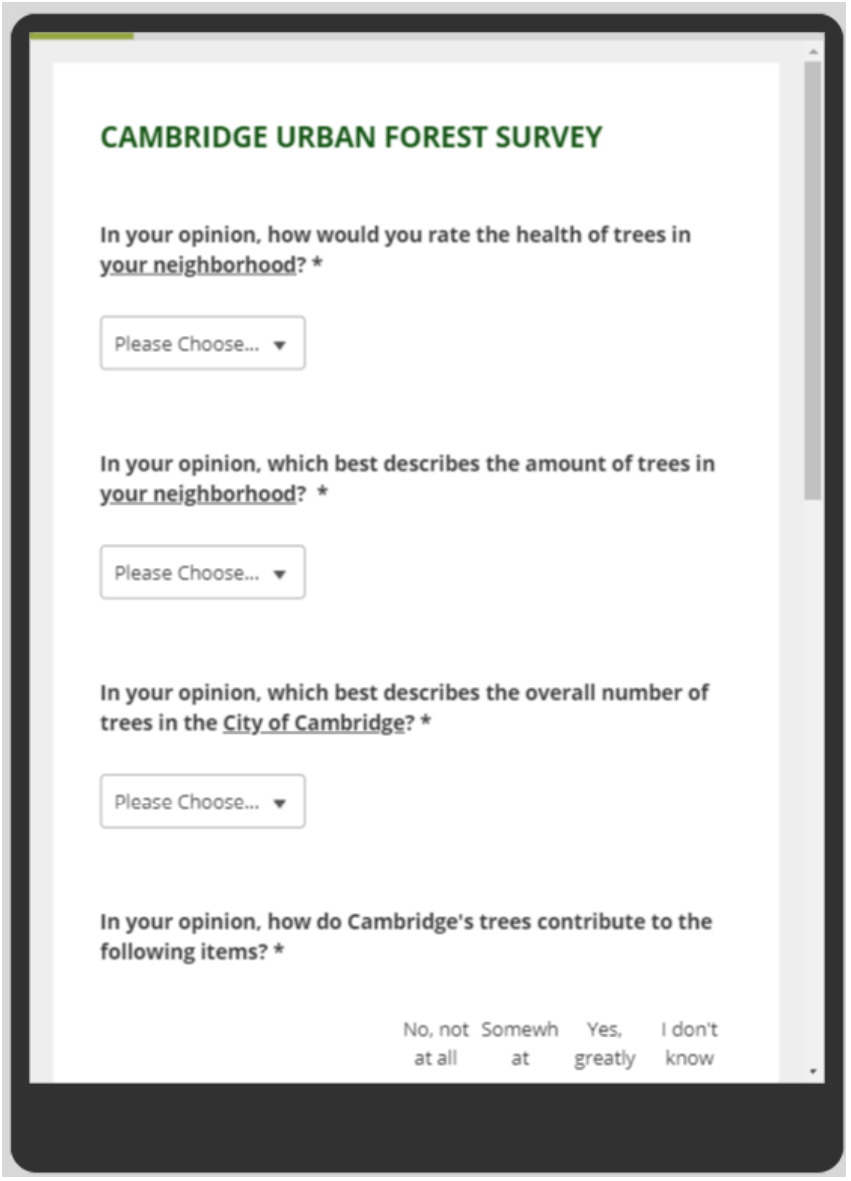
How do perceptions and awareness differ by neighborhood and housing tenure?

These survey results are based on a self-selected sample, not a random sample and therefore may not be representative of all residents. The survey was made available online through the Department of Public Works website in eight languages. However, only six surveys were completed in a language other than English including four in Spanish, one in Bengali, and one in Mandarin. The survey was promoted through city newsletters and on social media.

Additionally, the project team hand collected several dozen hard copy surveys from English classes at the Cambridge Community Learning Center. Some surveys were also collected via IPad at the City of Cambridge Parking Day and the Department of Public Works cookout in Riverside Press Park. Finally, the project team conducted outreach by email to 60 community organizations and neighborhood associations.

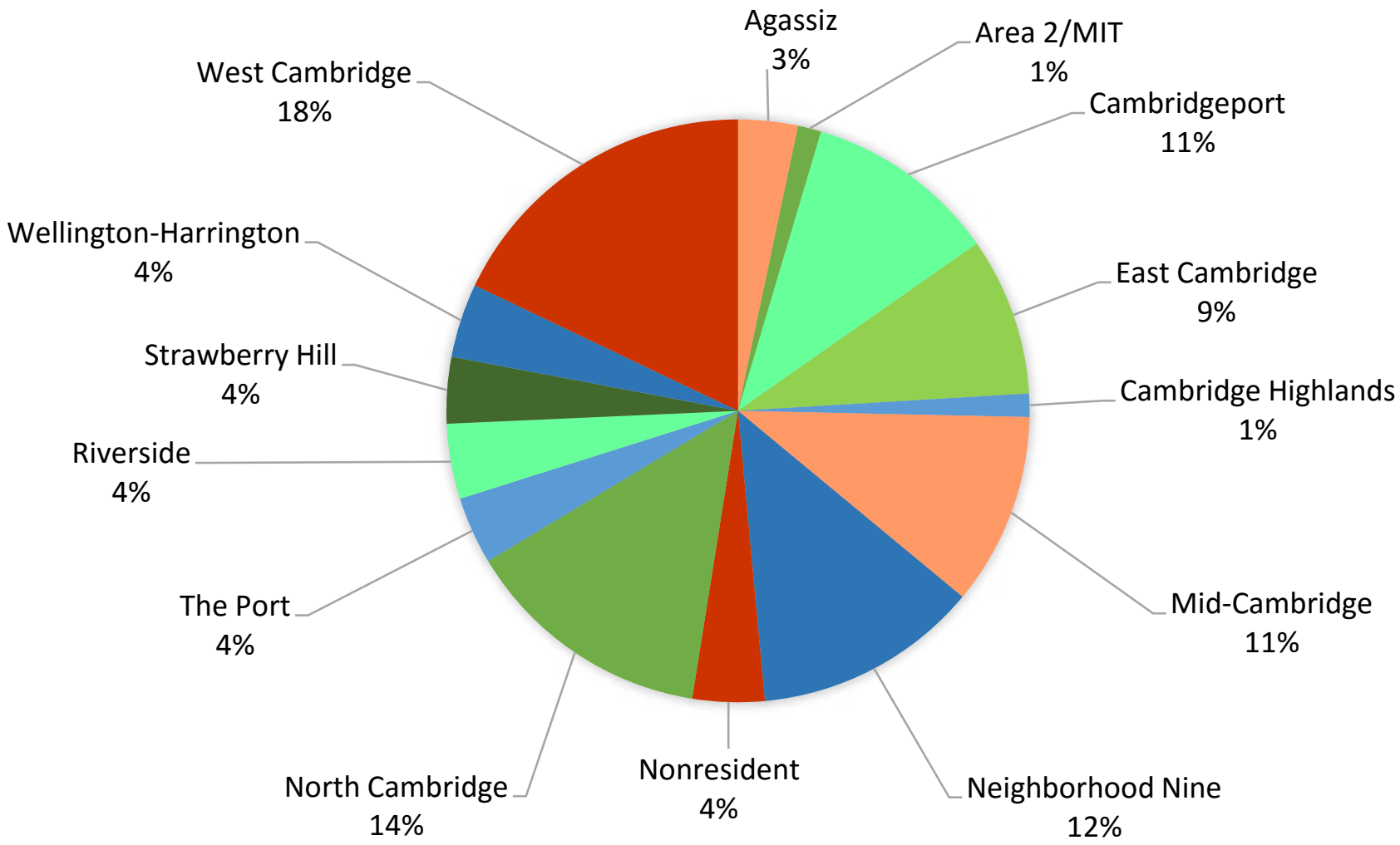
Screenshot of Public Opinion Survey



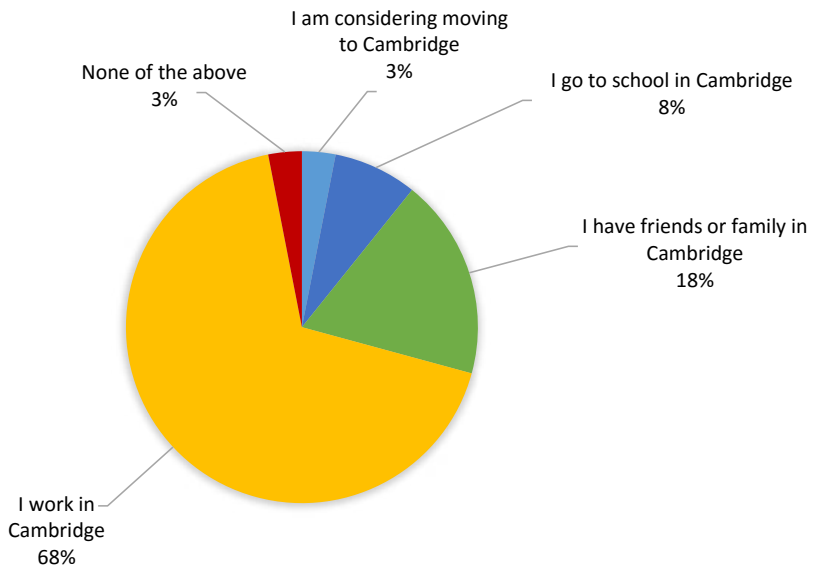


Survey Results

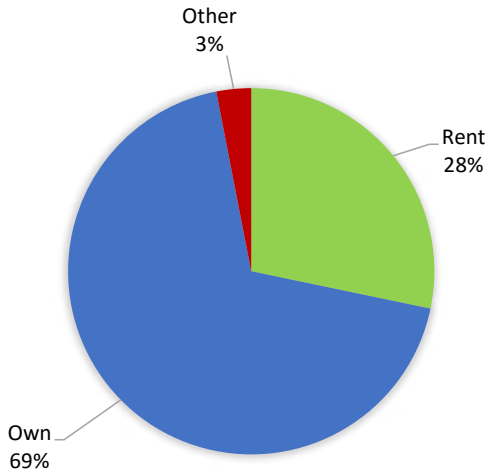
1. What neighborhood do you live in?



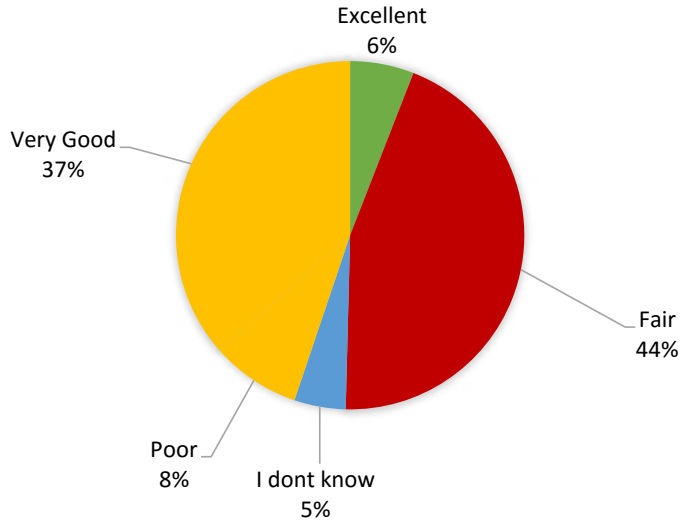
Follow up for respondents who indicated in question one they do not live in Cambridge: What is your interest in taking this survey?



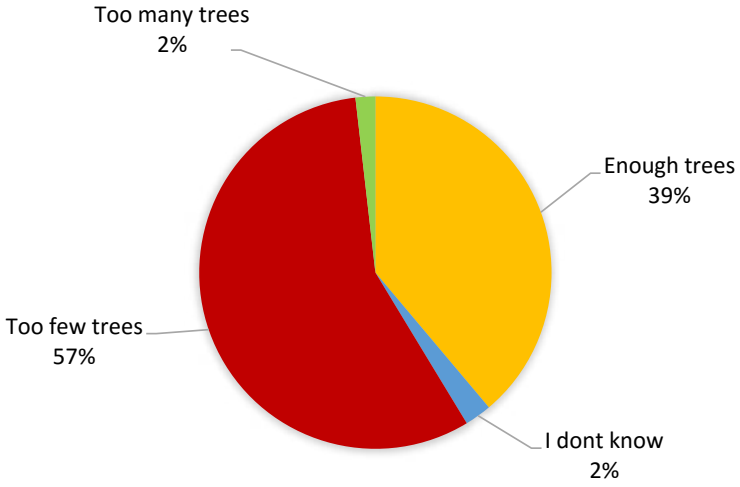
2. Do you rent or own your home?



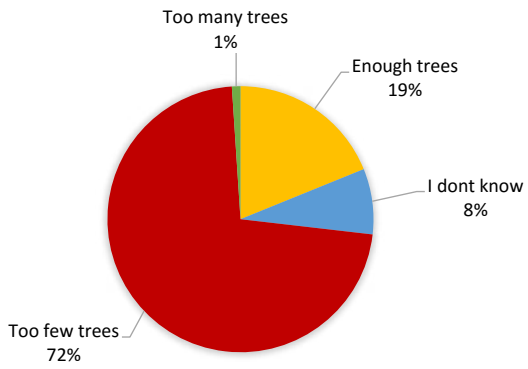
3. In your opinion, how would you rate the health of trees in your neighborhood?



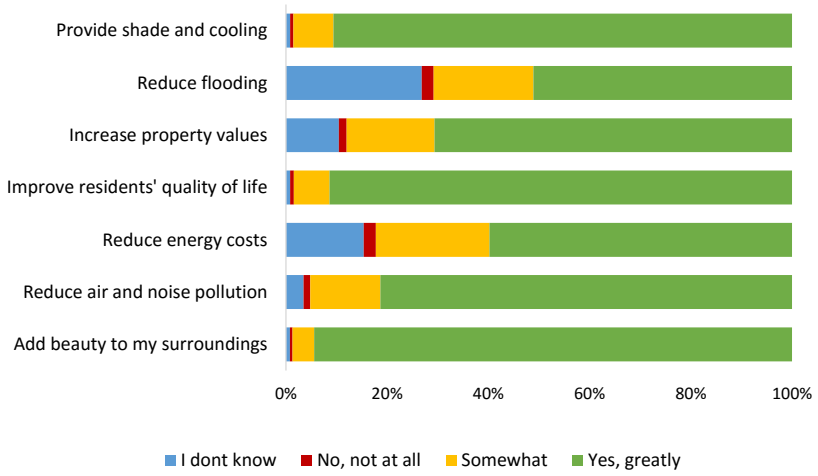
4. In your opinion, which best describes the amount of trees in your neighborhood?



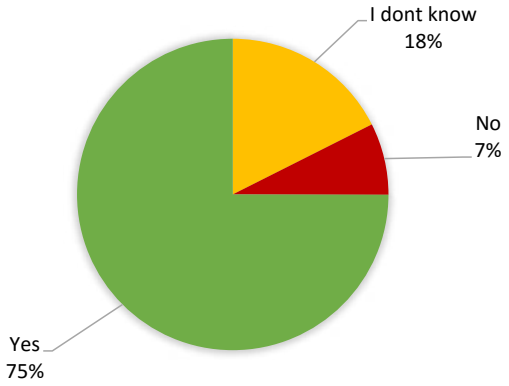
5. In your opinion, which best described the overall number of trees in the City of Cambridge?



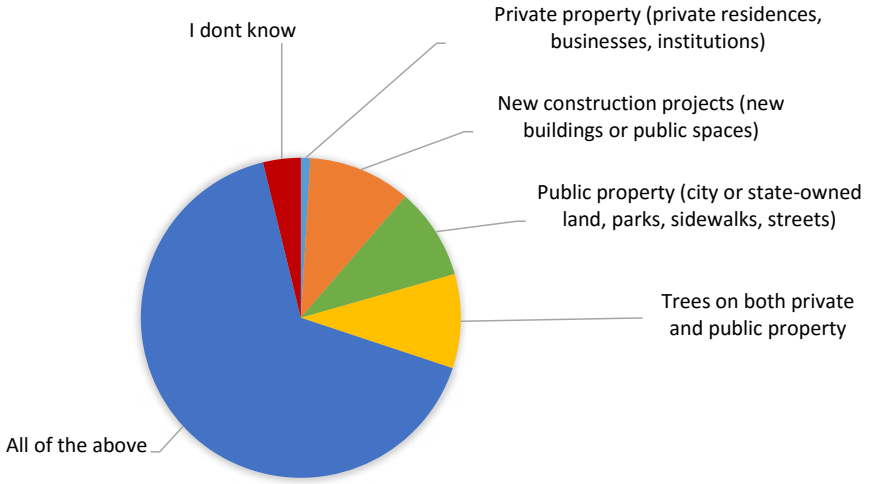
6. In your opinion, how do Cambridge's trees contribute to the following items?



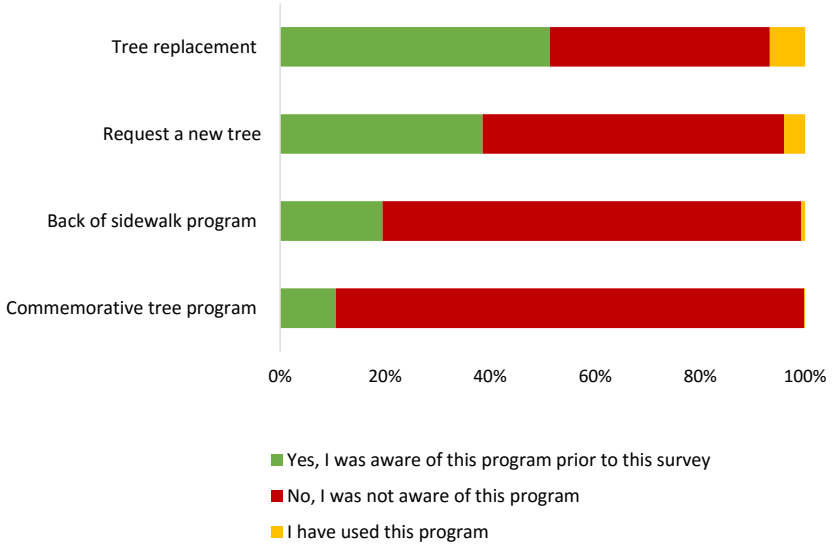
7. Should the City of Cambridge have laws about removing and replacing trees?



Follow up for respondents who answered "yes" in question seven:
To what types of properties should these laws apply?



8. Please tell us whether you were aware of each program or whether you have participated in them



Program descriptions provided to respondents:

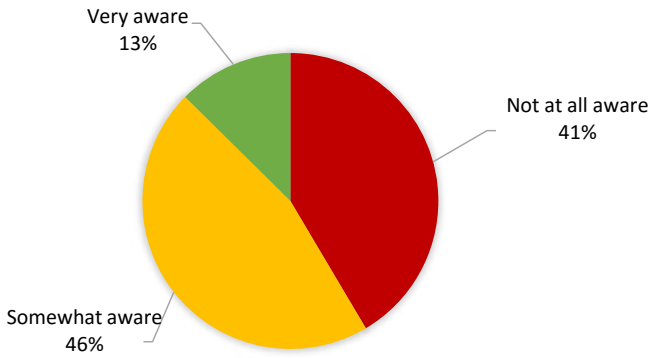
Tree replacement: the city will plant a new tree on the sidewalk in front of your home at no cost to you if one was removed.

Request a new tree: if you do not have a tree on the sidewalk in front of your home and you would like to have one, the city will inspect the area and determine if a public tree can be planted.

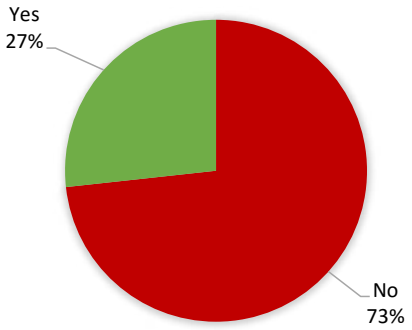
Back of sidewalk program: if there is no space for a tree on the sidewalk in front of your home, you can request the city plant one on your private property at no cost to you. You are responsible for ongoing maintenance.

Commemorative tree program: you can have a tree planted to honor a person, important event, or other idea for a $200 fee.

9. To what degree are you aware that the city has opportunities for residents to volunteer to take care of public trees?

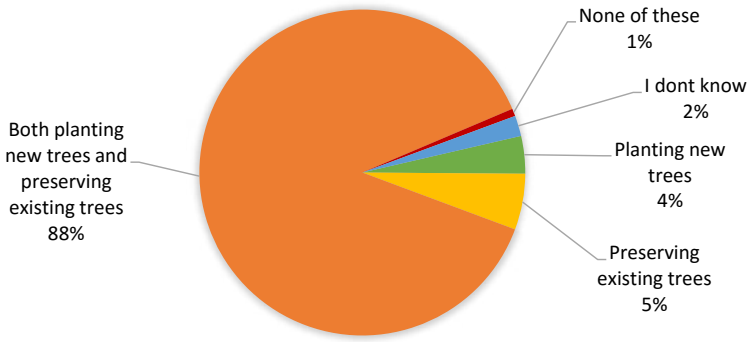


Follow up for respondents who answered “somewhat aware” or “very aware” in question nine: Have you ever volunteered your time to take care of public trees?

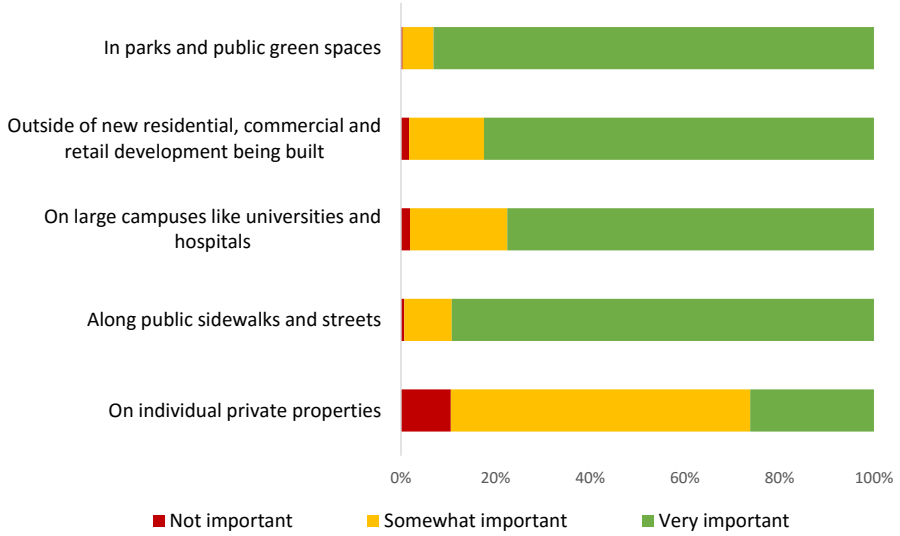


10. Please tell us how much you agree or disagree with the following statements

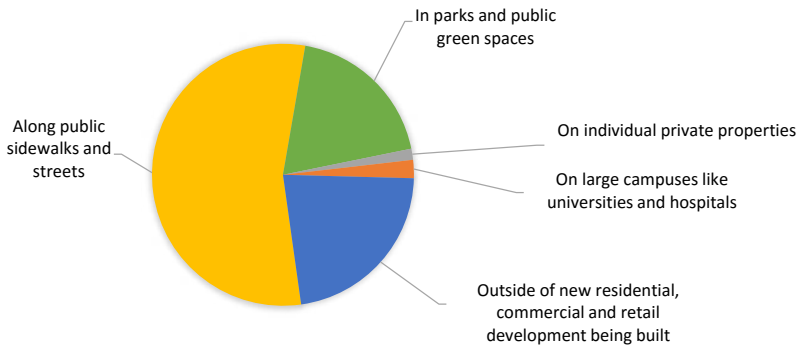
11. In your opinion, which of the following should the city prioritize to protect and grow the Cambridge Urban Forest?



12. In your opinion, how important is it that new trees be planted in the following locations?



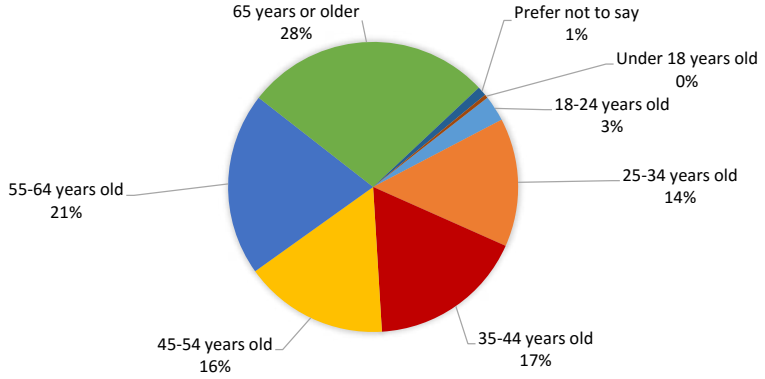
13. In your opinion, what is the single most important location to plant new trees?



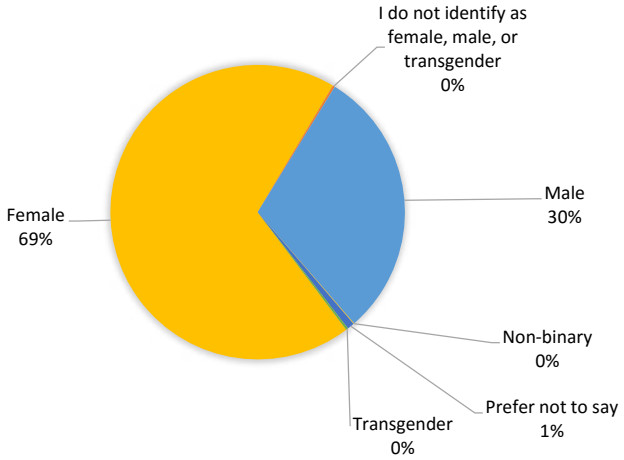
Optional Demographic Information

At the end of the survey, we asked respondents if they were willing to provide optional demographic information to help to city meet its goal of ensuring that the survey is "as representative and inclusive as possible to reflect the voices and views of all Cambridge residents." This portion of the survey collected information on resident age, gender, race, ethnicity, and income. Approximately 1,286 respondents answered at least one demographic question. Some respondents chose not to answer all demographic questions so the sample size was not equal.

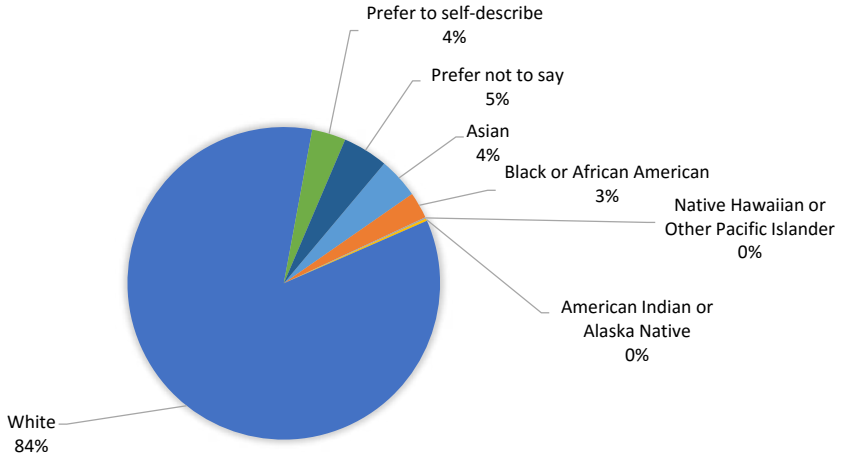
1. What is your age?



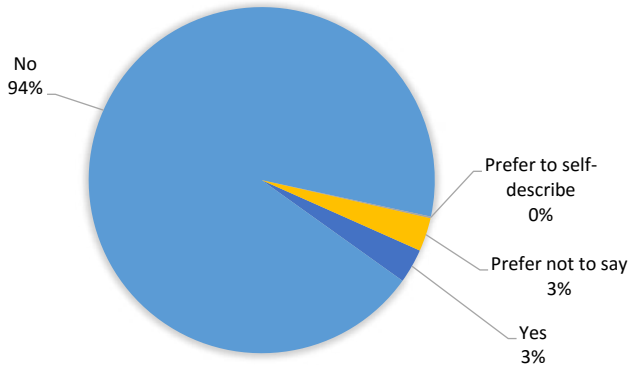
2. How would you describe yourself?



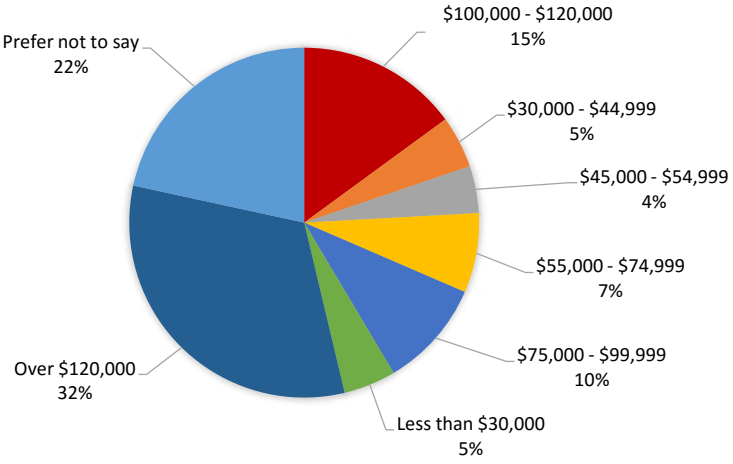
3. Which of the following best describes you?



4. Are you of Hispanic, Latinx, or Spanish origin?



5. What is your annual household income?

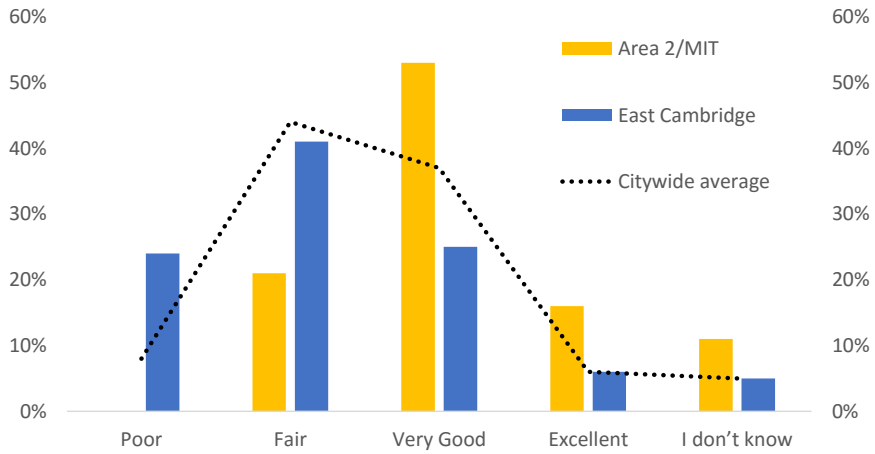


Select Cross Tabulations

Question #3 by respondent's neighborhood: "In your opinion, how would you rate the health of trees in your neighborhood?"

Neighborhood	I don't know	Poor	Fair	Very Good	Excellent
Agassiz	4%	4%	48%	42%	2%
Area 2/MIT	11%	0%	21%	53%	16%
Cambridge Highlands	10%	5%	38%	43%	5%
Cambridgeport	6%	5%	45%	38%	7%
East Cambridge	5%	24%	41%	25%	6%
Mid-Cambridge	4%	6%	45%	41%	5%
Neighborhood Nine	5%	6%	48%	35%	6%
North Cambridge	4%	11%	49%	31%	6%
Riverside	6%	12%	46%	29%	6%
Strawberry Hill	7%	9%	46%	33%	5%
The Port	5%	10%	41%	41%	2%
Wellington-Harrington	9%	5%	42%	37%	8%
West Cambridge	3%	5%	42%	43%	6%

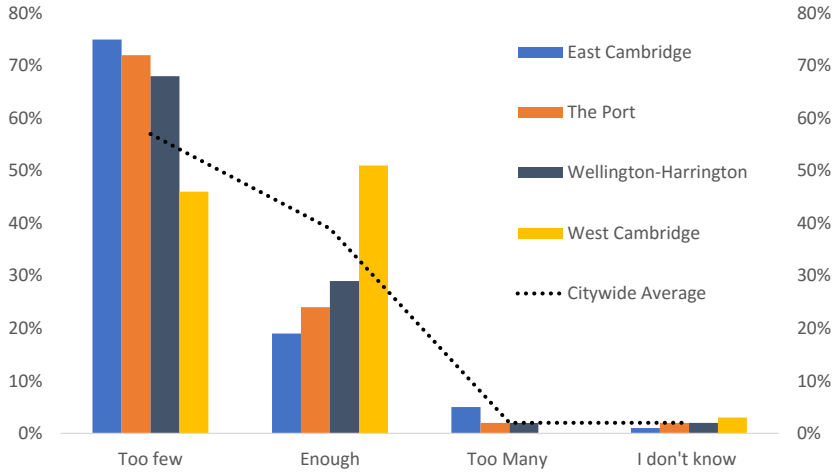
Responses from East Cambridge and Area 2/MIT residents as compared to citywide responses



Question #4 by respondent's neighborhood: "In your opinion, which best describes the amount of trees in your neighborhood?"

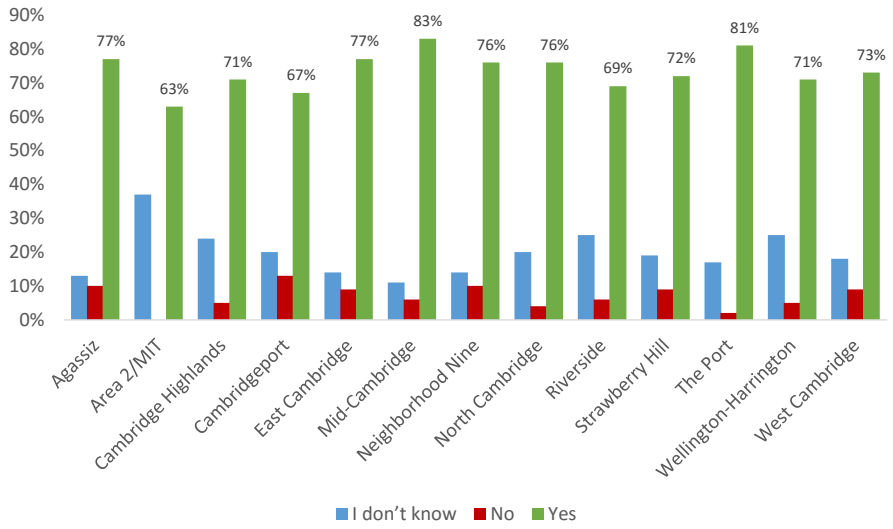
Neighborhood	I don't know	Too few	Enough	Too many
Agassiz	0%	56%	40%	4%
Area 2/MIT	5%	53%	42%	0%
Cambridge Highlands	0%	52%	43%	5%
Cambridgeport	2%	57%	39%	1%
East Cambridge	1%	75%	19%	5%
Mid-Cambridge	2%	53%	43%	1%
Neighborhood Nine	1%	55%	44%	1%
North Cambridge	2%	64%	31%	2%
Riverside	3%	48%	48%	2%
Strawberry Hill	2%	46%	47%	5%
The Port	2%	72%	24%	2%
Wellington-Harrington	2%	68%	29%	2%
West Cambridge	3%	46%	51%	0%

Responses from East Cambridge, The Port, Wellington-Harrington, and West Cambridge residents as compared to citywide responses



Question #7 by neighborhood: "Should the City of Cambridge have laws about removing and replacing trees?"

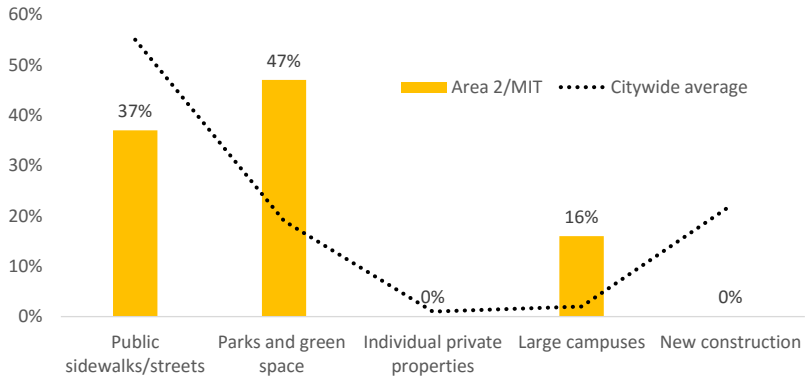
Responses to question 7 by neighborhood



Question #13 by neighborhood: "In your opinion, what is the single most important location to plant new trees?"

Neighborhood	Public sidewalks/streets	Parks & green space	Individual private properties	Large campuses	New construction
Agassiz	52%	22%	2%	2%	22%
Area 2/MIT	37%	47%	0%	16%	0%
Cambridge Highlands	50%	25%	6%	0%	19%
Cambridgeport	53%	19%	1%	3%	24%
East Cambridge	56%	23%	1%	1%	20%
Mid-Cambridge	61%	15%	1%	1%	22%
Neighborhood Nine	52%	19%	2%	2%	26%
North Cambridge	59%	19%	1%	3%	17%
Riverside	53%	13%	0%	2%	32%
Strawberry Hill	55%	24%	4%	4%	15%
The Port	47%	24%	2%	4%	24%
Wellington-Harrington	66%	21%	0%	2%	11%
West Cambridge	56%	15%	1%	1%	26%
Citywide average	55%	19%	1%	2%	22%

Responses from Area 2/MIT residents as compared to citywide responses



Key Findings

Health and Quantity of Existing Trees

Respondents were split on the perception of the health of trees in their neighborhood. About 42 percent of respondents said the health of trees was "very good" or "excellent" and 53 percent said the health of trees was "fair" or "poor."

Respondents had a similar perception of the amount of trees in their neighborhood. About 57 percent of respondents said the amount of trees is "too few" and 39 percent said the amount of trees is "enough." For both health and quantity of trees, the results were generally consistent across neighborhoods with a few notable differences.

- Responses from **East Cambridge** residents indicate a perception of poorer tree health and fewer trees as compared to the citywide average.
- Responses from **Area 2/MIT** residents indicate a perception of greater tree health when compared to the citywide average.
- Responses from **The Port and Wellington-Harrington** residents indicate a perception of fewer trees as compared to the citywide average.

Benefits of Trees

Respondents were asked about seven benefits of trees including shade and cooling effects, flood management, property value, quality of life, energy cost reduction, pollution reduction, and beauty. Results indicate that the majority of respondents agree that trees provide each of these benefits; however, there was more uncertainty about the benefits of flood management and energy cost reduction than other categories.

Awareness of Existing Programs & Policies

Most respondents were not aware of the city's existing tree planting programs. In cases where respondents were aware of a city program, very few indicated they had ever used the program.

However, 59 percent of respondents indicated that they were "somewhat aware" or "very aware" that the city has opportunities for residents to volunteer to take care of public trees. Of those who indicated they were aware, only 27 percent said they had ever volunteered their time to take care of public trees.

Attitudes toward Tree Preservation & Growth

The majority of respondents said that the city should have laws about removing and replacing trees. This was generally consistent across neighborhoods. About 66 percent of all respondents indicated that these laws should apply to all types of property including public property, new development, private residences, businesses, and institutions.

We asked respondents to indicate how much they agreed or disagreed with a series of statements about tree preservation and growth. Responses were on a scale of "strongly agree" to "strongly disagree" as well as an option for "I don't know." The breakdown of responses for each statement is included in the next section but the following summarizes the main takeaways from this series:

- The overwhelming majority of respondents agreed that the city should have laws to **protect large, healthy trees on public property** (70 percent "strongly agree" and 23 percent "agree).
- While the majority of respondents also agreed that the city should have laws to **protect large, healthy trees on private property** (27 percent "strongly agree" and 31 percent "agree") the agreement was not as strong.
- The majority of respondents agreed that the **city should use more resources to maintain and protect existing trees**. However, when asked whether the city should prioritize resources for other services over tree planting and maintenance, 43 percent said "I don't know."
- The majority of respondents agreed that the **city should incentivize, not require, tree planting and maintenance on private property** (67 percent "strongly agree" or "agree") and that the city should provide resources for residents to plant trees on private property (77 percent "strongly agree" or agree").
- The majority of respondents agreed that the **city should have laws about removing trees during construction** (86 percent "strongly agree" or "agree") and that all new construction should be required to plant new trees on-site if existing trees cannot be preserved (88 percent "strongly agree" or "agree").
- Despite preference for incentives over requirements on private property, 50 percent of respondents disagreed that private property owners should make decisions about trees on their property without input from the city.

There was also a strong preference (88 percent) for the city to prioritize both planting new trees and preserving existing trees to protect and grow the urban forest.

Respondents were asked to rate the importance of planting new trees in a series of locations including: on individual properties, along public sidewalks and streets, on large institutional campuses, outside of new development projects, and in parks and public green spaces.

Parks and public green spaces: majority (93 percent) said "very important"
Public sidewalks and streets: majority (89 percent) said "very important"
New development projects: majority (82 percent) said "very important"
Large institutional campuses: majority (78 percent) said "very important"
Individual private properties: majority (63 percent) said "somewhat important"

When asked a follow up question about the single most important location to plant new trees, the majority of respondents (55 percent) said public sidewalks and streets followed by new development (22 percent) and parks and green spaces (19 percent).

This breakdown was consistent by neighborhood aside from Area 2/MIT respondents who indicated a stronger preference (47 percent) for new trees in parks and green spaces.

Demographics

Survey respondents were given the option to provide demographic information. Not all respondents that opted to provide demographic information answered every question therefore the sample size varies (ranges from 1,249 to 1,286 respondents).

Of those that opted to provide this information, the majority were 45 years or older (63 percent), female (69 percent), non-Hispanic (93 percent), and white (84 percent). The income range of the majority of respondents was $75,000 or more (57 percent).

Outreach to Non-governmental Organizations

The following community organizations, neighborhood associations, and other groups were contacted by phone or email with the survey link and asked to distribute it to their networks:

Neighborhood	Outreach Date
A Better Cambridge	9/7/2018
Agassiz Baldwin Community	9/10/2018
Alchemists	10/6/2018
Area Four Neighborhood Coalition	9/7/2018
Buena Vista Social Club	9/10/2018
Cambridge Association of Neighborhoods	9/7/2018
Cambridge Community Development Corporation	9/11/2018
Cambridge Community Center	9/10/2018
Cambridge Community Foundation	9/11/2018
Cambridge Energy Alliance	9/12/2018
Cambridge Forum	9/7/2018
Cambridge Highlands Neighborhood Association	9/10/2018
Cambridge Historical Society	9/12/2018
Cambridge Housing Authority	9/11/2018
Cambridge NAACP	9/14/2018
Cambridge Public School Volunteers	9/11/2018
Cambridge Public Schools	9/11/2018
Cambridge Residents Alliance	9/7/2018
Cambridge Trees .net	9/12/2018
Cambridgeport Neighborhood Association	9/7/2018
Charles River Conservancy	9/7/2018
Charles River Watershed Association	9/12/2018
Climate Protection Action Committee	9/12/2018
Climate Protection Action Committee	9/12/2018
Committee on Public Planting	9/12/2018
Community Learning Center	9/11/2018
East Cambridge Business Association	9/7/2018
East Cambridge Planning Team	9/6/2018
East End House	9/6/2018
Essex Street Neighbors	9/7/2018
First Church Cambridge	9/11/2018
Fresh Pond Residents Alliance	9/10/2018
Friends at Open Table Dinner Church	9/11/2018
Friends of Alewife Reservation	9/7/2018
Green Cambridge	9/11/2018
Green Streets Initiative	9/11/2018
Greenport	9/11/2018
Groundwork Somerville	9/12/2018
Grow Native Massachusetts	9/7/2018
Harvard Community Garden	9/12/2018
Harvard Square Neighborhood Association	9/7/2018
Harvard University, Office for Sustainability	9/12/2018
Inman Square Neighborhood Association	9/7/2018
Jewish Climate Action Network	9/11/2018
Jewish Climate Action Network	9/11/2018
LivableStreets	9/12/2018
Margaret Fuller Neighborhood House	9/7/2018
Massachusetts Peace Action	9/11/2018
Massachusetts Peace Action	9/11/2018
Mid-Cambridge Residents Alliance	9/7/2018
MIT Office of Sustainability	9/12/2018
Mystic River Watershed Association	9/12/2018
Neighborhood Association of East Cambridge	9/6/2018
North Cambridge Stabilization Committee	9/10/2018
North Commons	9/10/2018
Porter Square Neighbors Association	9/7/2018
Richdale Avenue	9/10/2018
Riverside Neighborhood Association	9/10/2018
Senior Centers & Council on Aging (Tufts UEP)	9/11/2018
Taylor Square Neighborhood Association	9/10/2018
Wellington-Harrington Neighborhood Association	9/7/2018
Wicked Local: Cambridge	9/12/2018

APPENDIX H : SOILS TESTING REPORTS AND SUMMARY

F2 CAMBRIDGE SOIL REPORT SUMMARY

Objective:

Diagnose on site environmental conditions and soil in relation to optimal horticultural performance, for possible environmental/landscape restoration throughout the city of Cambridge. This is focusing on current conditions as well as forecasting plant health in coming years, in relation to climate change. Soil samples were taken from twenty (20) different predetermined site locations throughout the city of Cambridge.

Executive summary:

The primary constraints to tree health, related to soils, in Cambridge are a lack of nutrient cycling capacity, compaction, and poor drainage in lower root zone. These can be remediated in the below listed areas.

A. General recommendations for existing trees:

1. **Poor Nutrient Cycling** - We believe that one of the most practical and economically feasible ways of improving these environmental conditions is through promoting healthy soil biology. If the City of Cambridge developed a composting, vertical composting (augering into the top 12" and back filling with compost and amendments), and biological infusion (compost tea) program, some very positive significant results could be achieved. Good examples of this are the results we have seen at Battery Park City, Harvard University, Rose F. Kennedy Greenway, Storm King Art Center, Brooklyn Bridge Park, The Highline, and Chicago Botanic Garden. These methods would be the most easily implemented and could be done in segments. Optimal times for Biological Infusions are in Spring when we have reached a minimum of 24 GDD (growing degree days) until approximately June 15, and Fall (September 15 through November 30). This is when microbial activity, in the soil, is highest and the landscape most receptive to applications. Soil Organic Matter percentage in many of the sites is fairly low, so we can add organic matter without any problem. This should be done with a high quality compost. This will also increase the cation exchange capacity, which is low in many of the sites.

Amendments – Pelletized Humate and Bio Char could be utilized to positive effect to increase fungal presence and Cation Exchange Capacity (9 of the 20 sites had lower than optimal cation exchange capacity. This would work perfectly with a composting and biological infusion program.

Mulch – A good quality leaf mulch regularly applied would also help to keep the natural nutrient cycling capacity going.

2. **Compaction** - Properly engineered biological infusions can have very positive results on compaction. This would be particularly effective in the park areas observed. An aerator could be utilized in combination with compost, biological infusions, and amendments to speed up the process.

3. **Poor Drainage** – Several areas have drainage issues in the lower root zones. We would recommend to auger wicks/drywells in these areas, with a coarse sand in order to keep excessive water out of the root zones of these trees.

B. Management Protocols

1. **Trees that are failing or non existent and need to be replaced –** Excavate tree pit, make sure there is proper drainage, and plant tree in proper soils according to specification (we should incorporate biological guidelines into the specification). Cambridge tree planting specification states: "Perform percolation of subsoil or placed fills to determine whether or not the subgrade will drain properly". This is key to perform before tree is planted.
2. **Trees that are stressed and in various stages of decline –** Soil needs to be assessed for nutrient cycling, compaction, and drainage. We have already assessed that most of the sites need to be improved in terms of nutrient cycling so this can be assumed. The application of a high quality compost, biological infusion, and or a good quality mulch would greatly improve tree growing conditions.

1. It would be optimal to mulch all trees annually.
2. Biolgical infusion to all trees annually
3. Vertical composting where trees are in decline

Program should be set up in accordance with the cities schedules and ability to implement. Perhaps we start with a pilot program in one or two areas.

C. Recommendations for New Plantings and Replacements

We recommend taking a close look at the City of Cambridge's current tree planting specifications and see where they may be tightened up in terms of components, and implementation. We believe there should be biological requirements that need to be met within the soil specifications. It is best to incorporate the right components to start with. In all the soils collected, we found that they stop functioning properly as a drainage medium at somewhere between 87 and 90% standard proctor. The Cambridge specification for structural planting medium specifies compaction of 92 to 94% modified proctor.

We may want to discuss soil specification options moving forward. In addition, we observed in many tree pits, with newly planted trees, that gator bags had been put on the tree stakes rather than on the trees. Considering the sandy nature of these soils, we do not believe this to be optimal for the trees initial establishment. Most of the trees had been grown in soils with good amounts of silt and clay in them. A heavier soil than the medium they are planted in. The tendency will be for water to run down the side of the root ball, and not get the root ball itself sufficiently moist.

Test Results and Diagnosis

This is a synopsis/representation of where we are at this point in our analysis. The textural analysis results vary greatly from site to site however mostly are in the "sandy loam classification". Adding up the very fine sand, silt, and clay the samples range from 19.4% to 53% fines. This indicates that these soils are fairly sandy and somewhat resistant to compaction, however this varies by degree from site to site. These soils still need to be handled carefully. The UMass test results indicated that macronutrients are fairly well in balance. Micronutrients are somewhat out of balance in certain areas, which would indicate the nutrient cycling capacity is not functioning as it should. The Cation Exchange Capacity ranges from 1.9 to 16.1. In eight (8) sites, 3, 7, 9, 10, 12, 14,17, 18 biologically, nutrient cycling capacity is very low at less than 25 lbs available Nitrogen per acre from microbial activity. In four (4) sites, 1, 6, 15, 19 biological nutrient cycling is still very low at 25 to 50 lbs available Nitrogen per acre from microbial activity. In two (2) sites, 2, 5 we have marginally better nutrient cycling at 50 to 75 lbs available Nitrogen per acre from microbial activity. These 14 sites need significant improvement of nutrient cycling capacities of soils. We want to see Nitrogen availability of between 100 to 150 lbs per acre from microbial activity. Fungal biomass, and diversity are low. This causes poor nutrient metabolization, and disease resistance. With increased biological activity and a balanced diversity, the proper growing environment could be provided.

In three (3) sites, 4,13, 16 the biological nutrient cycling capacity is at 75 to 100 lbs available Nitrogen per acre from microbial activity. This is good. In three (3) sites 8, 11, 20 we have 100 to 150 lbs available Nitrogen per acre from microbial activity. This is excellent.

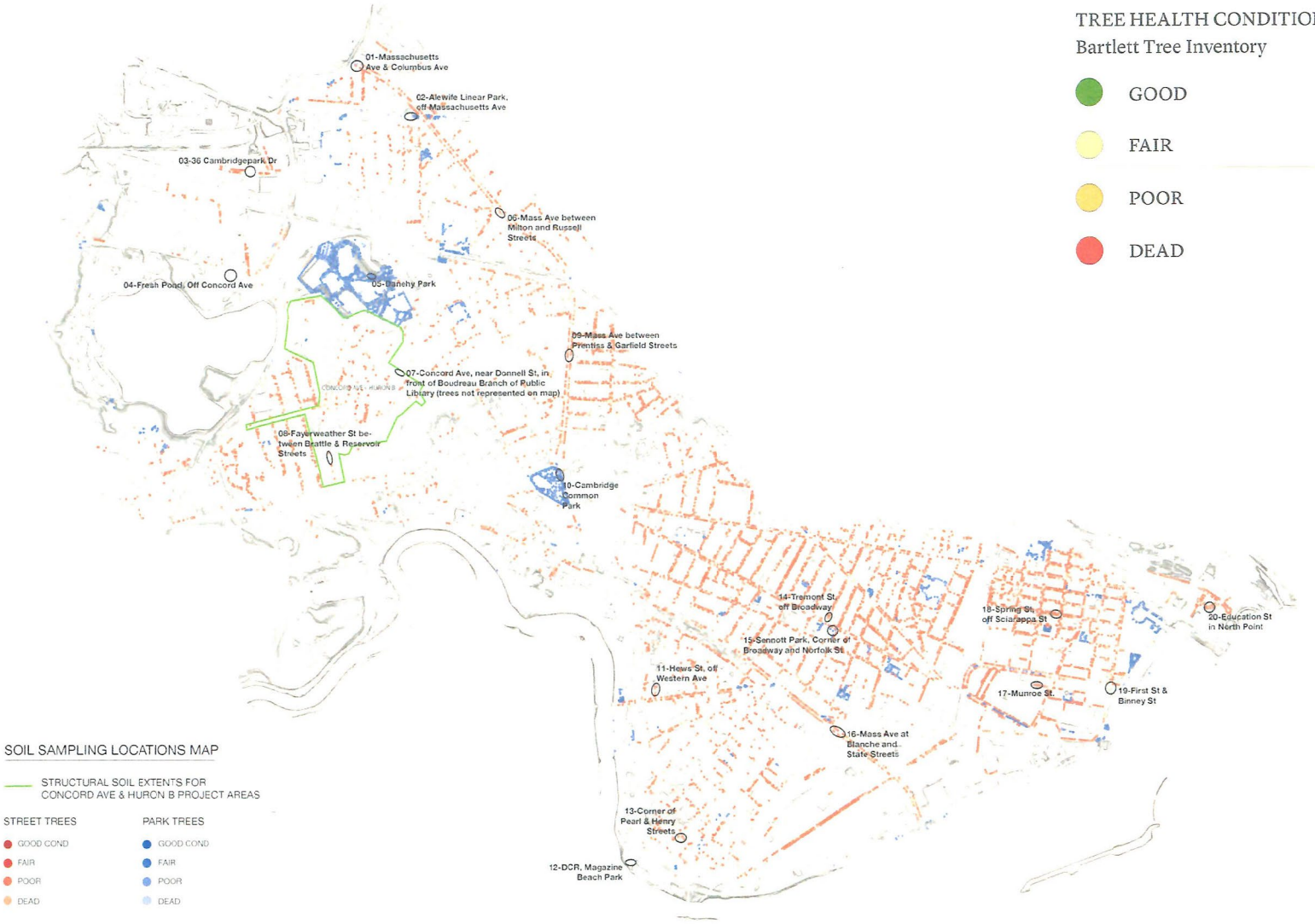
Soluble salts are generally in a good range. Only site 7 showed and elevated level at 24 to 36" depth of 6.1. This was somewhat surprising, however soluble salts dissipate very quickly especially considering the generally sandy nature of the soils.

pH ranges in top 12" range from 5.1 to 7.2. This is acceptable as long as we increase bio mass and diversity.

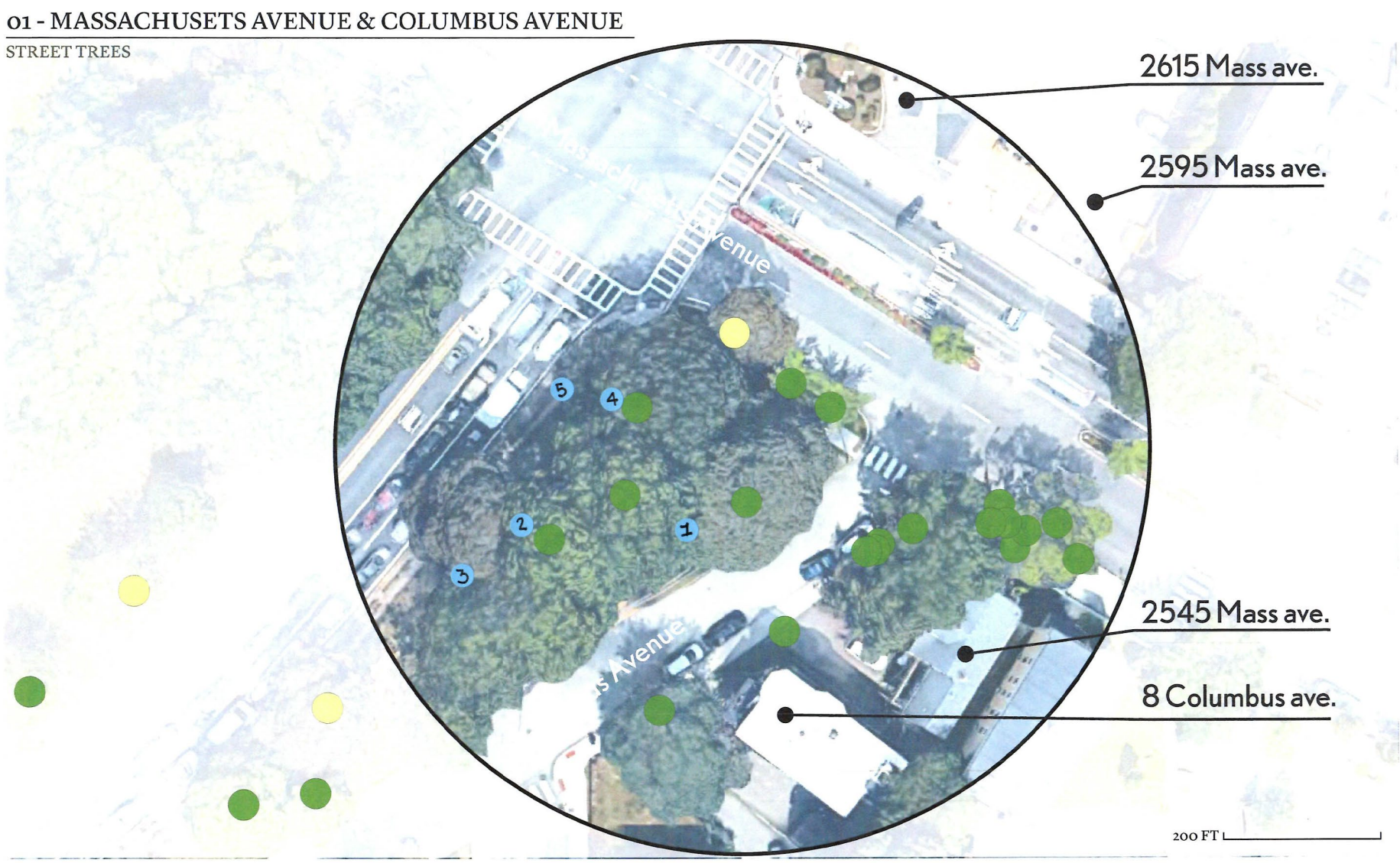
Physical Characteristics

Sixteen (16) of the twenty (20) sites had significant compaction levels. Seven (7) of the twenty (20) sites had issues of poor drainage in the lower root zones. Within these findings we are seeing inconsistencies in textural gradation going down through the root zones. In some cases we are seeing an increased silt, clay, and fines percentage going down through the root zone, so that drainage in the lower root zone is impeded. Several areas we inspected had gravel, recycled concrete (rc), and chunks of asphalt in the soil. Some of this was in areas that were supposed to be structural soil. This would imply that soil specifications had not been followed properly, particularly since the Cambridge structural soil specifications are sand based. Other areas observed that were fairly new plantings showed that the planting specification was somewhat followed in the top 20", but below that was not amended.

The soils generally have a good texture but are fragile and susceptible to compaction, and should never be handled if wet or frozen. These soils will stop functioning as a drainage medium if compacted beyond 87% to 90% standard proctor.



REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN | SOIL SAMPLE LOCATIONS | AUGUST 09, 2018


01 - MASSACHUSETS AVENUE & COLUMBUS AVENUE
STREET TREES
2615 Mass ave.
2595 Mass ave.
2545 Mass ave.
8 Columbus ave.
1
2
3
4
5
200 FT
REED HILDERBRAND
CAMBRIDGE URBAN FOREST MASTER PLAN
SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

02 - ALEWIFE LINEAR PARK, OFF MASSACHUSETTS AVENUE

STREET TREES

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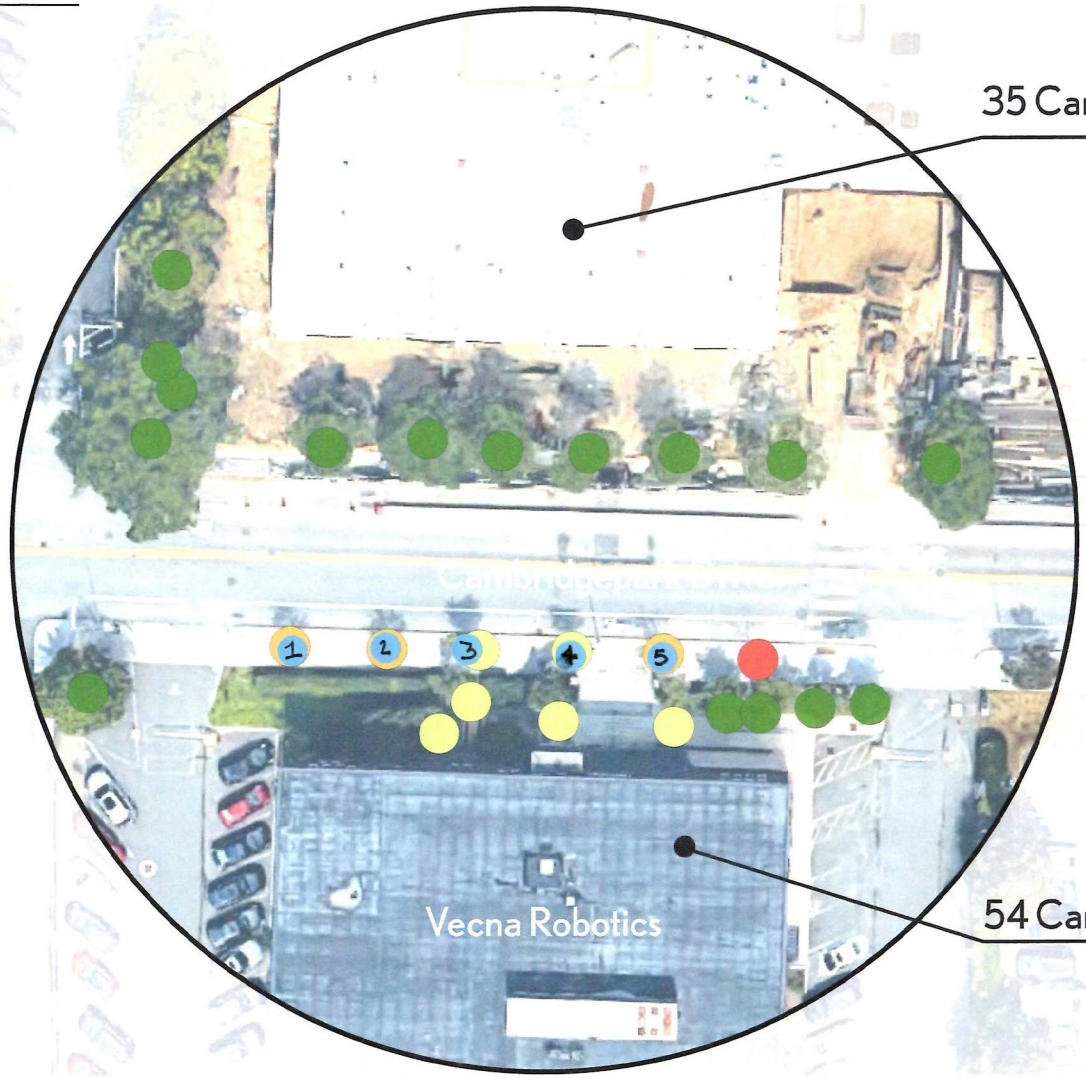
SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

03 - 36 CAMBRIDGEPARK DRIVE

STREET TREES

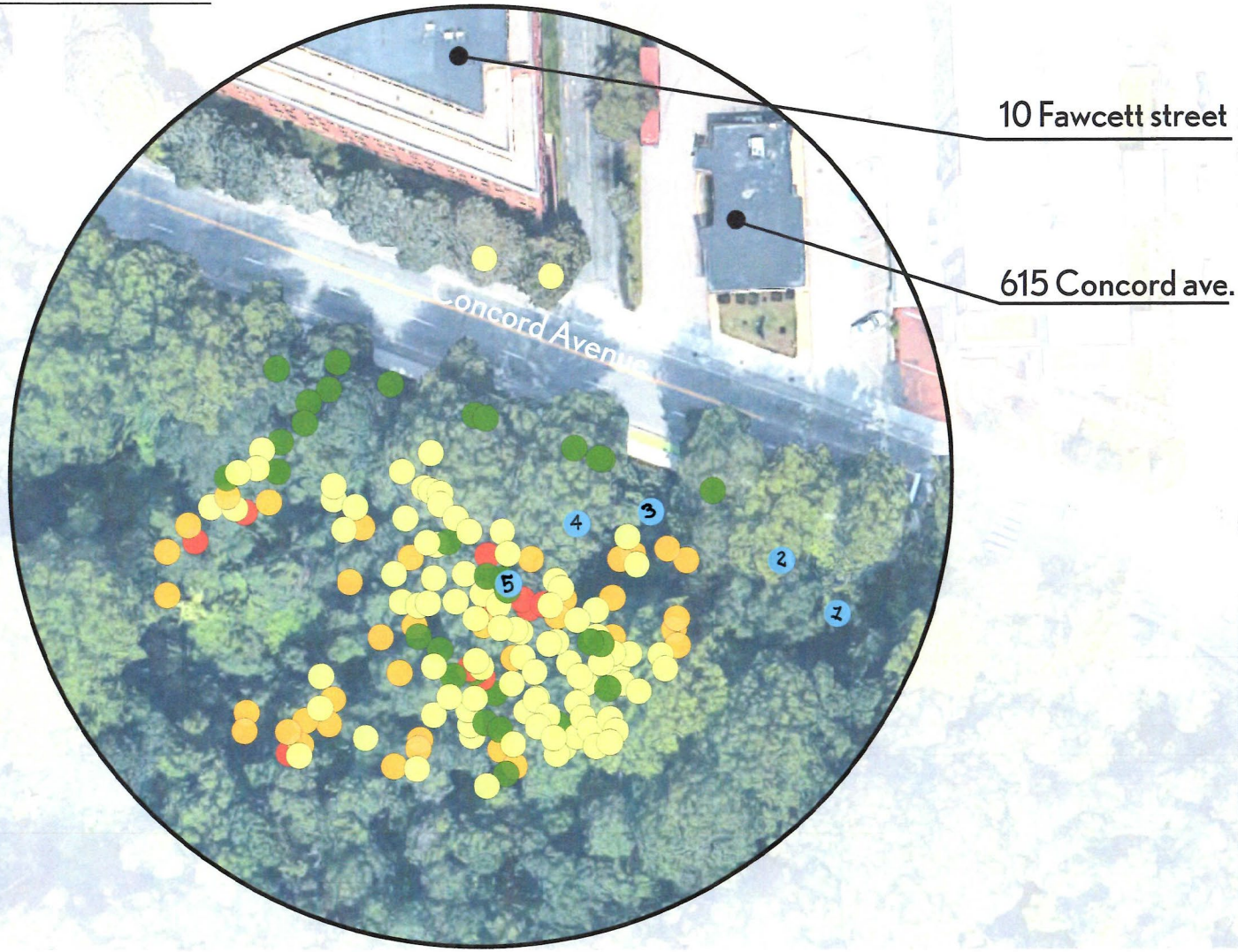


REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

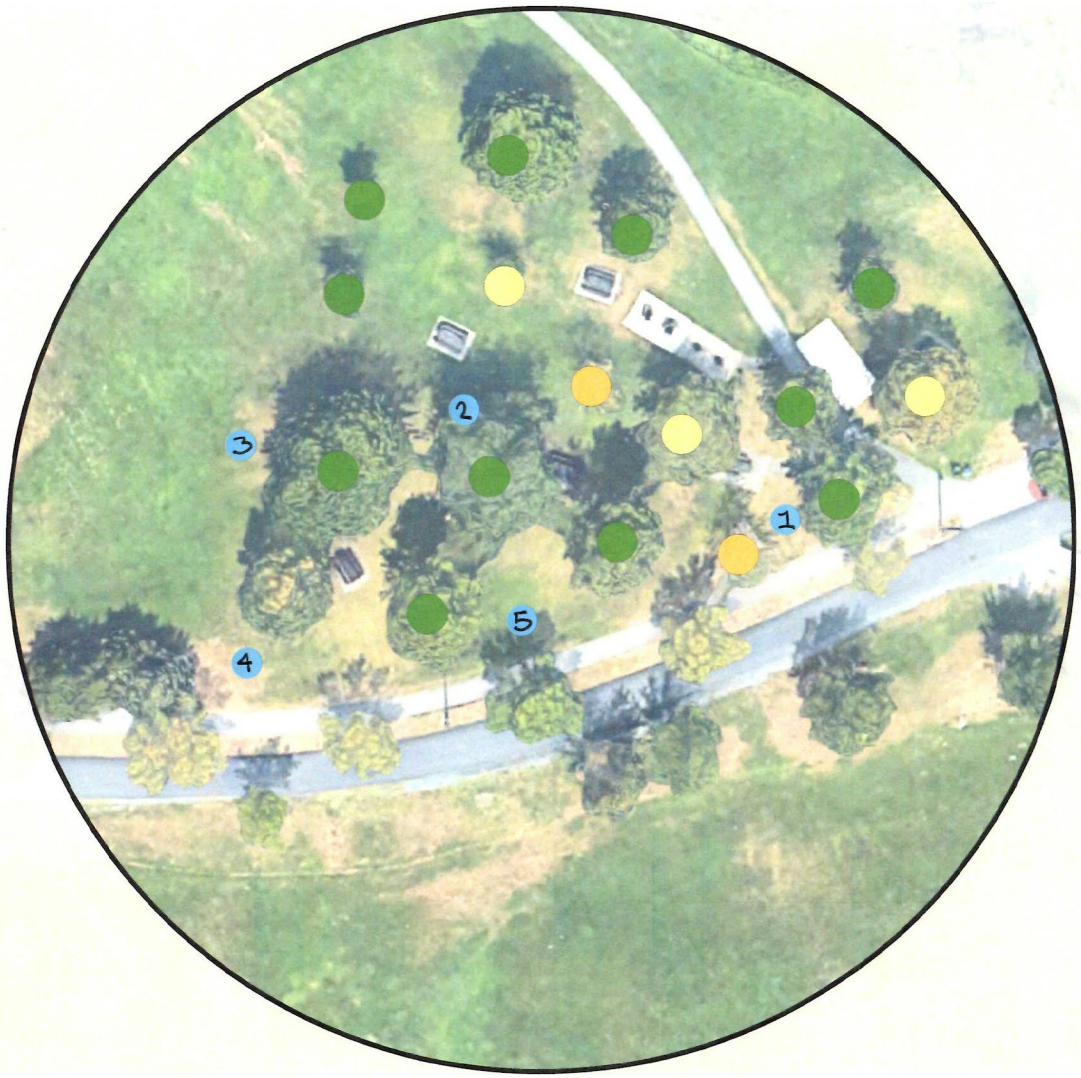
04 - FRESH POND, OFF CONCORD AVENUE

PARK TREES



05 - DANEHY PARK

PARK TREES

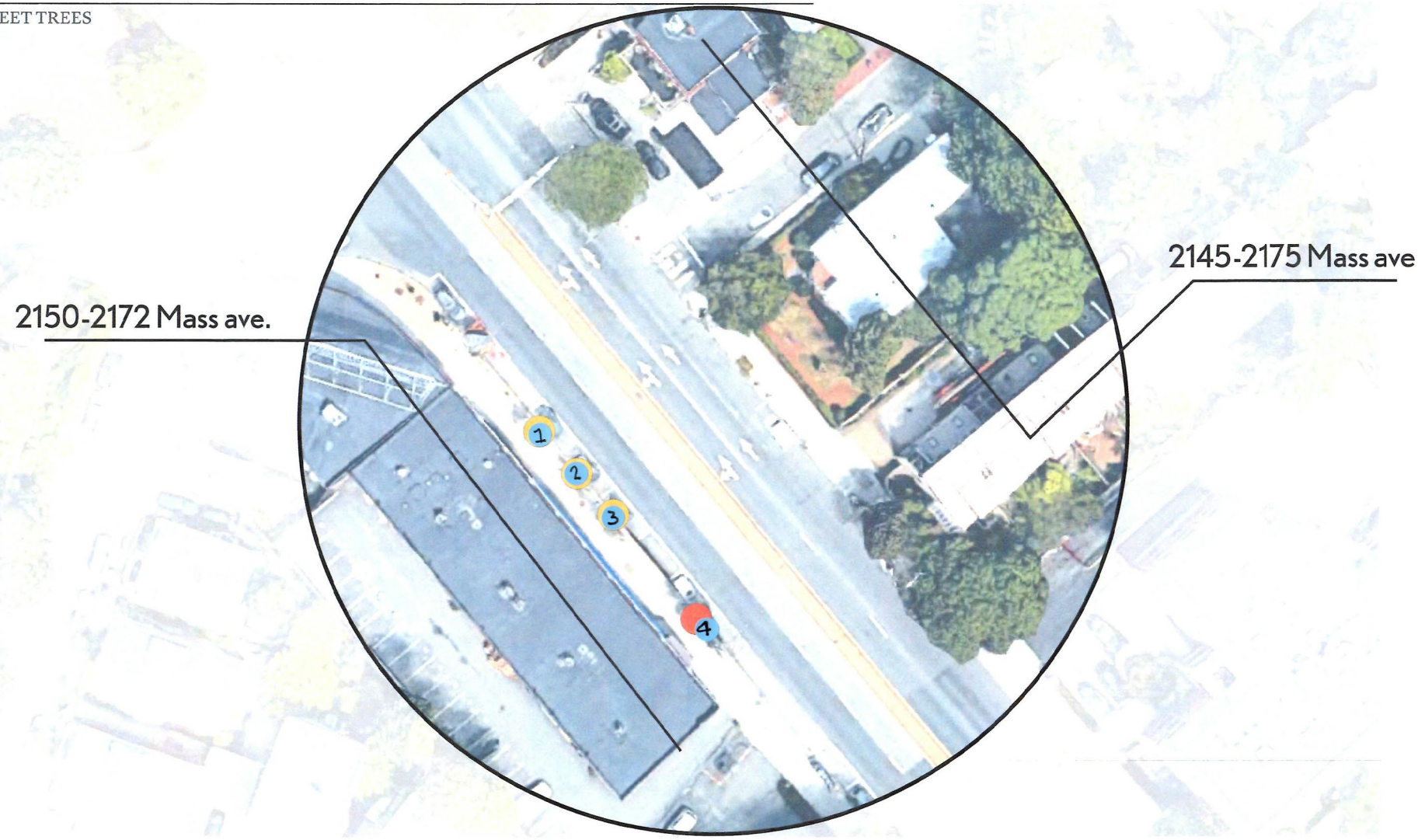


REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

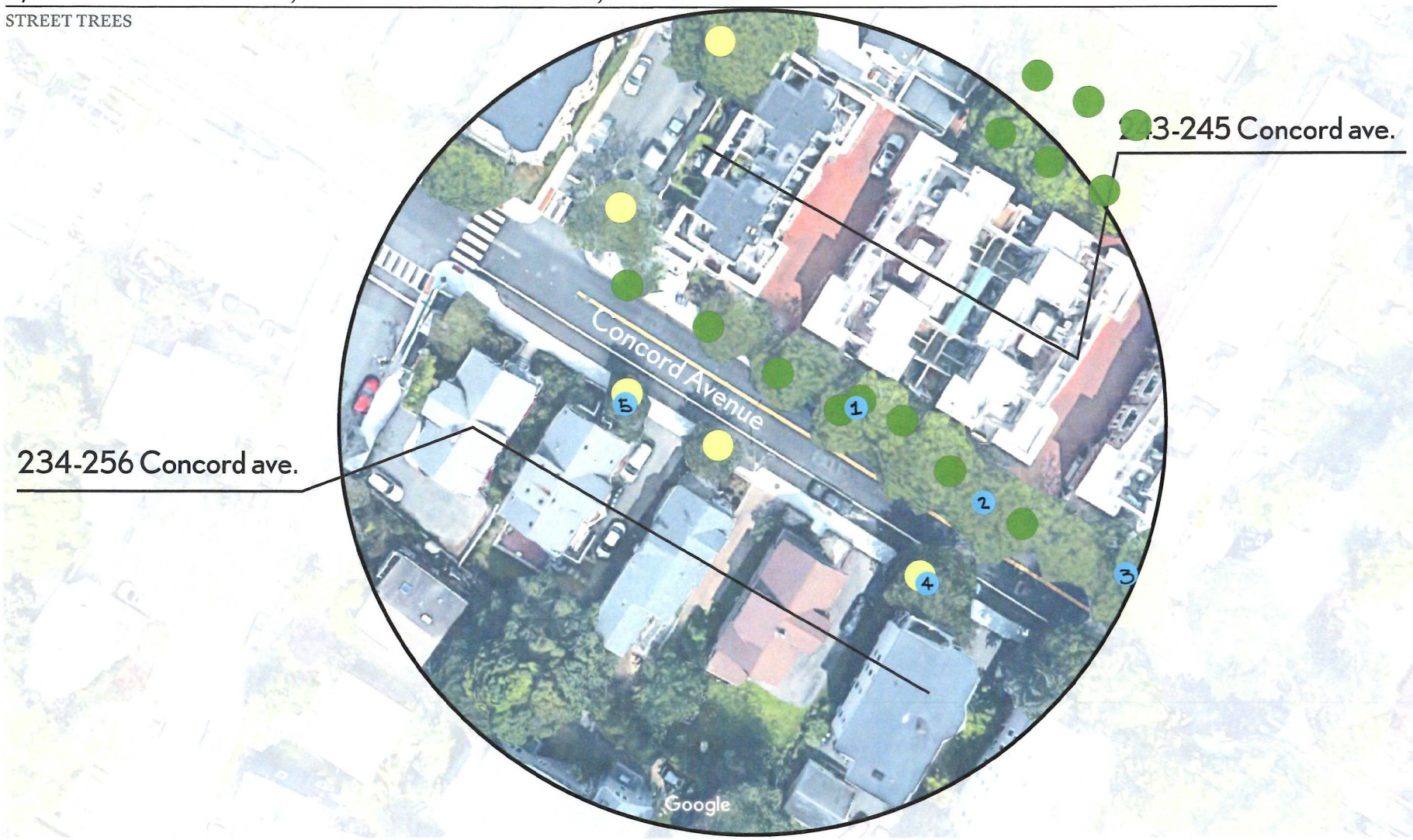
06 - MASSACHUSETTS AVENUE BETWEEN MILTON ST AND RUSSELL ST

STREET TREES



07 - CONCORD AVENUE, NEAR DONNELL STREET, IN FRONT OF BOUDREAU BRANCH OF PUBLIC LIBRARY

STREET TREES



REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

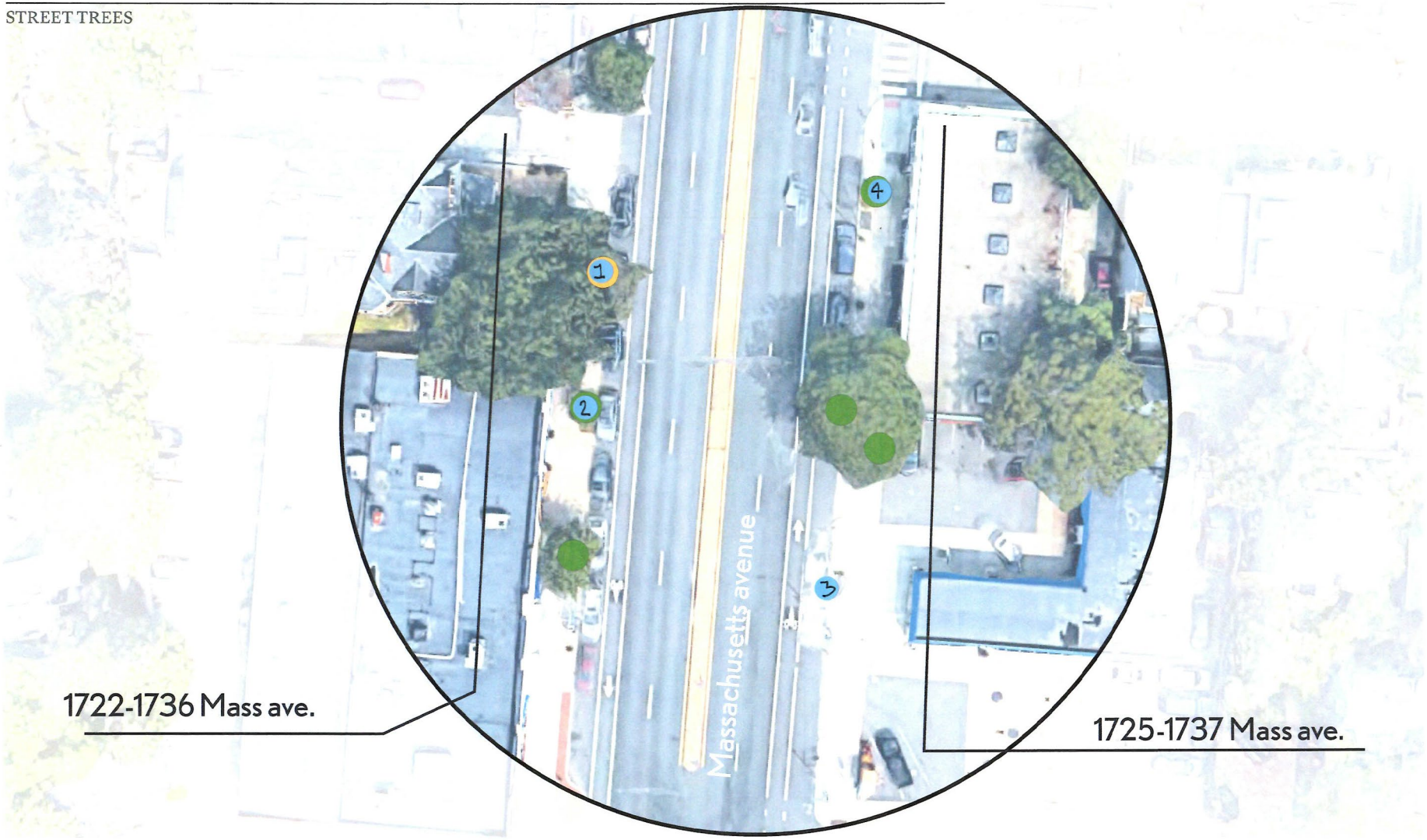
08 - FAYERWEATHER STREET BETWEEN BRATTLE AND RESERVOIR STREETS

STREET TREES

REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN 1 SOIL SAMPLE LOCATIONS | AUGUST 09, 2018 9

09 - MASSACHUETTS AVENUE BETWEEN PRENTISS AND GARFIELD STREETS

STREET TREES



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SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

10

10 - CAMBRIDGE COMMON PARK

PARK TREES

REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

11 - HEWS STREET OFF WESTERN AVENUE

STREET TREES

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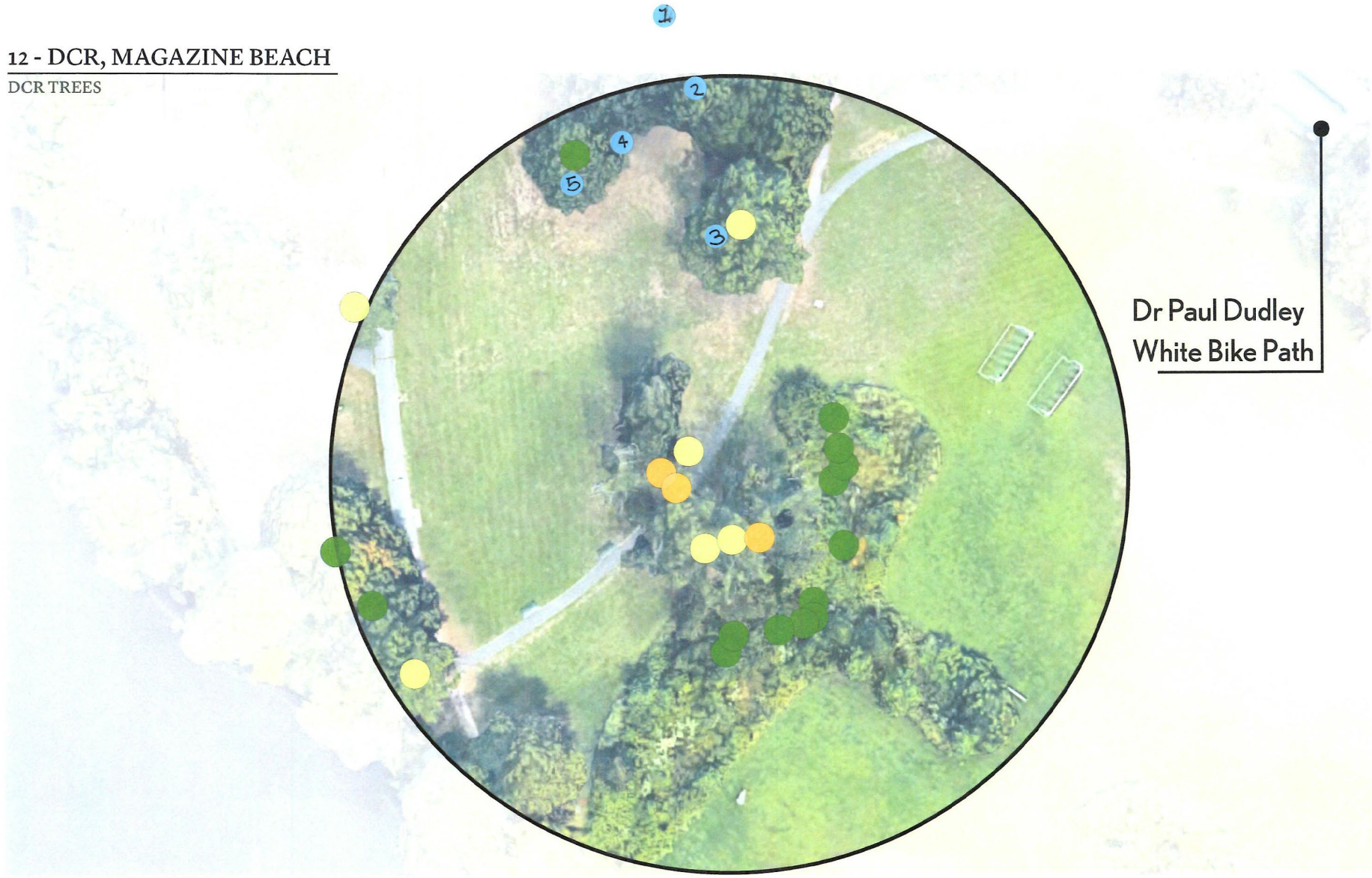
SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

12

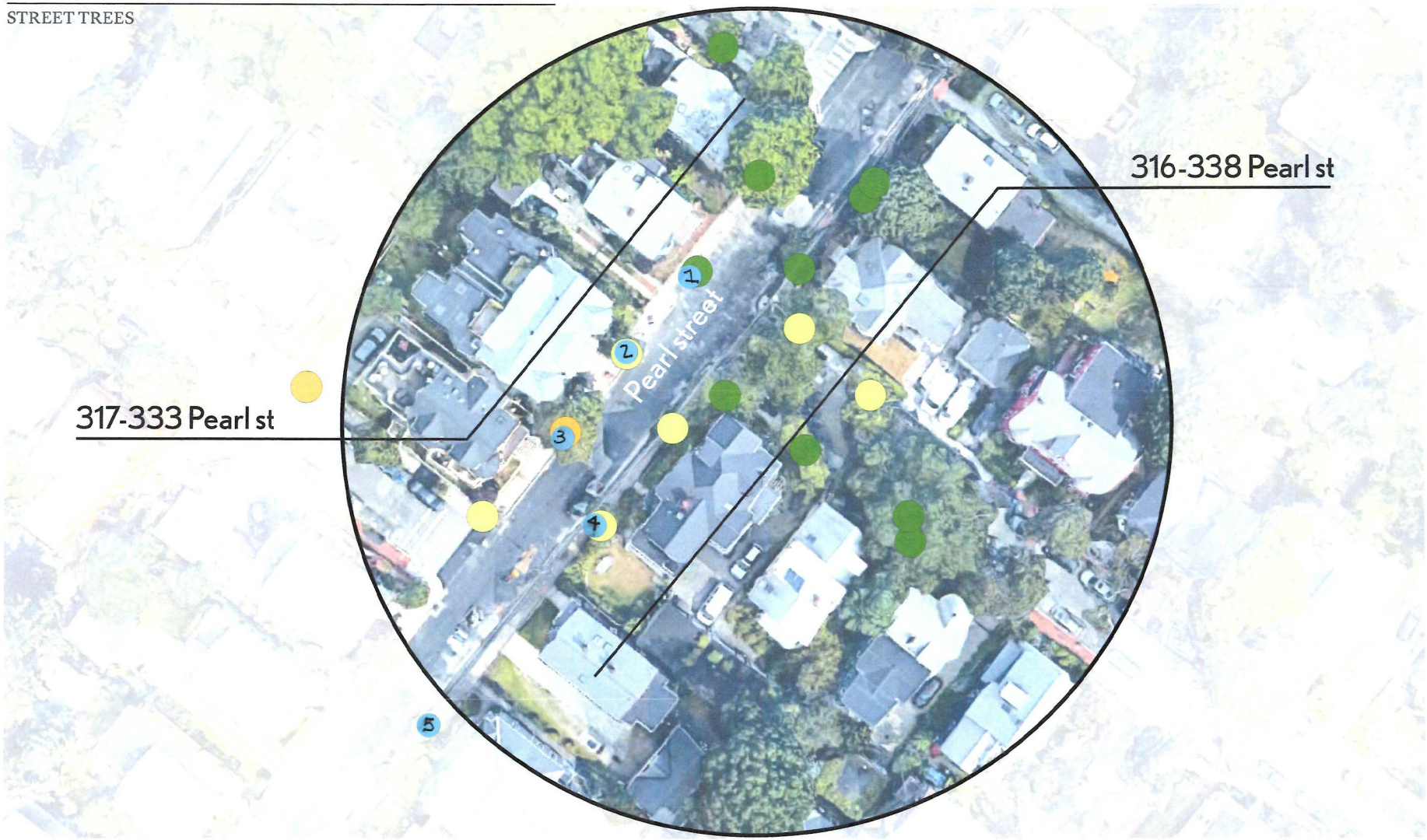
12 - DCR, MAGAZINE BEACH

DCR TREES



13 - CORNER OF PEARL AND HENRY STREETS

STREET TREES



REED HILDERBRAND | EF²

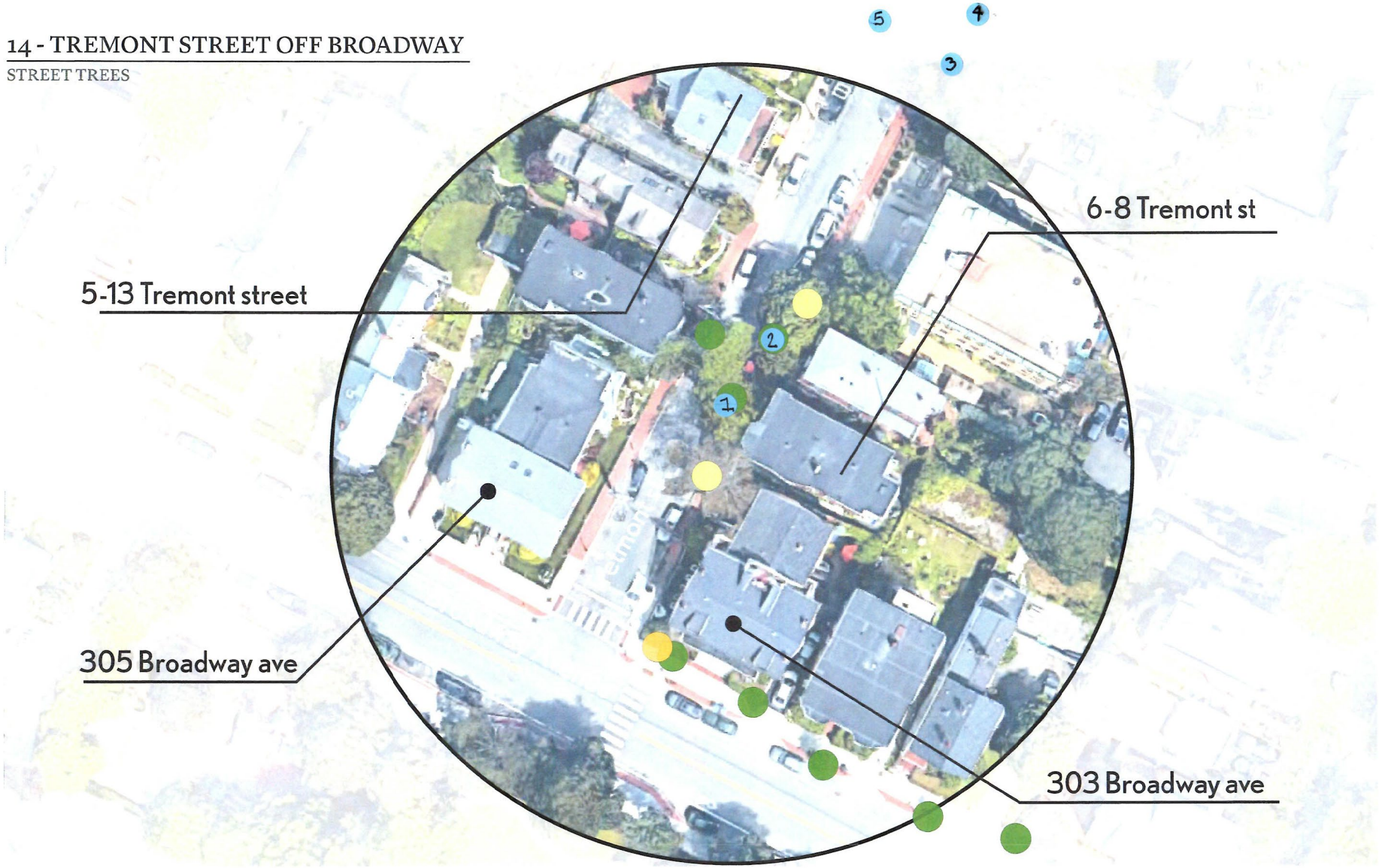
CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

14

14 - TREMONT STREET OFF BROADWAY

STREET TREES

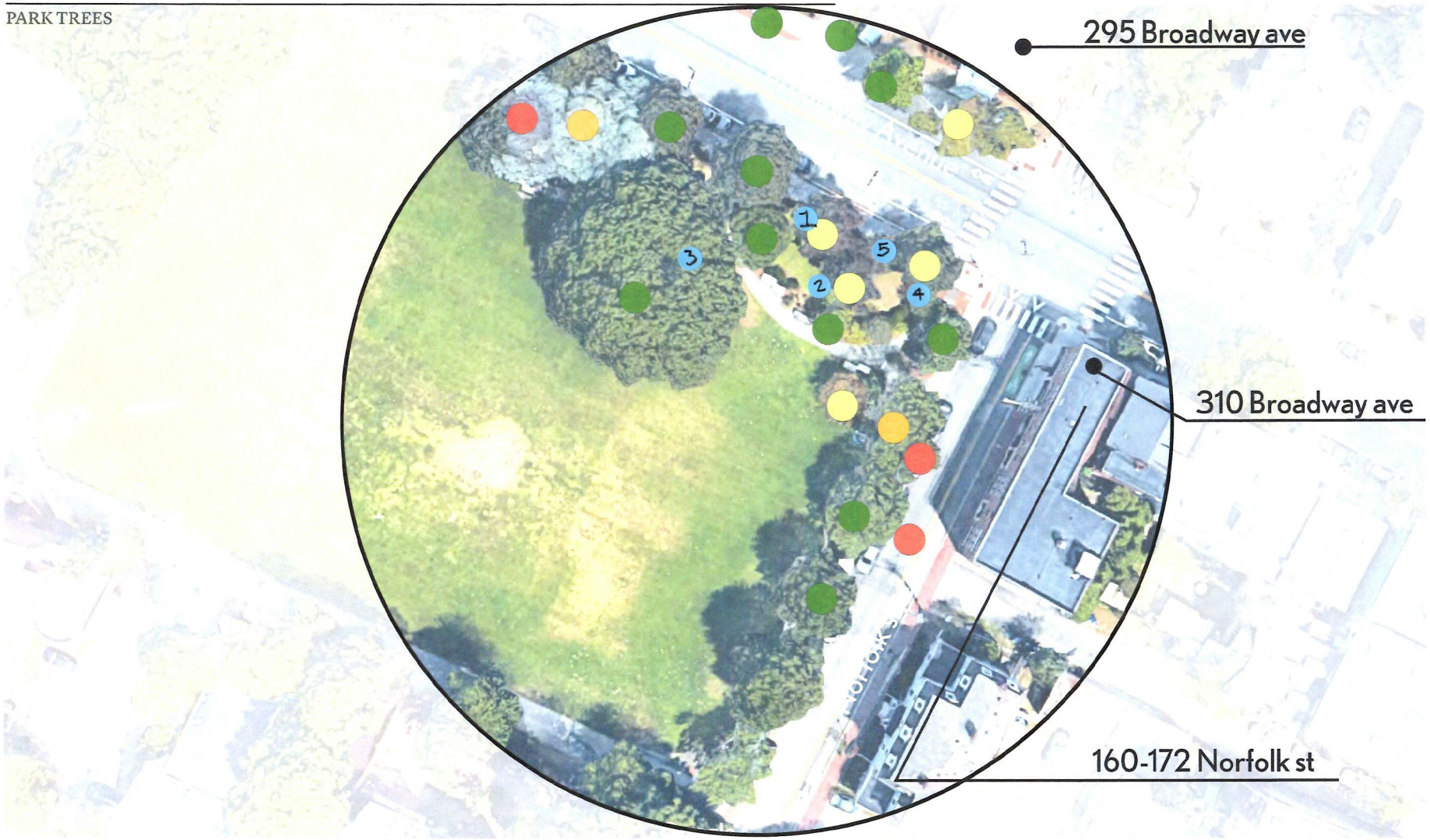


REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

15 - SENNOTT PARK, CORNER OF BROADWAY AND NORFOLK STREET

PARK TREES



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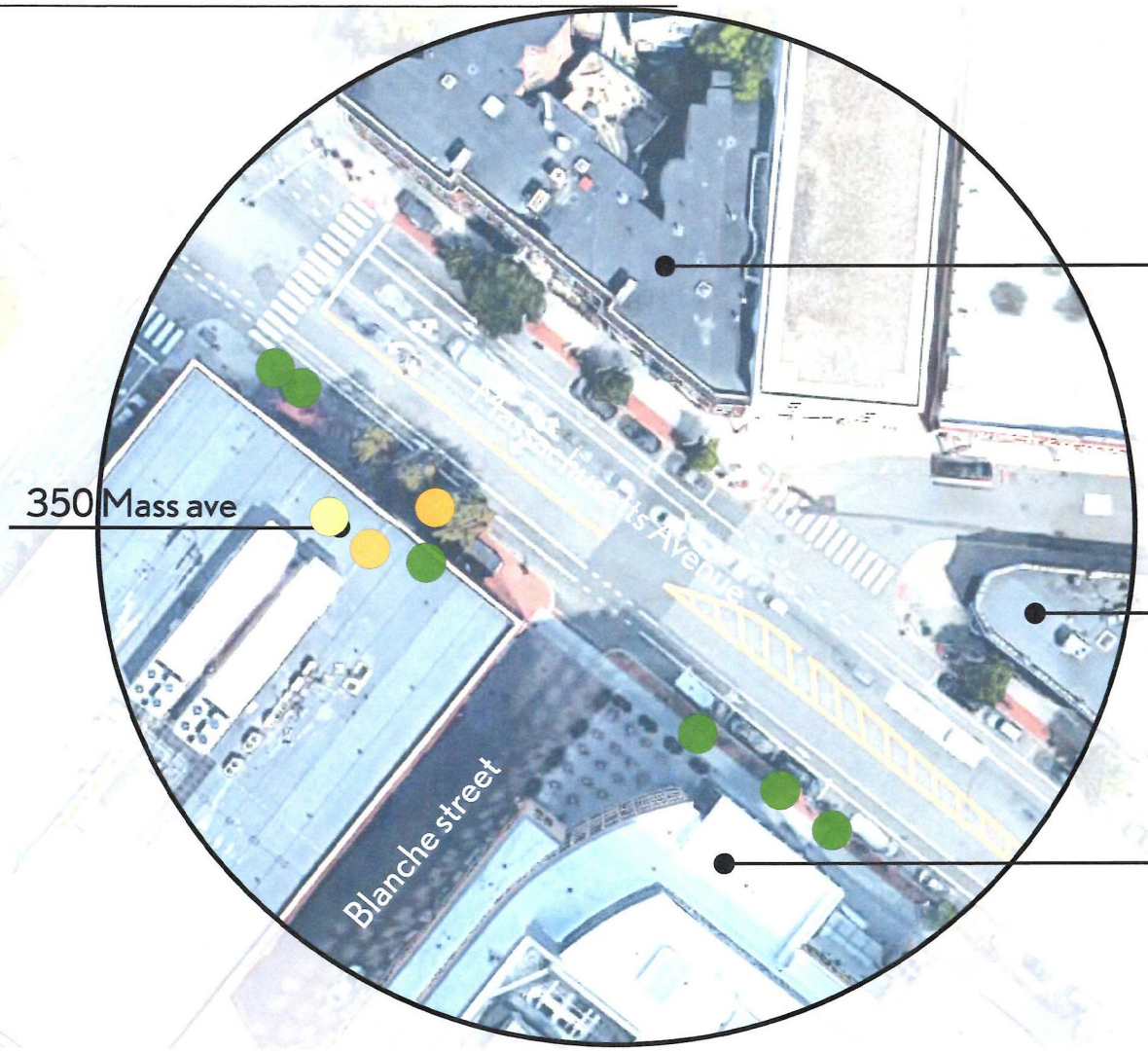
SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

16

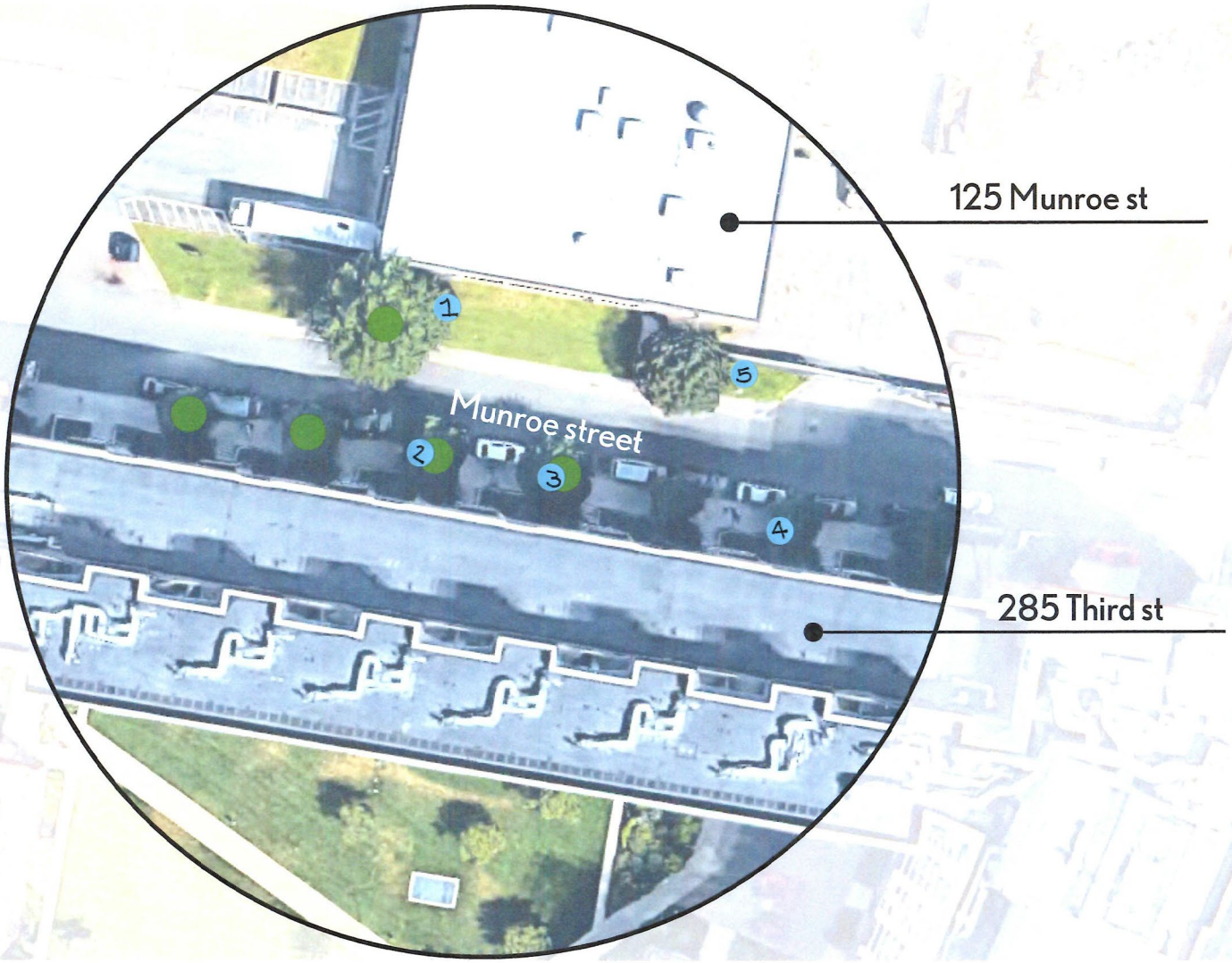
16 - MASSACHUSETTS AVENUE AT BLANCHE AND STATE STREETS

STREET TREES



17 - MUNROE STREET

STREET TREES



REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

18

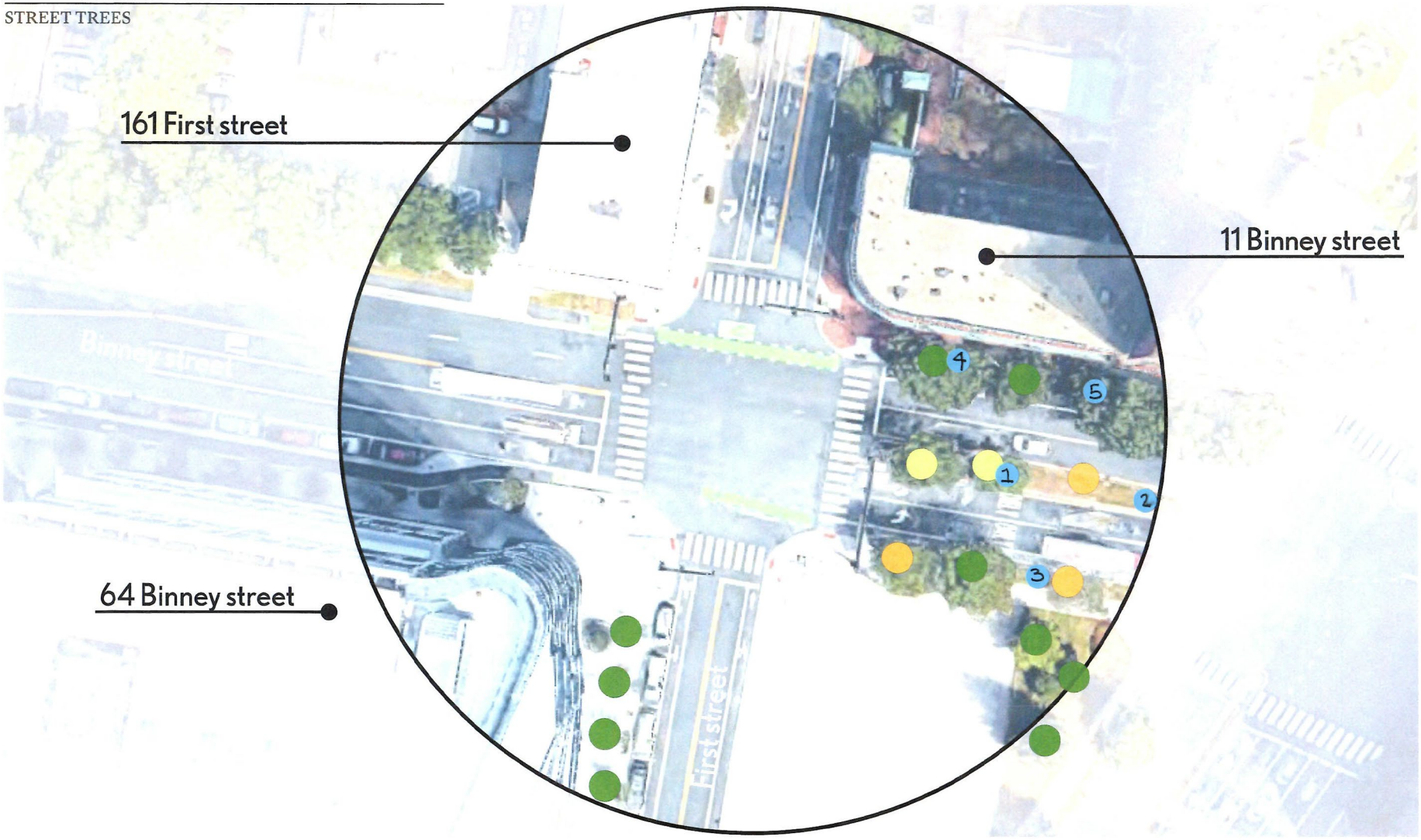
18 - SPRING STREET, OFF SCIARAPPA STREET

STREET TREES

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

19 - FIRST STREET & BINNEY STREET

STREET TREES



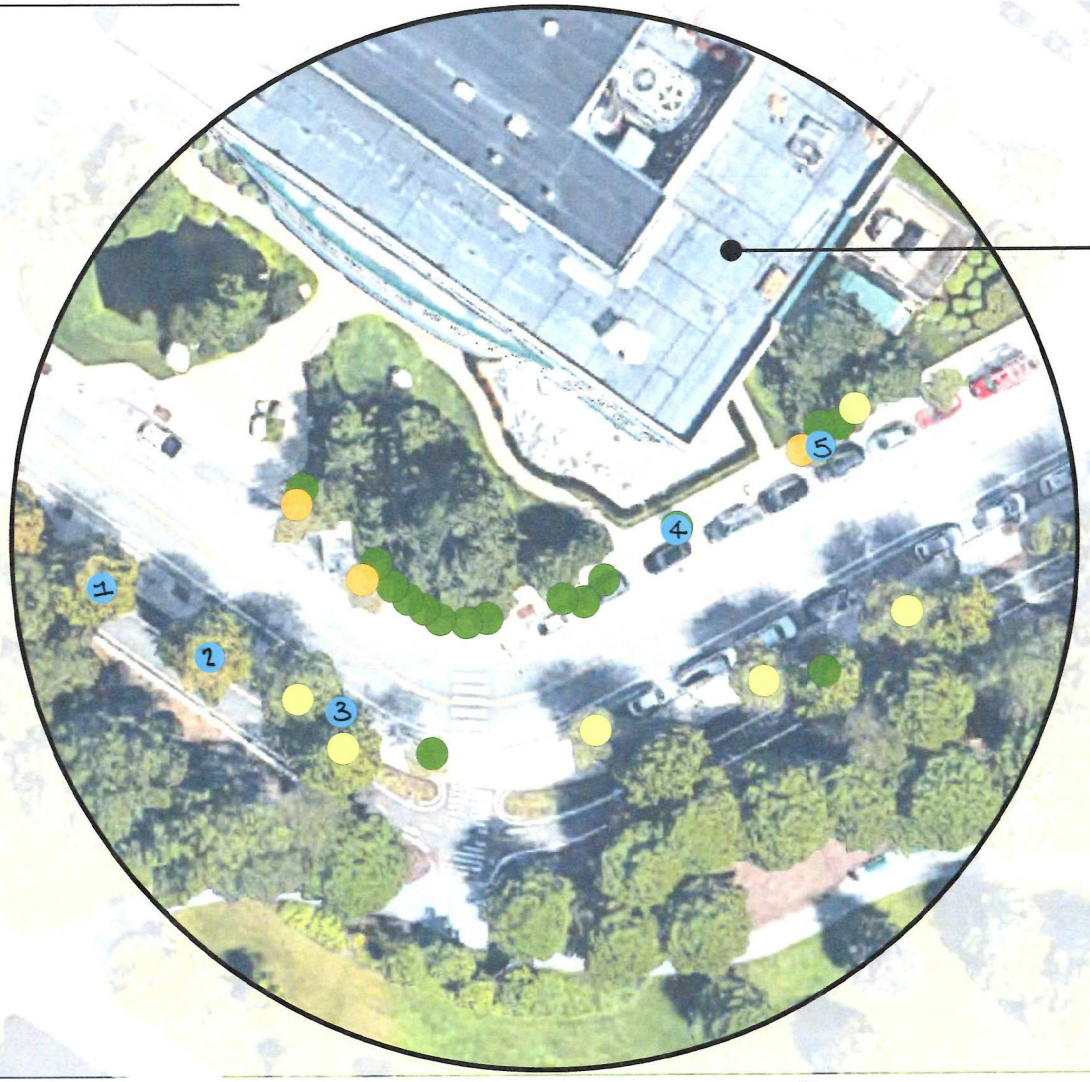
REED HILDERBRAND | CAMBRIDGE URBAN FOREST MASTER PLAN

SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

20

20 - EDUCATION STREET IN NORTH POINT

STREET TREES



SOIL SAMPLE LOCATIONS | AUGUST 09, 2018

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

	Location 1 EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	619.32	>20,000	Low
Flagellates	4,961.05	>20,000	Low
Ciliates	49.55	<56	
Nutrient Cycling Capacity from Microbial Activity	25-50 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	641.83	>300	
Fungal Biomass	416.53	>1,500	Low
Hyphal Diameter	3.25	>2.5	
Location 1 0-12"			
CEC	13	>10	
PH	5.6	6.5-7.0	
OM	4.8	4-8%	
Soluble Salts	0.09	<0.6	
Sand	66.30%		
Silt	22.60%		
Clay	11.10%		
Clay, Silt, VF Sand	39.00%		
Lead	74.5	<22	High
Location 1 12"-24"			
CEC	10	>10	
PH	6.7	6.5-7.0	
OM	2.7	4-8%	
Soluble Salts	0.1	<0.6	
Sand	60.90%		
Silt	26.20%		
Clay	12.90%		
Clay, Silt, VF Sand	42.80%		
Lead	48.3	<22	High
Location 1 24"-36"			
CEC	10.4	>10	
PH	6.1	6.5-7.0	
OM	2.9	4-8%	
Soluble Salts	0.09	<0.6	
Sand	54.00%		
Silt	26.60%		
Clay	19.30%		
Clay, Silt, VF Sand	50.30%		
Lead	14.1	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11890
Unique ID: Cambridge Loc 1
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.93	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	13.55	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	416.53	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.25	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	22.02	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	641.83	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.65		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.03		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.03		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.62		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	4,961.05	number/g	> 20,000.00	Lacking species diversity.
Amoebae	619.32	number/g	> 20,000.00	
Ciliates	49.55	number/g	< 56.00	
Nitrogen Cycling Potential	25-50	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.31	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.19	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.12	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	14.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11890
Unique ID: Cambridge Loc 1
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Panagrolaimus	0.03	number/g	Bacterial Feeders	
Plectus	0.03	number/g	Bacterial Feeders	
Rhabditidae	0.12	number/g	Bacterial Feeders	
Meloidogyne	0.05	number/g	Root Feeders	Root-Knot nematode
Pratylenchus	0.08	number/g	Root Feeders	Lesion nematode

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #1 0-12"
Order Number: 40083
Lab Number: S180904-302
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.6		**Cation Exch. Capacity, meq/100g**	13.0	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	8.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.2	4-14	Calcium Base Saturation	26	50-80
Potassium (K)	66	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	688	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	59	50-120	**Scoop Density, g/cc**	1.18	
Sulfur (S)	9.6	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.8	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.09	<0.6
Manganese (Mn)	2.8	1.1-6.3			
Zinc (Zn)	12.8	1.0-7.6			
Copper (Cu)	1.1	0.3-0.6			
Iron (Fe)	15.3	2.7-9.4			
Aluminum (Al)	78	<75			
Lead (Pb)	74.5	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #1 0-12"
Order Number: 40148
Lab Number: X180907-101
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	66.3
Silt	0.002-0.05	22.6
Clay	<0.002	11.1

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	8.4
Coarse	0.5-1.0	17.5
Medium	0.25-0.5	22.7
Fine	0.10-0.25	12.4
Very Fine	0.05-0.10	5.3

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	10.4
Medium	0.005-0.02	9.9
Fine	0.002-0.005	2.4

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	91.5
1.00	#18	83.9
0.50	#35	67.8
0.25	#60	47.0
0.10	#140	35.7
0.053	#270	30.9
0.02	20 um	21.4
0.005	5 um	12.3
0.002	2 um	10.1

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 8.5

Clay 11.1
Silt - 22.6
VF Sand 5.3
39.0

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

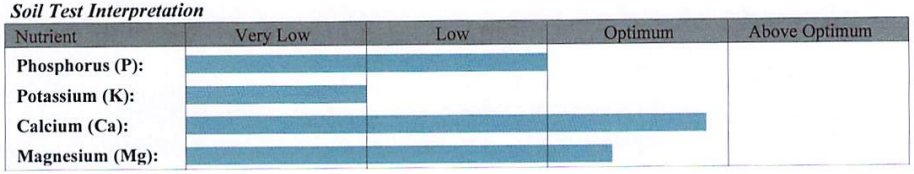
Sample Information:
Sample ID: Cambridge Loc #1 12-24"
Order Number: 40083
Lab Number: S180904-303
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.7		**Cation Exch. Capacity, meq/100g**	10.0	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	2.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.0	4-14	Calcium Base Saturation	73	50-80
Potassium (K)	51	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	1448	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	75	50-120	**Scoop Density, g/cc**	1.28	
Sulfur (S)	14.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.7	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.10	<0.6
Manganese (Mn)	1.7	1.1-6.3			
Zinc (Zn)	10.1	1.0-7.6			
Copper (Cu)	3.4	0.3-0.6			
Iron (Fe)	10.2	2.7-9.4			
Aluminum (Al)	40	<75			
Lead (Pb)	48.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #1 12-24"
Order Number: 40148
Lab Number: X180907-102
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	60.9
Silt	0.002-0.05	26.2
Clay	<0.002	12.9

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	6.5
Coarse	0.5-1.0	14.2
Medium	0.25-0.5	22.1
Fine	0.10-0.25	14.4
Very Fine	0.05-0.10	3.7

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	11.9
Medium	0.005-0.02	9.2
Fine	0.002-0.005	5.2

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	65.8
1.00	#18	61.5
0.50	#35	52.2
0.25	#60	37.6
0.10	#140	28.1
0.053	#270	25.7
0.02	20 um	17.9
0.005	5 um	11.9
0.002	2 um	8.5

USDA Textural Class: gravelly sandy loam

Gravel Content: (%) 34.2

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

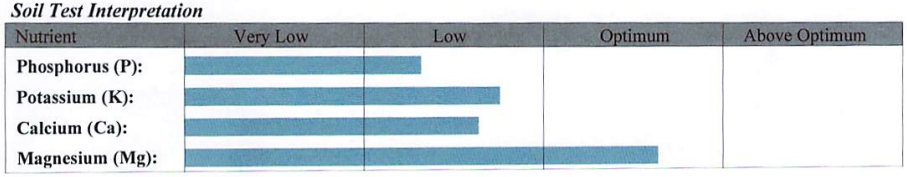
Sample Information:
Sample ID: Cambridge Loc #1 24-36"
Order Number: 40083
Lab Number: S180904-304
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.1		**Cation Exch. Capacity, meq/100g**	10.4	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	5.3	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.6	4-14	Calcium Base Saturation	39	50-80
Potassium (K)	88	100-160	Magnesium Base Saturation	7	10-30
Calcium (Ca)	818	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	95	50-120	**Scoop Density, g/cc**	1.17	
Sulfur (S)	11.0	>10	**Optional tests**		
*Micronutrients **			Soil Organic Matter (LOI), %	2.9	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.09	<0.6
Manganese (Mn)	2.2	1.1-6.3			
Zinc (Zn)	11.8	1.0-7.6			
Copper (Cu)	3.9	0.3-0.6			
Iron (Fe)	17.0	2.7-9.4			
Aluminum (Al)	45	<75			
Lead (Pb)	14.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #1 24-36"
Order Number: 40148
Lab Number: X180907-103
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	54.0
Silt	0.002-0.05	26.6
Clay	<0.002	19.3
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	5.1
Coarse	0.5-1.0	13.2
Medium	0.25-0.5	19.6
Fine	0.10-0.25	11.7
Very Fine	0.05-0.10	4.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	9.7
Medium	0.005-0.02	7.9
Fine	0.002-0.005	9.0

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	63.8
1.00	#18	60.5
0.50	#35	52.1
0.25	#60	39.6
0.10	#140	32.1
0.053	#270	29.3
0.02	20 um	23.1
0.005	5 um	18.1
0.002	2 um	12.3

USDA Textural Class: gravelly sandy loam

Gravel Content: (%) 36.2

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 2

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	9,003.33	>20,000	Low
Flagellates	1,500.19	>20,000	Low
Ciliates	30.31	<105	
Nutrient Cycling Capacity from Microbial Activity	50-75 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	793.94	>300	
Fungal Biomass	566.45	>1,500	Low
Hyphal Diameter	3.5	>2.5	
Location 2 0-12"			
CEC	15.2	>10	
PH	5.1	6.5-7.0	
OM	7.8	4-8%	
Soluble Salts	0.18	<0.6	
Sand	69.90%		
Silt	24.90%		
Clay	5.20%		
Clay, Silt, VF Sand	36.70%		
Lead	3.1	<22	
Location 2 12"-24"			
CEC	10.9	>10	
PH	5.3	6.5-7.0	
OM	4	4-8%	
Soluble Salts	0.14	<0.6	
Sand	74.30%		
Silt	19.10%		
Clay	6.60%		
Clay, Silt, VF Sand	33.10%		
Lead	2.2	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11891
Unique ID: Cambridge Loc 2
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.92	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	25.41	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	566.45	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.50	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	16.32	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	793.94	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.71		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.04		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.02		> 0.10	Low bacterial activity, foods may be required.
AF:AB	1.56		5.00 to 10.00	Bacterial dominated, becoming more fungal.
Protozoa (Protists)				
Flagellates	1,500.19	number/g	> 20,000.00	Lacking species diversity.
Amoebae	9,003.33	number/g	> 20,000.00	
Ciliates	30.31	number/g	< 105.00	
Nitrogen Cycling Potential	50-75	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.79	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.33	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.10	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.36	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	12.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11891
Unique ID: Cambridge Loc 2
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Plectus	0.08	number/g	Bacterial Feeders	
Rhabditidae	0.25	number/g	Bacterial Feeders	
Filenchus	0.10	number/g	Fungal/Root Feeders	
Meloidogyne	0.36	number/g	Root Feeders	Root-Knot nematode

UMass Extension

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Amherst, MA 01003
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

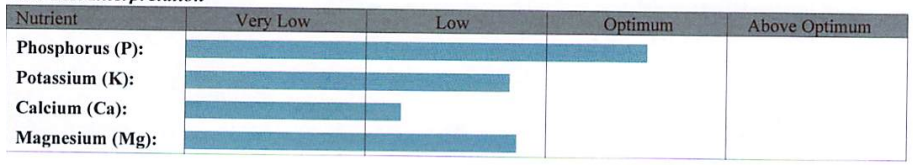
Sample Information:
Sample ID: Cambridge Loc #2 0-12"
Order Number: 40083
Lab Number: S180904-305
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.1		**Cation Exch. Capacity, meq/100g**	15.2	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	11.6	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	9.7	4-14	Calcium Base Saturation	20	50-80
Potassium (K)	89	100-160	Magnesium Base Saturation	2	10-30
Calcium (Ca)	595	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	46	50-120	**Scoop Density, g/cc**	1.04	
Sulfur (S)	10.3	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	7.8	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.18	<0.6
Manganese (Mn)	18.2	1.1-6.3			
Zinc (Zn)	5.7	1.0-7.6			
Copper (Cu)	0.3	0.3-0.6			
Iron (Fe)	12.5	2.7-9.4			
Aluminum (Al)	88	<75			
Lead (Pb)	3.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #2 0-12"
Order Number: 40148
Lab Number: X180907-104
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	69.9
Silt	0.002-0.05	24.9
Clay	<0.002	5.2
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.7
Coarse	0.5-1.0	17.8
Medium	0.25-0.5	23.5
Fine	0.10-0.25	12.3
Very Fine	0.05-0.10	6.6
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	12.4
Medium	0.005-0.02	10.3
Fine	0.002-0.005	2.2

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	83.2
1.00	#18	75.2
0.50	#35	60.3
0.25	#60	40.7
0.10	#140	30.6
0.053	#270	25.1
0.02	20 um	14.7
0.005	5 um	6.1
0.002	2 um	4.3

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 16.8

UMass Extension

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Phone: (413) 545-2311
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

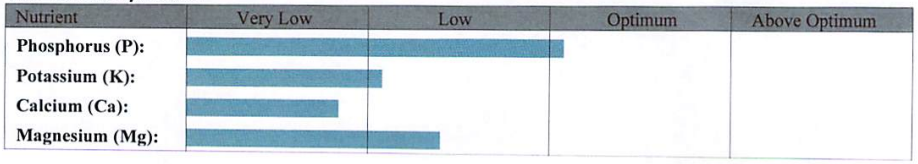
Sample Information:
Sample ID: Cambridge Loc #2 12-24"
Order Number: 40083
Lab Number: S180904-306
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.3		**Cation Exch. Capacity, meq/100g**	10.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	8.4	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.8	4-14	Calcium Base Saturation	19	50-80
Potassium (K)	53	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	421	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	35	50-120	**Scoop Density, g/cc**	1.24	
Sulfur (S)	9.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.0	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.14	<0.6
Manganese (Mn)	9.2	1.1-6.3			
Zinc (Zn)	3.4	1.0-7.6			
Copper (Cu)	0.2	0.3-0.6			
Iron (Fe)	10.5	2.7-9.4			
Aluminum (Al)	72	<75			
Lead (Pb)	2.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #2 12-24"
Order Number: 40148
Lab Number: X180907-105
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	74.3
Silt	0.002-0.05	19.1
Clay	<0.002	6.6
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.9
Coarse	0.5-1.0	19.0
Medium	0.25-0.5	21.5
Fine	0.10-0.25	16.6
Very Fine	0.05-0.10	7.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	11.1
Medium	0.005-0.02	5.0
Fine	0.002-0.005	3.0

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	79.3
1.00	#18	71.4
0.50	#35	56.4
0.25	#60	39.4
0.10	#140	26.2
0.053	#270	20.4
0.02	20 um	11.6
0.005	5 um	7.7
0.002	2 um	5.3

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 20.7

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 3

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	1,500.13	>20,000	Low
Flagellates	3,001.34	>20,000	Low
Ciliates	0.00	<45	
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	665.88	>300	
Fungal Biomass	150.73	>1,500	
Hyphal Diameter	2.75	>2.5	
Location 3 0-12"			
CEC	7.6	>10	
PH	6.7	6.5-7.0	
OM	3.8	4-8%	
Soluble Salts	0.12	<0.6	
Sand	66.90%		
Silt	25.10%		
Clay	8.00%		
Clay, Silt, VF Sand	38.30%		
Lead	4.80	<22	
Location 3 12"-24"			
CEC	8.3	>10	
PH	6.2	6.5-7.0	
OM	4.2	4-8%	
Soluble Salts	0.26	<0.6	
Sand	66.80%		
Silt	23.20%		
Clay	9.90%		
Clay, Silt, VF Sand	40.20%		
Lead	4.8	<22	
Location 3 24"-36"			
CEC	7.2	>10	
PH	6.4	6.5-7.0	
OM	3.7	4-8%	
Soluble Salts	0.27	<0.6	
Sand	67.70%		
Silt	20.40%		
Clay	11.90%		
Clay, Silt, VF Sand	38.70%		
Lead	10.7	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11892
Unique ID: Cambridge Loc 3
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.92	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	1.96	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	150.73	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	2.75	µm	> 2.50	Good balance of fungi. -
Active Bacteria	34.88	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	665.88	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.23		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.01		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.05		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.06		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	3,001.34	number/g	> 20,000.00	Lacking species diversity.
Amoebae	1,500.13	number/g	> 20,000.00	
Ciliates	0.00	number/g	< 45.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.42	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.13	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.05	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.23	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	24.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11892
Unique ID: Cambridge Loc 3
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
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soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Prismatolaimus	0.08	number/g	Bacterial Feeders	
Teratocephalus	0.05	number/g	Bacterial Feeders	
Filenchus	0.05	number/g	Fungal/Root Feeders	
Xiphinema	0.23	number/g	Root Feeders	Dagger nematode

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

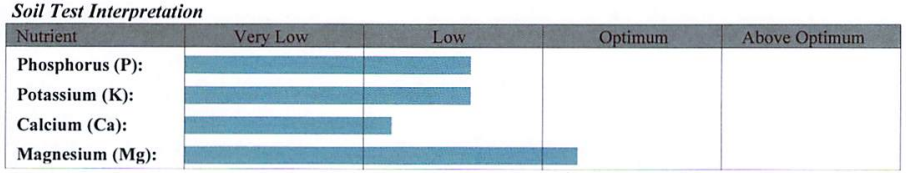
Sample Information:
Sample ID: Cambridge Loc #3 0-12"
Order Number: 40083
Lab Number: S180904-307
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.7		**Cation Exch. Capacity, meq/100g**	7.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.2	4-14	Calcium Base Saturation	38	50-80
Potassium (K)	79	100-160	Magnesium Base Saturation	7	10-30
Calcium (Ca)	572	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	63	50-120	**Scoop Density, g/cc**	1.13	
Sulfur (S)	8.6	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.8	
Boron (B)	0.2	0.1-0.5	Soluble Salts (1:2), dS/m	0.12	<0.6
Manganese (Mn)	2.0	1.1-6.3			
Zinc (Zn)	5.5	1.0-7.6			
Copper (Cu)	0.3	0.3-0.6			
Iron (Fe)	4.1	2.7-9.4			
Aluminum (Al)	48	<75			
Lead (Pb)	4.8	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Amherst, MA 01003
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website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #3 0-12"
Order Number: 40148
Lab Number: X180907-106
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	66.9
Silt	0.002-0.05	25.1
Clay	<0.002	8.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	4.3
Coarse	0.5-1.0	13.8
Medium	0.25-0.5	29.4
Fine	0.10-0.25	14.1
Very Fine	0.05-0.10	5.2
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	13.3
Medium	0.005-0.02	8.7
Fine	0.002-0.005	3.1

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	74.4
1.00	#18	71.1
0.50	#35	60.9
0.25	#60	39.0
0.10	#140	28.5
0.053	#270	24.6
0.02	20 um	14.7
0.005	5 um	8.3
0.002	2 um	5.9

USDA Textural Class: sandy loam

Gravel Content: (%) 25.6

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #3 12-24"
Order Number: 40083
Lab Number: S180904-308
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.2		**Cation Exch. Capacity, meq/100g**	8.3	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.3	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.6	4-14	Calcium Base Saturation	41	50-80
Potassium (K)	61	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	688	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	50	50-120	**Scoop Density, g/cc**	1.05	
Sulfur (S)	13.8	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.2	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.26	<0.6
Manganese (Mn)	1.8	1.1-6.3			
Zinc (Zn)	4.7	1.0-7.6			
Copper (Cu)	0.2	0.3-0.6			
Iron (Fe)	7.2	2.7-9.4			
Aluminum (Al)	73	<75			
Lead (Pb)	4.8	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #3 12-24"
Order Number: 40148
Lab Number: X180907-107
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	66.8
Silt	0.002-0.05	23.2
Clay	<0.002	9.9
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	4.5
Coarse	0.5-1.0	11.6
Medium	0.25-0.5	22.9
Fine	0.10-0.25	20.7
Very Fine	0.05-0.10	7.1
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	10.3
Medium	0.005-0.02	8.5
Fine	0.002-0.005	4.5

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	91.3
1.00	#18	87.2
0.50	#35	76.6
0.25	#60	55.7
0.10	#140	36.7
0.053	#270	30.3
0.02	20 um	20.9
0.005	5 um	13.1
0.002	2 um	9.1

USDA Textural Class: sandy loam

Gravel Content: (%) 8.7

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

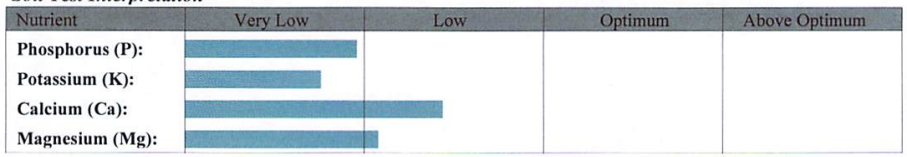
Sample Information:
Sample ID: Cambridge Loc #3 24-36"
Order Number: 40083
Lab Number: S180904-309
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.4		**Cation Exch. Capacity, meq/100g**	7.2	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.3	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.9	4-14	Calcium Base Saturation	50	50-80
Potassium (K)	39	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	719	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	27	50-120	**Scoop Density, g/cc**	1.09	
Sulfur (S)	12.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.7	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.27	<0.6
Manganese (Mn)	2.2	1.1-6.3			
Zinc (Zn)	4.4	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	6.6	2.7-9.4			
Aluminum (Al)	57	<75			
Lead (Pb)	10.7	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:

Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:

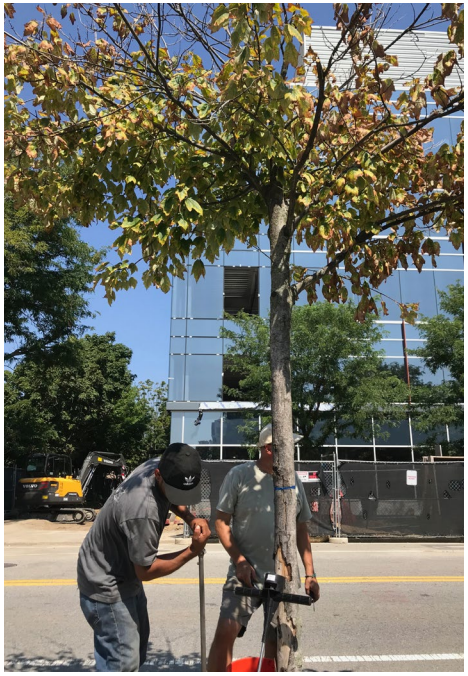
Sample ID: Cambridge Loc #3 24-36"
Order Number: 40148
Lab Number: X180907-108
Received: 9/7/2018
Reported: 9/13/2018

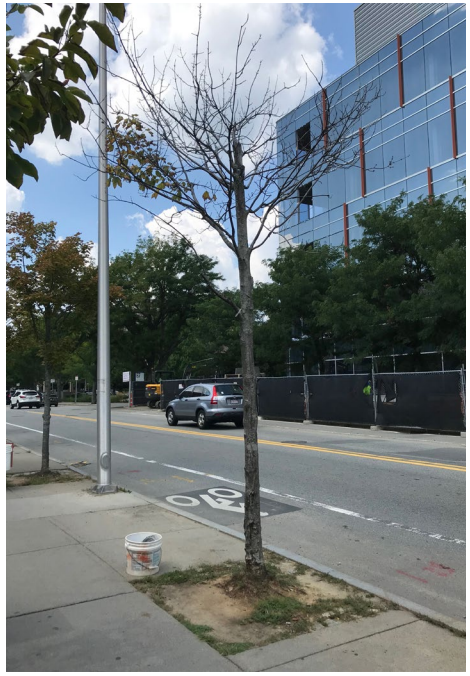
USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	67.7
Silt	0.002-0.05	20.4
Clay	<0.002	11.9
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	5.4
Coarse	0.5-1.0	13.5
Medium	0.25-0.5	25.3
Fine	0.10-0.25	17.1
Very Fine	0.05-0.10	6.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	7.8
Medium	0.005-0.02	8.7
Fine	0.002-0.005	3.9

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	66.1
1.00	#18	62.5
0.50	#35	53.6
0.25	#60	36.9
0.10	#140	25.6
0.053	#270	21.3
0.02	20 um	16.2
0.005	5 um	10.4
0.002	2 um	7.8

USDA Textural Class: gravelly sandy loam

Gravel Content: (%) 33.9





F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 4

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	17,483.71	>20,000	Low
Flagellates	3,487.25	>20,000	Low
Ciliates	17.66	<210	
Nutrient Cycling Capacity from Microbial Activity	75-100 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	944.47	>300	
Fungal Biomass	183.83	>1,500	
Hyphal Diameter	3.00	>2.5	
Location 4 0-12"			
CEC	16.1	>10	
PH	5.6	6.5-7.0	
OM	8.5	4-8%	
Soluble Salts	0.08	<0.6	
Sand	55.60%		
Silt	25.20%		
Clay	19.20%		
Clay, Silt, VF Sand	50.30%		
Lead	17.3	<22	
Location 4 12"-24"			
CEC	9.6	>10	
PH	5.7	6.5-7.0	
OM	3	4-8%	
Soluble Salts	0.05	<0.6	
Sand	82.40%		
Silt	7.50%		
Clay	10.10%		
Clay, Silt, VF Sand	21.70%		
Lead	9.2	<22	
Location 4 24"-36"			
CEC	7.1	>10	
PH	5.8	6.5-7.0	
OM	2.2	4-8%	
Soluble Salts	0.04	<0.6	
Sand	80.20%		
Silt	9.00%		
Clay	10.80%		
Clay, Silt, VF Sand	24.90%		
Lead	4.6	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11893
Unique ID: Cambridge Loc 4
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.79	N/A	0.45 to 0.85	Within normal moisture levels.
Active Fungi	1.36	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	183.83	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.00	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	17.28	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	944.47	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.19		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.01		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.02		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.08		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	3,497.25	number/g	> 20,000.00	Lacking species diversity.
Amoebae	17,483.71	number/g	> 20,000.00	
Ciliates	17.66	number/g	< 210.00	
Nitrogen Cycling Potential	75-100	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.31	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.74	number/g	> 4.00	
Fungal	0.29	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.29	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	15.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
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Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11893
Unique ID: Cambridge Loc 4
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

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17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Prismatolaimus	0.20	number/g	Bacterial Feeders	
Rhabditidae	0.53	number/g	Bacterial Feeders	
Aporcelaimium	0.12	number/g	Fungal Feeders	
Eudorylaimus	0.16	number/g	Fungal Feeders	
Gracilacus	0.12	number/g	Root Feeders	Pin nematode
Hemicriconemoides	0.08	number/g	Root Feeders	False Sheath nematode
Paratylenchus	0.08	number/g	Root Feeders	Pin nematode

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

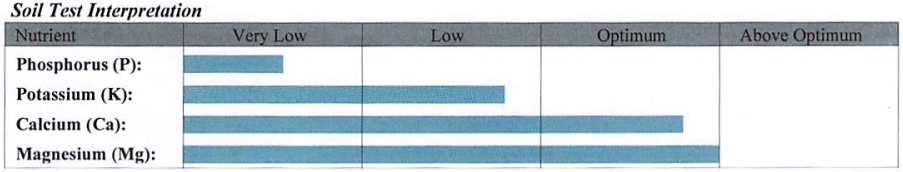
Sample Information:
Sample ID: Cambridge Loc #4 0-12"
Order Number: 40083
Lab Number: S180904-310
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.6		**Cation Exch. Capacity, meq/100g**	16.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	7.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.1	4-14	Calcium Base Saturation	44	50-80
Potassium (K)	91	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	1403	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	119	50-120	**Scoop Density, g/cc**	0.90	
Sulfur (S)	15.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	8.5	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	3.4	1.1-6.3			
Zinc (Zn)	7.7	1.0-7.6			
Copper (Cu)	0.2	0.3-0.6			
Iron (Fe)	25.9	2.7-9.4			
Aluminum (Al)	73	<75			
Lead (Pb)	17.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #4 0-12"
Order Number: 40148
Lab Number: X180907-109
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	55.6
Silt	0.002-0.05	25.2
Clay	<0.002	19.2
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	6.7
Coarse	0.5-1.0	12.9
Medium	0.25-0.5	16.9
Fine	0.10-0.25	13.2
Very Fine	0.05-0.10	5.9
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	10.9
Medium	0.005-0.02	9.6
Fine	0.002-0.005	4.7

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	79.4
1.00	#18	74.0
0.50	#35	63.8
0.25	#60	50.4
0.10	#140	39.9
0.053	#270	35.3
0.02	20 um	26.6
0.005	5 um	19.0
0.002	2 um	15.2

USDA Textural Class: sandy loam

Gravel Content: (%) 20.6

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

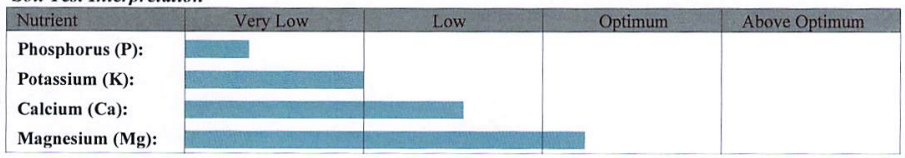
Sample Information:
Sample ID: Cambridge Loc #4 12-24"
Order Number: 40083
Lab Number: S180904-311
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.7		**Cation Exch. Capacity, meq/100g**	9.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	5.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	0.7	4-14	Calcium Base Saturation	40	50-80
Potassium (K)	51	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	770	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	68	50-120	**Scoop Density, g/cc**	1.18	
Sulfur (S)	7.3	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.0	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.05	<0.6
Manganese (Mn)	1.5	1.1-6.3			
Zinc (Zn)	3.0	1.0-7.6			
Copper (Cu)	0.1	0.3-0.6			
Iron (Fe)	10.3	2.7-9.4			
Aluminum (Al)	30	<75			
Lead (Pb)	9.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #4 12-24"
Order Number: 40148
Lab Number: X180907-110
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	82.4
Silt	0.002-0.05	7.5
Clay	<0.002	10.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	8.6
Coarse	0.5-1.0	17.0
Medium	0.25-0.5	35.0
Fine	0.10-0.25	17.6
Very Fine	0.05-0.10	4.1
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	1.3
Medium	0.005-0.02	3.3
Fine	0.002-0.005	2.9

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	59.8
1.00	#18	54.6
0.50	#35	44.4
0.25	#60	23.5
0.10	#140	13.0
0.053	#270	10.5
0.02	20 um	9.7
0.005	5 um	7.8
0.002	2 um	6.0

USDA Textural Class: gravelly loamy coarse sand

Gravel Content: (%) 40.2

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

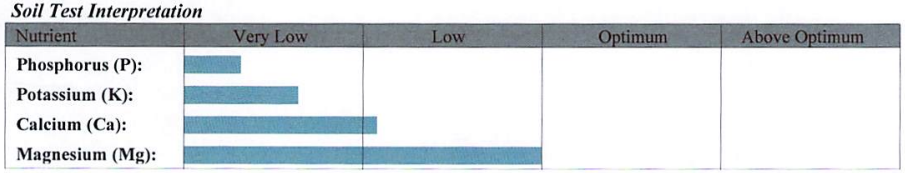
Sample Information:
Sample ID: Cambridge Loc #4 24-36"
Order Number: 40083
Lab Number: S180904-313
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.8		**Cation Exch. Capacity, meq/100g**	7.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	0.7	4-14	Calcium Base Saturation	38	50-80
Potassium (K)	32	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	535	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	50	50-120	**Scoop Density, g/cc**	1.23	
Sulfur (S)	5.4	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.2	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.04	<0.6
Manganese (Mn)	2.6	1.1-6.3			
Zinc (Zn)	2.2	1.0-7.6			
Copper (Cu)	0.1	0.3-0.6			
Iron (Fe)	8.1	2.7-9.4			
Aluminum (Al)	29	<75			
Lead (Pb)	4.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #4 24-36"
Order Number: 40148
Lab Number: X180907-111
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	80.2
Silt	0.002-0.05	9.0
Clay	<0.002	10.8
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	13.5
Coarse	0.5-1.0	19.6
Medium	0.25-0.5	27.4
Fine	0.10-0.25	14.6
Very Fine	0.05-0.10	5.1
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	2.0
Medium	0.005-0.02	4.0
Fine	0.002-0.005	2.9

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	58.0
1.00	#18	50.2
0.50	#35	38.8
0.25	#60	22.9
0.10	#140	14.4
0.053	#270	11.5
0.02	20 um	10.3
0.005	5 um	8.0
0.002	2 um	6.3

USDA Textural Class: gravelly coarse sandy loam

Gravel Content: (%) 42.0

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 5

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	15,413.36	>20,000	Low
Flagellates	2,380.44	>20,000	Low
Ciliates	6.67	<178	
Nutrient Cycling Capacity from Microbial Activity	50-75 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	942.48	>300	
Fungal Biomass	122.25	>1,500	
Hyphal Diameter	2.50	>2.5	
Location 5 0-12"			
CEC	4.5	>10	
PH	5.7	6.5-7.0	
OM	1.7	4-8%	
Soluble Salts	0.09	<0.6	
Sand	77.70%		
Silt	12.20%		
Clay	10.10%		
Clay, Silt, VF Sand	27.40%		
Lead	1.2	<22	
Location 5 12"-24"			
CEC	0.7	>10	
PH	6.1	6.5-7.0	
OM	0.3	4-8%	
Soluble Salts	0.14	<0.6	
Sand	92.20%		
Silt	2.40%		
Clay	5.40%		
Clay, Silt, VF Sand	16.00%		
Lead	0.1	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11894
Unique ID: Cambridge Loc 5
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.90	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	2.48	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	122.25	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	2.50	µm	> 2.50	Good balance of fungi. -
Active Bacteria	24.27	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	942.48	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.13		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.02		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.03		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.10		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	2,380.44	number/g	> 20,000.00	Lacking species diversity.
Amoebae	15,413.36	number/g	> 20,000.00	
Ciliates	6.67	number/g	< 178.00	
Nitrogen Cycling Potential	50-75	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.85	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.85	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	9.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11894
Unique ID: Cambridge Loc 5
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.13	number/g	Bacterial Feeders	
Plectus	0.13	number/g	Bacterial Feeders	
Prismatolaimus	0.21	number/g	Bacterial Feeders	
Rhabditidae	0.38	number/g	Bacterial Feeders	

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

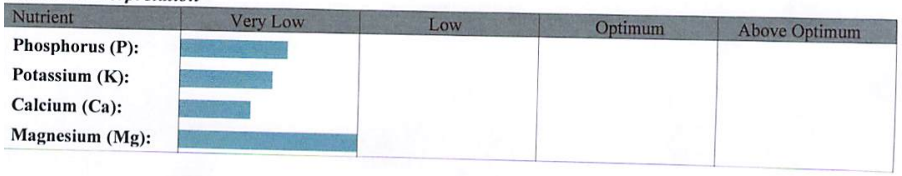
Sample Information:
Sample ID: Cambridge Loc #5 0-12"
Order Number: 40083
Lab Number: S180904-314
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.7		**Cation Exch. Capacity, meq/100g**	4.5	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.2	4-14	Calcium Base Saturation	23	50-80
Potassium (K)	25	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	209	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	25	50-120	**Scoop Density, g/cc**	1.16	
Sulfur (S)	5.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.7	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.09	<0.6
Manganese (Mn)	1.8	1.1-6.3			
Zinc (Zn)	0.4	1.0-7.6			
Copper (Cu)	0.1	0.3-0.6			
Iron (Fe)	19.1	2.7-9.4			
Aluminum (Al)	65	<75			
Lead (Pb)	1.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



23 of 56

Sample ID: Cambridge Loc #5 0-12"

Lab N...

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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #5 0-12"
Order Number: 40148
Lab Number: X180907-112
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	77.7
Silt	0.002-0.05	12.2
Clay	<0.002	10.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.6
Coarse	0.5-1.0	19.7
Medium	0.25-0.5	29.1
Fine	0.10-0.25	16.3
Very Fine	0.05-0.10	5.1
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	4.1
Medium	0.005-0.02	5.2
Fine	0.002-0.005	2.9

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	80.2
1.00	#18	74.1
0.50	#35	58.3
0.25	#60	35.0
0.10	#140	21.9
0.053	#270	17.9
0.02	20 um	14.5
0.005	5 um	10.4
0.002	2 um	8.1

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 19.8

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

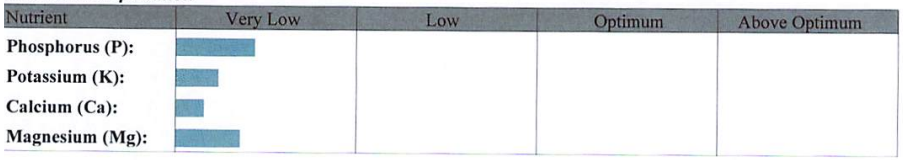
Sample Information:
Sample ID: Cambridge Loc #5 12-24"
Order Number: 40083
Lab Number: S180904-315
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.1		**Cation Exch. Capacity, meq/100g**	0.7	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.2	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	0.8	4-14	Calcium Base Saturation	59	50-80
Potassium (K)	13	100-160	Magnesium Base Saturation	10	10-30
Calcium (Ca)	87	1000-1500	Potassium Base Saturation	4	2.0-7.0
Magnesium (Mg)	9	50-120	**Scoop Density, g/cc**	1.33	
Sulfur (S)	2.8	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	0.3	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.14	<0.6
Manganese (Mn)	0.4	1.1-6.3			
Zinc (Zn)	0.1	1.0-7.6			
Copper (Cu)	0.0	0.3-0.6			
Iron (Fe)	3.4	2.7-9.4			
Aluminum (Al)	17	<75			
Lead (Pb)	0.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

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Sample Information:
Sample ID: Cambridge Loc #5 12-24"
Order Number: 40148
Lab Number: X180907-113
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	92.2
Silt	0.002-0.05	2.4
Clay	<0.002	5.4
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.0
Coarse	0.5-1.0	17.7
Medium	0.25-0.5	29.7
Fine	0.10-0.25	29.5
Very Fine	0.05-0.10	8.2
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	-0.3
Medium	0.005-0.02	-0.8
Fine	0.002-0.005	3.5

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	82.1
1.00	#18	76.3
0.50	#35	61.8
0.25	#60	37.4
0.10	#140	13.2
0.053	#270	6.4
0.02	20 um	6.7
0.005	5 um	7.3
0.002	2 um	4.5

USDA Textural Class: sand

Gravel Content: (%) 17.9

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

	Location 6		
	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	5,108.16	>20,000	
Flagellates	1,537.11	>20,000	
Ciliates	313.85	<66	
Nutrient Cycling Capacity from Microbial Activity	25-50 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	977.39	>300	
Fungal Biomass	1,004.87	>1,500	
Hyphal Diameter	3.00	>2.5	
Location 6 0-12"			
CEC	7.7	>10	
PH	6.4	6.5-7.0	
OM	5.4	4-8%	
Soluble Salts	0.12	<0.6	
Sand	77.20%		
Silt	13.00%		
Clay	9.80%		
Clay, Silt, VF Sand	29.30%		
Lead	9.4	<22	
Location 6 12"-24"			
CEC	4.5	>10	
PH	6.4	6.5-7.0	
OM	2.6	4-8%	
Soluble Salts	0.16	<0.6	
Sand	77.20%		
Silt	13.40%		
Clay	9.40%		
Clay, Silt, VF Sand	29.30%		
Lead	7.2	<22	
Location 6 24"-36"			
CEC	3.9	>10	
PH	6.2	6.5-7.0	
OM	2	4-8%	
Soluble Salts	0.17	<0.6	
Sand	84.30%		
Silt	7.60%		
Clay	8.10%		
Clay, Silt, VF Sand	21.10%		
Lead	10.6	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11895
Unique ID: Cambridge Loc 6
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.90	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	11.93	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	1,004.87	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.00	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	12.14	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	977.39	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	1.03		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.01		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.01		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.98		5.00 to 10.00	Balanced fungal and bacterial biomass, likely to stay balanced.
Protozoa (Protists)				
Flagellates	1,537.11	number/g	> 20,000.00	High ciliate numbers indicate possible anaerobic conditions.
Amoebae	5,108.16	number/g	> 20,000.00	
Ciliates	313.85	number/g	< 66.00	
Nitrogen Cycling Potential	25-50	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.67	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	1.60	number/g	> 4.00	
Fungal	0.07	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	17.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11895
Unique ID: Cambridge Loc 6
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.15	number/g	Bacterial Feeders	
Cuticularia	0.22	number/g	Bacterial Feeders	
Eumonhystera	0.29	number/g	Bacterial Feeders	
Plectus	0.44	number/g	Bacterial Feeders	
Prismatolaimus	0.22	number/g	Bacterial Feeders	
Rhabditidae	0.29	number/g	Bacterial Feeders	
Epidorylaimus	0.07	number/g	Fungal Feeders	

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

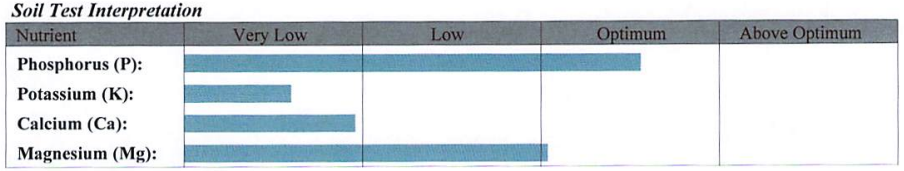
Sample Information:
Sample ID: Cambridge Loc #6 0-12"
Order Number: 40083
Lab Number: S180904-316
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.4		**Cation Exch. Capacity, meq/100g**	7.7	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.8	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	9.7	4-14	Calcium Base Saturation	31	50-80
Potassium (K)	31	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	475	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	52	50-120	**Scoop Density, g/cc**	0.95	
Sulfur (S)	11.1	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	5.4	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.12	<0.6
Manganese (Mn)	2.7	1.1-6.3			
Zinc (Zn)	14.4	1.0-7.6			
Copper (Cu)	2.4	0.3-0.6			
Iron (Fe)	26.3	2.7-9.4			
Aluminum (Al)	44	<75			
Lead (Pb)	9.4	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

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Amherst, MA 01003
Phone: (413) 545-2311
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website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #6 0-12"
Order Number: 40148
Lab Number: X180907-114
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	77.2
Silt	0.002-0.05	13.0
Clay	<0.002	9.8
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.2
Coarse	0.5-1.0	20.6
Medium	0.25-0.5	26.2
Fine	0.10-0.25	16.6
Very Fine	0.05-0.10	6.5
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	5.4
Medium	0.005-0.02	4.3
Fine	0.002-0.005	3.3

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	81.0
1.00	#18	75.1
0.50	#35	58.4
0.25	#60	37.2
0.10	#140	23.7
0.053	#270	18.4
0.02	20 um	14.1
0.005	5 um	10.6
0.002	2 um	7.9

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 19.0

UMass Extension

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161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #6 12-24"
Order Number: 40083
Lab Number: S180904-317
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.4		**Cation Exch. Capacity, meq/100g**	4.5	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.7	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.3	4-14	Calcium Base Saturation	15	50-80
Potassium (K)	23	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	137	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	17	50-120	**Scoop Density, g/cc**	1.12	
Sulfur (S)	8.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.6	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.16	<0.6
Manganese (Mn)	2.9	1.1-6.3			
Zinc (Zn)	4.8	1.0-7.6			
Copper (Cu)	1.9	0.3-0.6			
Iron (Fe)	20.6	2.7-9.4			
Aluminum (Al)	67	<75			
Lead (Pb)	7.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

Soil and Plant Nutrient Testing Laboratory
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University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #6 12-24"
Order Number: 40148
Lab Number: X180907-115
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	77.2
Silt	0.002-0.05	13.4
Clay	<0.002	9.4
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.7
Coarse	0.5-1.0	14.7
Medium	0.25-0.5	24.8
Fine	0.10-0.25	21.3
Very Fine	0.05-0.10	8.7
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	4.6
Medium	0.005-0.02	5.4
Fine	0.002-0.005	3.4

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	81.3
1.00	#18	75.0
0.50	#35	63.0
0.25	#60	42.9
0.10	#140	25.6
0.053	#270	18.5
0.02	20 um	14.7
0.005	5 um	10.3
0.002	2 um	7.6

USDA Textural Class: sandy loam

Gravel Content: (%) 18.8

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161 Holdsworth Way
University of Massachusetts
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e-mail: soiltest@umass.edu
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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

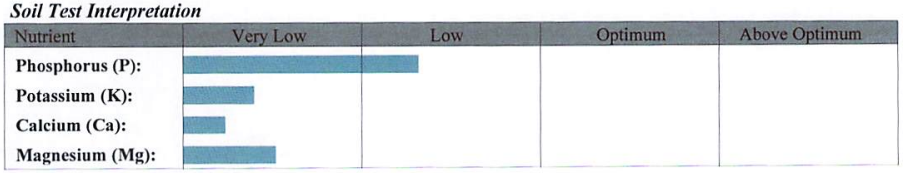
Sample Information:
Sample ID: Cambridge Loc #6 24-36"
Order Number: 40083
Lab Number: S180904-318
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.2		**Cation Exch. Capacity, meq/100g**	3.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.6	4-14	Calcium Base Saturation	15	50-80
Potassium (K)	19	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	112	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	13	50-120	**Scoop Density, g/cc**	1.16	
Sulfur (S)	17.6	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.0	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.17	<0.6
Manganese (Mn)	2.5	1.1-6.3			
Zinc (Zn)	7.1	1.0-7.6			
Copper (Cu)	1.5	0.3-0.6			
Iron (Fe)	20.5	2.7-9.4			
Aluminum (Al)	50	<75			
Lead (Pb)	10.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

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Amherst, MA 01003
Phone: (413) 545-2311
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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #6 24-36"
Order Number: 40148
Lab Number: X180907-116
Received: 9/7/2018
Reported: 9/13/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	84.3
Silt	0.002-0.05	7.6
Clay	<0.002	8.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	8.5
Coarse	0.5-1.0	19.6
Medium	0.25-0.5	35.2
Fine	0.10-0.25	15.7
Very Fine	0.05-0.10	5.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	1.4
Medium	0.005-0.02	3.1
Fine	0.002-0.005	3.0

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	82.8
1.00	#18	75.8
0.50	#35	59.6
0.25	#60	30.4
0.10	#140	17.4
0.053	#270	13.0
0.02	20 um	11.8
0.005	5 um	9.2
0.002	2 um	6.7

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 17.2

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

	Location 7 EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	3,079.03	>20,000	Low
Flagellates	923.82	>20,000	Low
Ciliates	64.40	<40	
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	785.40	>300	
Fungal Biomass	197.22	>1,500	
Hyphal Diameter	2.75	>2.5	
Location 7 0-12"			
CEC	1.9	>10	
PH	7	6.5-7.0	
OM	3.3	4-8%	
Soluble Salts	0.07	<0.6	
Sand	70.50%		
Silt	21.50%		
Clay	8.00%		
Clay, Silt, VF Sand	36.00%		
Lead	9	<22	
Location 7 12"-24"			
CEC	1.8	>10	
PH	7.4	6.5-7.0	
OM	1.6	4-8%	
Soluble Salts	0.12	<0.6	
Sand	74.50%		
Silt	19.40%		
Clay	6.20%		
Clay, Silt, VF Sand	32.80%		
Lead	4.8	<22	
Location 7 24"-36"			
CEC	2.9	>10	
PH	7.3	6.5-7.0	
OM	1	4-8%	
Soluble Salts	0.61	<0.6	
Sand	56.30%		
Silt	28.70%		
Clay	15.10%		
Clay, Silt, VF Sand	53.00%		
Lead	1	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11896
Unique ID: Cambridge Loc 7
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.90	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	6.01	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	197.22	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	2.75	µm	> 2.50	Good balance of fungi. -
Active Bacteria	39.44	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	785.40	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.25		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.03		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.05		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.15		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	923.82	number/g	> 20,000.00	High ciliate numbers indicate possible anaerobic conditions.
Amoebae	3,079.03	number/g	> 20,000.00	
Ciliates	64.40	number/g	< 40.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.19	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	1.06	number/g	> 4.00	
Fungal	0.14	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	Processing	%	> 40	Low colonization, foods may be required. -
ECTO	Processing	%	> 40	
Ericoid	Processing	%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11896
Unique ID: Cambridge Loc 7
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.07	number/g	Bacterial Feeders	
Diploscapter	0.10	number/g	Bacterial Feeders	
Eumonhystera	0.10	number/g	Bacterial Feeders	
Heterocephalobus	0.31	number/g	Bacterial Feeders	
Panagrolaimus	0.10	number/g	Bacterial Feeders	
Prismatolaimus	0.20	number/g	Bacterial Feeders	
Rhabditidae	0.17	number/g	Bacterial Feeders	
Eudorylaimus	0.14	number/g	Fungal Feeders	

UMass Extension

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161 Holdsworth Way
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Amherst, MA 01003
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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

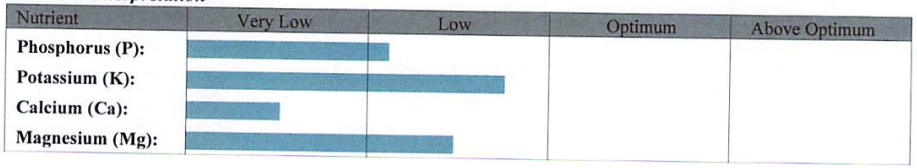
Sample Information:
Sample ID: Cambridge Loc #7 0-12"
Order Number: 40083
Lab Number: S180904-319
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.0		**Cation Exch. Capacity, meq/100g**	1.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.2	4-14	Calcium Base Saturation	71	50-80
Potassium (K)	88	100-160	Magnesium Base Saturation	16	10-30
Calcium (Ca)	265	1000-1500	Potassium Base Saturation	12	2.0-7.0
Magnesium (Mg)	37	50-120	**Scoop Density, g/cc**	1.00	
Sulfur (S)	6.7	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.3	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.07	<0.6
Manganese (Mn)	2.9	1.1-6.3			
Zinc (Zn)	7.1	1.0-7.6			
Copper (Cu)	0.9	0.3-0.6			
Iron (Fe)	9.4	2.7-9.4			
Aluminum (Al)	50	<75			
Lead (Pb)	9.0	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 7 0-12"

Order Number: 40264
Lab Number: X180914-101
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	70.5
Silt	0.002-0.05	21.5
Clay	<0.002	8.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.9
Coarse	0.5-1.0	15.7
Medium	0.25-0.5	22.5
Fine	0.10-0.25	15.8
Very Fine	0.05-0.10	6.5
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	13.9
Medium	0.005-0.02	7.0
Fine	0.002-0.005	0.6

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	72.7
1.00	#18	65.5
0.50	#35	54.1
0.25	#60	37.7
0.10	#140	26.2
0.053	#270	21.4
0.02	20 um	11.3
0.005	5 um	6.2
0.002	2 um	5.8

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 27.3

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #7 12-24"

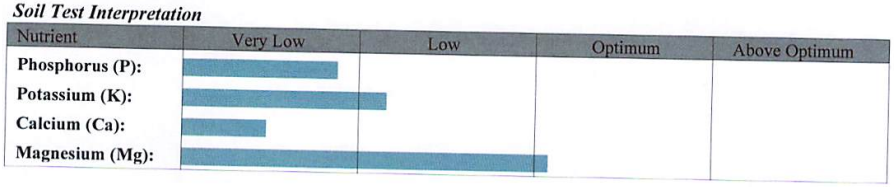
Order Number: 40083
Lab Number: S180904-320
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.4		**Cation Exch. Capacity, meq/100g**	1.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.7	4-14	Calcium Base Saturation	66	50-80
Potassium (K)	58	100-160	Magnesium Base Saturation	26	10-30
Calcium (Ca)	234	1000-1500	Potassium Base Saturation	8	2.0-7.0
Magnesium (Mg)	55	50-120	**Scoop Density, g/cc**	1.14	
Sulfur (S)	4.3	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.6	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.12	<0.6
Manganese (Mn)	2.2	1.1-6.3			
Zinc (Zn)	3.8	1.0-7.6			
Copper (Cu)	0.6	0.3-0.6			
Iron (Fe)	6.1	2.7-9.4			
Aluminum (Al)	30	<75			
Lead (Pb)	4.8	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 7 12-24"
Order Number: 40264
Lab Number: X180914-102
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	74.5
Silt	0.002-0.05	19.4
Clay	<0.002	6.2

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	6.7
Coarse	0.5-1.0	13.6
Medium	0.25-0.5	23.6
Fine	0.10-0.25	23.4
Very Fine	0.05-0.10	7.2

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	9.7
Medium	0.005-0.02	7.0
Fine	0.002-0.005	2.8

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	60.1
1.00	#18	56.1
0.50	#35	48.0
0.25	#60	33.8
0.10	#140	19.7
0.053	#270	15.3
0.02	20 um	9.5
0.005	5 um	5.4
0.002	2 um	3.7

USDA Textural Class: gravelly sandy loam

Gravel Content: (%) 39.9

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

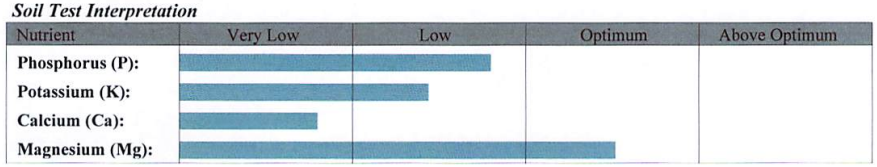
Sample Information:
Sample ID: Cambridge Loc #7 24-36"
Order Number: 40083
Lab Number: S180904-321
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.3		**Cation Exch. Capacity, meq/100g**	2.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.6	4-14	Calcium Base Saturation	69	50-80
Potassium (K)	71	100-160	Magnesium Base Saturation	25	10-30
Calcium (Ca)	397	1000-1500	Potassium Base Saturation	6	2.0-7.0
Magnesium (Mg)	87	50-120	**Scoop Density, g/cc**	1.14	
Sulfur (S)	8.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.0	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.61	<0.6
Manganese (Mn)	1.7	1.1-6.3			
Zinc (Zn)	1.5	1.0-7.6			
Copper (Cu)	0.1	0.3-0.6			
Iron (Fe)	1.6	2.7-9.4			
Aluminum (Al)	18	<75			
Lead (Pb)	1.0	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 7 24-36"
Order Number: 40264
Lab Number: X180914-103
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	56.3
Silt	0.002-0.05	28.7
Clay	<0.002	15.1

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	4.2
Coarse	0.5-1.0	7.9
Medium	0.25-0.5	13.8
Fine	0.10-0.25	21.2
Very Fine	0.05-0.10	9.2

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	12.2
Medium	0.005-0.02	11.7
Fine	0.002-0.005	4.8

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	90.6
1.00	#18	86.8
0.50	#35	79.6
0.25	#60	67.1
0.10	#140	47.9
0.053	#270	39.6
0.02	20 um	28.6
0.005	5 um	18.0
0.002	2 um	13.6

USDA Textural Class: fine sandy loam

Gravel Content: (%) 9.4

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 8

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	52,977.44	>20,000	
Flagellates	6,618.15	>20,000	Low
Ciliates	66.71	<596	
Nutrient Cycling Capacity from Microbial Activity	100-150 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	794.43	>300	
Fungal Biomass	427.44	>1,500	Low
Hyphal Diameter	3.25	>2.5	
Location 8 0-12"			
CEC	6.6	>10	
PH	7.2	6.5-7.0	
OM	4.1	4-8%	
Soluble Salts	0.08	<0.6	
Sand	69.60%		
Silt	24.70%		
Clay	5.70%		
Clay, Silt, VF Sand	34.90%		
Lead	4.9	<22	
Location 8 12"-24"			
CEC	90.8	>10	
PH	7.5	6.5-7.0	
OM	2.5	4-8%	
Soluble Salts	0.08	<0.6	
Sand	69.40%		
Silt	21.60%		
Clay	9.00%		
Clay, Silt, VF Sand	37.20%		
Lead	20.3	<22	
Location 8 24"-36"			
CEC	7.2	>10	
PH	7.1	6.5-7.0	
OM	2.1	4-8%	
Soluble Salts	0.06	<0.6	
Sand	66.10%		
Silt	19.70%		
Clay	14.10%		
Clay, Silt, VF Sand	39.30%		
Lead	17.3	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11897
Unique ID: Cambridge Loc 8
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.87	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	15.93	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	427.44	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.25	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	25.11	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	794.43	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.54		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.04		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.03		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.63		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	6,618.15	number/g	> 20,000.00	Lacking species diversity.
Amoebae	52,977.44	number/g	> 20,000.00	
Ciliates	66.71	number/g	< 596.00	
Nitrogen Cycling Potential	100-150	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	2.70	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	2.56	number/g	> 4.00	
Fungal	0.15	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	21.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11897
Unique ID: Cambridge Loc 8
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Achromadora	0.22	number/g	Bacterial Feeders	
Cephalobus	0.29	number/g	Bacterial Feeders	
Cuticularia	0.58	number/g	Bacterial Feeders	
Plectus	0.29	number/g	Bacterial Feeders	
Prismatolaimus	0.29	number/g	Bacterial Feeders	
Protorhabditis	0.88	number/g	Bacterial Feeders	
Eudorylaimus	0.15	number/g	Fungal Feeders	

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

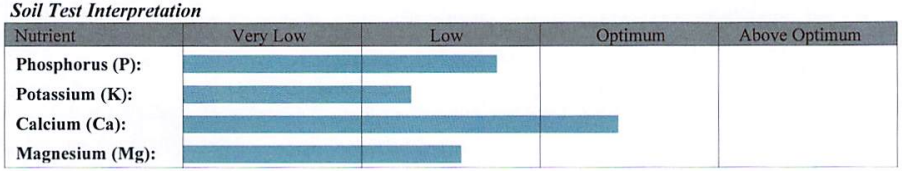
Sample Information:
Sample ID: Cambridge Loc #8 0-12"
Order Number: 40083
Lab Number: S180904-322
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.2		**Cation Exch. Capacity, meq/100g**	6.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.5	4-14	Calcium Base Saturation	93	50-80
Potassium (K)	63	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	1226	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	39	50-120	**Scoop Density, g/cc**	1.05	
Sulfur (S)	10.1	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.1	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	5.3	1.1-6.3			
Zinc (Zn)	3.1	1.0-7.6			
Copper (Cu)	0.1	0.3-0.6			
Iron (Fe)	5.5	2.7-9.4			
Aluminum (Al)	35	<75			
Lead (Pb)	4.9	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
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F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 8 0-12"

Order Number: 40264
Lab Number: X180914-104
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	69.6
Silt	0.002-0.05	24.7
Clay	<0.002	5.7
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	8.6
Coarse	0.5-1.0	17.3
Medium	0.25-0.5	30.4
Fine	0.10-0.25	8.8
Very Fine	0.05-0.10	4.5
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	12.6
Medium	0.005-0.02	8.3
Fine	0.002-0.005	3.8

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	75.3
1.00	#18	68.8
0.50	#35	55.8
0.25	#60	32.9
0.10	#140	26.3
0.053	#270	22.9
0.02	20 um	13.4
0.005	5 um	7.2
0.002	2 um	4.3

USDA Textural Class: coarse sandy loam

Gravel Content: (%) **24.7**

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #8 12-24"

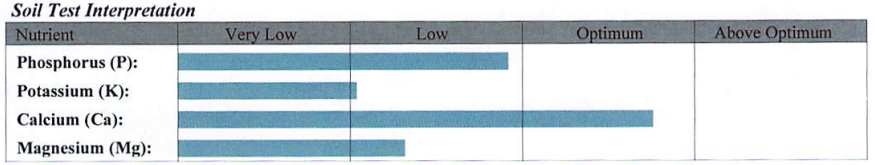
Order Number: 40083
Lab Number: S180904-324
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.5		**Cation Exch. Capacity, meq/100g**	90.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	83.5	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.8	4-14	Calcium Base Saturation	8	50-80
Potassium (K)	51	100-160	Magnesium Base Saturation	0	10-30
Calcium (Ca)	1375	1000-1500	Potassium Base Saturation	0	2.0-7.0
Magnesium (Mg)	33	50-120	**Scoop Density, g/cc**	1.03	
Sulfur (S)	10.8	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.5	
Boron (B)	0.2	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	9.7	1.1-6.3			
Zinc (Zn)	2.9	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	4.3	2.7-9.4			
Aluminum (Al)	24	<75			
Lead (Pb)	20.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
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andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 8 12-24"
Order Number: 40264
Lab Number: X180914-105
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	69.4
Silt	0.002-0.05	21.6
Clay	<0.002	9.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	11.3
Coarse	0.5-1.0	15.4
Medium	0.25-0.5	19.0
Fine	0.10-0.25	17.1
Very Fine	0.05-0.10	6.6
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	10.9
Medium	0.005-0.02	7.9
Fine	0.002-0.005	2.7

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	47.5
1.00	#18	42.1
0.50	#35	34.8
0.25	#60	25.8
0.10	#140	17.7
0.053	#270	14.5
0.02	20 um	9.4
0.005	5 um	5.6
0.002	2 um	4.3

USDA Textural Class: gravelly coarse sandy loam

Gravel Content: (%) 52.5

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

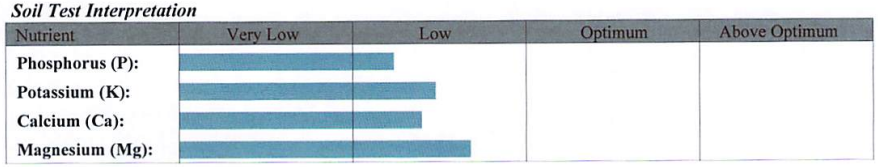
Sample Information:
Sample ID: Cambridge Loc #8 24-36"
Order Number: 40083
Lab Number: S180904-325
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.1		**Cation Exch. Capacity, meq/100g**	7.2	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.4	4-14	Calcium Base Saturation	49	50-80
Potassium (K)	74	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	696	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	42	50-120	**Scoop Density, g/cc**	1.02	
Sulfur (S)	7.2	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.1	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	2.7	1.1-6.3			
Zinc (Zn)	4.2	1.0-7.6			
Copper (Cu)	0.9	0.3-0.6			
Iron (Fe)	5.1	2.7-9.4			
Aluminum (Al)	30	<75			
Lead (Pb)	17.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 8 24-36"
Order Number: 40264
Lab Number: X180914-106
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	66.1
Silt	0.002-0.05	19.7
Clay	<0.002	14.1

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	4.9
Coarse	0.5-1.0	7.3
Medium	0.25-0.5	21.7
Fine	0.10-0.25	26.7
Very Fine	0.05-0.10	5.5

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	4.8
Medium	0.005-0.02	11.4
Fine	0.002-0.005	3.5

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	81.5
1.00	#18	77.5
0.50	#35	71.6
0.25	#60	53.9
0.10	#140	32.1
0.053	#270	27.6
0.02	20 um	23.7
0.005	5 um	14.4
0.002	2 um	11.5

USDA Textural Class: sandy loam

Gravel Content: (%) 18.5

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 9

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	2,958.07	>20,000	Low
Flagellates	1,478.50	>20,000	Low
Ciliates	61.87	<44	High
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	743.62	>300	
Fungal Biomass	168.54	>1,500	Low
Hyphal Diameter	3.00	>2.5	
Location 9 0-12"			
CEC	11.7	>10	
PH	6.9	6.5-7.0	
OM	5.9	4-8%	
Soluble Salts	0.18	<0.6	
Sand	70.10%		
Silt	21.10%		
Clay	8.80%		
Clay, Silt, VF Sand	37.80%		
Lead	19	<22	
Location 9 12"-24"			
CEC	7.1	>10	
PH	7	6.5-7.0	
OM	3.6	4-8%	
Soluble Salts	0.16	<0.6	
Sand	73.30%		
Silt	19.20%		
Clay	7.50%		
Clay, Silt, VF Sand	31.30%		
Lead	17.3	<22	
Location 9 24"-36"			
CEC	12.2	>10	
PH	6.9	6.5-7.0	
OM	2.3	4-8%	
Soluble Salts	0.19	<0.6	
Sand	77.10%		
Silt	14.70%		
Clay	8.20%		
Clay, Silt, VF Sand	28.60%		
Lead	8.3	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11898
Unique ID: Cambridge Loc 9
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.94	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	6.85	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	168.54	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.00	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	15.61	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	743.62	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.23		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.04		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.02		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.44		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	1,478.50	number/g	> 20,000.00	High ciliate numbers indicate possible anaerobic conditions.
Amoebae	2,958.07	number/g	> 20,000.00	
Ciliates	61.87	number/g	< 44.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.84	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.47	number/g	> 4.00	
Fungal	0.12	number/g	> 4.00	
Fungal/Root	0.17	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.07	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	26.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11898
Unique ID: Cambridge Loc 9
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.22	number/g	Bacterial Feeders	
Prismatolaimus	0.10	number/g	Bacterial Feeders	
Rhabditidae	0.15	number/g	Bacterial Feeders	
Pungentus	0.12	number/g	Fungal Feeders	
Aphelenchoides	0.10	number/g	Fungal/Root Feeders	Foliar nematode
Filenchus	0.07	number/g	Fungal/Root Feeders	
Gracilacus	0.07	number/g	Root Feeders	Pin nematode

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

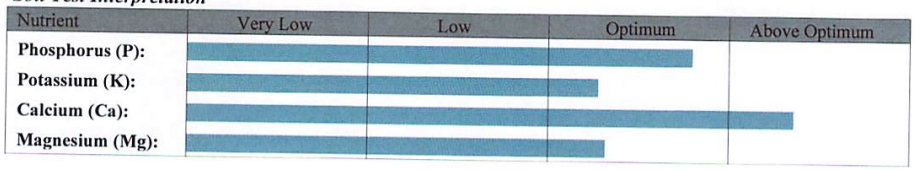
Sample Information:
Sample ID: Cambridge Loc #9 0-12"
Order Number: 40083
Lab Number: S180904-326
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.9		**Cation Exch. Capacity, meq/100g**	11.7	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	2.4	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	11.9	4-14	Calcium Base Saturation	72	50-80
Potassium (K)	115	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	1679	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	74	50-120	**Scoop Density, g/cc**	1.13	
Sulfur (S)	12.7	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	5.9	
Boron (B)	0.2	0.1-0.5	Soluble Salts (1:2), dS/m	0.18	<0.6
Manganese (Mn)	3.3	1.1-6.3			
Zinc (Zn)	16.5	1.0-7.6			
Copper (Cu)	0.7	0.3-0.6			
Iron (Fe)	6.2	2.7-9.4			
Aluminum (Al)	29	<75			
Lead (Pb)	19.0	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 9 0-12"

Order Number: 40264
Lab Number: X180914-107
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	70.1
Silt	0.002-0.05	21.1
Clay	<0.002	8.8
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.0
Coarse	0.5-1.0	17.8
Medium	0.25-0.5	21.4
Fine	0.10-0.25	16.1
Very Fine	0.05-0.10	7.9
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	11.5
Medium	0.005-0.02	8.6
Fine	0.002-0.005	0.9

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	86.5
1.00	#18	80.4
0.50	#35	65.0
0.25	#60	46.6
0.10	#140	32.7
0.053	#270	25.8
0.02	20 um	15.8
0.005	5 um	8.4
0.002	2 um	7.6

USDA Textural Class: sandy loam

Gravel Content: (%) 13.5

UMass Extension

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Amherst, MA 01003
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #9 12-24"

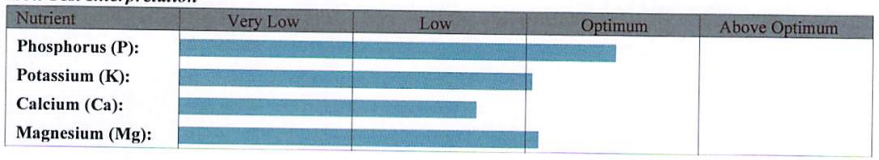
Order Number: 40083
Lab Number: S180904-327
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.0		**Cation Exch. Capacity, meq/100g**	7.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	2.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	9.3	4-14	Calcium Base Saturation	60	50-80
Potassium (K)	102	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	864	1000-1500	Potassium Base Saturation	4	2.0-7.0
Magnesium (Mg)	54	50-120	**Scoop Density, g/cc**	1.27	
Sulfur (S)	10.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.6	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.16	<0.6
Manganese (Mn)	3.5	1.1-6.3			
Zinc (Zn)	9.4	1.0-7.6			
Copper (Cu)	0.6	0.3-0.6			
Iron (Fe)	5.5	2.7-9.4			
Aluminum (Al)	28	<75			
Lead (Pb)	17.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 9 12-24"
Order Number: 40264
Lab Number: X180914-108
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	73.3
Silt	0.002-0.05	19.2
Clay	<0.002	7.5
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	11.1
Coarse	0.5-1.0	20.7
Medium	0.25-0.5	24.3
Fine	0.10-0.25	12.6
Very Fine	0.05-0.10	4.6
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	8.7
Medium	0.005-0.02	7.3
Fine	0.002-0.005	3.1

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	78.5
1.00	#18	69.8
0.50	#35	53.6
0.25	#60	34.5
0.10	#140	24.6
0.053	#270	21.0
0.02	20 um	14.1
0.005	5 um	8.4
0.002	2 um	5.9

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 21.5

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

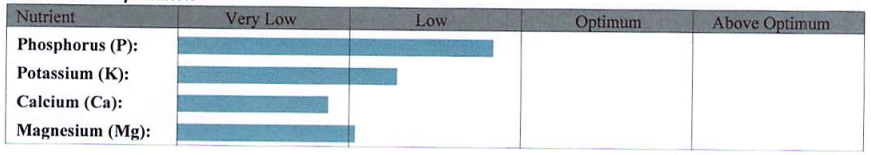
Sample Information:
Sample ID: Cambridge Loc #9 24-36"
Order Number: 40083
Lab Number: S180904-328
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.9		**Cation Exch. Capacity, meq/100g**	12.2	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	9.7	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.7	4-14	Calcium Base Saturation	18	50-80
Potassium (K)	65	100-160	Magnesium Base Saturation	2	10-30
Calcium (Ca)	432	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	26	50-120	**Scoop Density, g/cc**	1.35	
Sulfur (S)	19.1	>10	**Optional tests**		
*Micronutrients **			Soil Organic Matter (LOI), %	2.3	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.19	<0.6
Manganese (Mn)	2.6	1.1-6.3			
Zinc (Zn)	4.4	1.0-7.6			
Copper (Cu)	0.6	0.3-0.6			
Iron (Fe)	6.5	2.7-9.4			
Aluminum (Al)	39	<75			
Lead (Pb)	8.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 9 24-36"
Order Number: 40264
Lab Number: X180914-109
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	77.1
Silt	0.002-0.05	14.7
Clay	<0.002	8.2
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.8
Coarse	0.5-1.0	20.1
Medium	0.25-0.5	28.5
Fine	0.10-0.25	15.1
Very Fine	0.05-0.10	5.7
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	6.0
Medium	0.005-0.02	7.0
Fine	0.002-0.005	1.7

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	82.3
1.00	#18	75.9
0.50	#35	59.4
0.25	#60	35.9
0.10	#140	23.5
0.053	#270	18.9
0.02	20 um	13.9
0.005	5 um	8.1
0.002	2 um	6.7

USDA Textural Class: **coarse sandy loam**

Gravel Content: (%) **17.7**

9 of 16

Sample ID: Cambridge Loc 9 24-36"

Lab Number X180914-109

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

	Location 10		
	EXISTING CONDITION	***DESIRABLE RANGE***	***COMMENTS***
Biology			
Protozoa			
Amoeba	653.79	>20,000	Low
Flagellates	1.575.92	>20,000	Low
Ciliates	52.30	<22	High
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	1,017.45	>300	
Fungal Biomass	245.05	>1,500	Low
Hyphal Diameter	3.50	>2.5	
Location 10 0-12"			
CEC	12.6	>10	
PH	5.4	6.5-7.0	
OM	5.8	4-8%	
Soluble Salts	0.11	<0.6	
Sand	59.70%		
Silt	28.30%		
Clay	12.00%		
Clay, Silt, VF Sand	46.90%		
Lead	25	<22	High
Location 10 12"-24"			
CEC	8.5	>10	
PH	5.2	6.5-7.0	
OM	3	4-8%	
Soluble Salts	0.06	<0.6	
Sand	70.90%		
Silt	20.40%		
Clay	8.70%		
Clay, Silt, VF Sand	35.10%		
Lead	14.6	<22	
Location 10 24"-36"			
CEC	4.8	>10	
PH	5.2	6.5-7.0	
OM	1.5	4-8%	
Soluble Salts	0.04	<0.6	
Sand	80.50%		
Silt	13.50%		
Clay	6.00%		
Clay, Silt, VF Sand	23.50%		
Lead	6.4	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11899
Unique ID: Cambridge Loc 10
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.88	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	21.58	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	245.05	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.50	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	38.79	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	1,017.45	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.24		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.09		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.04		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.56		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	1,575.92	number/g	> 20,000.00	High ciliate numbers indicate possible anaerobic conditions.
Amoebae	653.79	number/g	> 20,000.00	
Ciliates	52.30	number/g	< 22.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	2.64	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.69	number/g	> 4.00	
Fungal	0.74	number/g	> 4.00	
Fungal/Root	0.11	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	1.11	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	23.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11899
Unique ID: Cambridge Loc 10
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Acrobeles	0.32	number/g	Bacterial Feeders	
Heterocephalobus	0.26	number/g	Bacterial Feeders	
Plectus	0.11	number/g	Bacterial Feeders	
Aporcelaimium	0.42	number/g	Fungal Feeders	
Eudorylaimus	0.16	number/g	Fungal Feeders	
Pungentus	0.16	number/g	Fungal Feeders	
Aphelenchoides	0.11	number/g	Fungal/Root Feeders	Foliar nematode
Gracilacus	0.21	number/g	Root Feeders	Pin nematode
Meloidogyne	0.53	number/g	Root Feeders	Root-Knot nematode
Xiphinema	0.37	number/g	Root Feeders	Dagger nematode

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

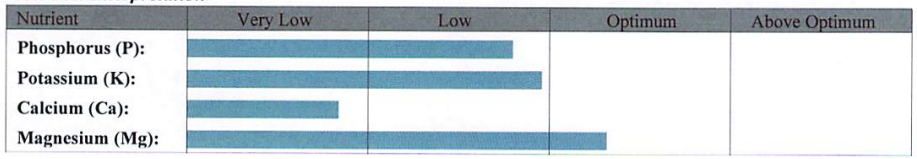
Sample Information:
Sample ID: Cambridge Loc #10 0-12"
Order Number: 40083
Lab Number: S180904-329
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.4		**Cation Exch. Capacity, meq/100g**	12.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	9.7	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.6	4-14	Calcium Base Saturation	16	50-80
Potassium (K)	98	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	413	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	72	50-120	**Scoop Density, g/cc**	0.96	
Sulfur (S)	16.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	5.8	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.11	<0.6
Manganese (Mn)	2.9	1.1-6.3			
Zinc (Zn)	3.7	1.0-7.6			
Copper (Cu)	0.7	0.3-0.6			
Iron (Fe)	17.4	2.7-9.4			
Aluminum (Al)	156	<75			
Lead (Pb)	25.0	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 10 0-12"
Order Number: 40264
Lab Number: X180914-110
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	59.7
Silt	0.002-0.05	28.3
Clay	<0.002	12.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	6.4
Coarse	0.5-1.0	15.2
Medium	0.25-0.5	17.8
Fine	0.10-0.25	13.7
Very Fine	0.05-0.10	6.6
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	12.6
Medium	0.005-0.02	13.5
Fine	0.002-0.005	2.1

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	90.0
1.00	#18	84.2
0.50	#35	70.5
0.25	#60	54.5
0.10	#140	42.2
0.053	#270	36.2
0.02	20 um	24.9
0.005	5 um	12.7
0.002	2 um	10.8

USDA Textural Class: sandy loam

Gravel Content: (%) 10.0

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #10 12-24"
Order Number: 40083
Lab Number: S180904-330
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.2		**Cation Exch. Capacity, meq/100g**	8.5	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	7.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.5	4-14	Calcium Base Saturation	14	50-80
Potassium (K)	42	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	236	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	28	50-120	**Scoop Density, g/cc**	1.04	
Sulfur (S)	17.7	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.0	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	1.2	1.1-6.3			
Zinc (Zn)	3.0	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	10.8	2.7-9.4			
Aluminum (Al)	123	<75			
Lead (Pb)	14.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

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University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 10 12-24"
Order Number: 40264
Lab Number: X180914-111
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	70.9
Silt	0.002-0.05	20.4
Clay	<0.002	8.7

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	8.1
Coarse	0.5-1.0	19.4
Medium	0.25-0.5	23.0
Fine	0.10-0.25	14.4
Very Fine	0.05-0.10	6.0

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	8.8
Medium	0.005-0.02	9.2
Fine	0.002-0.005	2.4

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	84.6
1.00	#18	77.7
0.50	#35	61.3
0.25	#60	41.9
0.10	#140	29.7
0.053	#270	24.7
0.02	20 um	17.2
0.005	5 um	9.4
0.002	2 um	7.4

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 15.4

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #10 24-36"
Order Number: 40083
Lab Number: S180904-331
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.2		**Cation Exch. Capacity, meq/100g**	4.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.8	4-14	Calcium Base Saturation	13	50-80
Potassium (K)	20	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	124	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	16	50-120	**Scoop Density, g/cc**	1.19	
Sulfur (S)	19.4	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.5	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.04	<0.6
Manganese (Mn)	1.4	1.1-6.3			
Zinc (Zn)	2.4	1.0-7.6			
Copper (Cu)	0.3	0.3-0.6			
Iron (Fe)	6.9	2.7-9.4			
Aluminum (Al)	90	<75			
Lead (Pb)	6.4	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

Soil and Plant Nutrient Testing Laboratory
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University of Massachusetts
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Phone: (413) 545-2311
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website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 10 24-36"
Order Number: 40264
Lab Number: X180914-112
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	80.5
Silt	0.002-0.05	13.5
Clay	<0.002	6.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	12.7
Coarse	0.5-1.0	24.9
Medium	0.25-0.5	24.5
Fine	0.10-0.25	14.5
Very Fine	0.05-0.10	4.0
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	7.8
Medium	0.005-0.02	3.2
Fine	0.002-0.005	2.5

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	77.2
1.00	#18	67.4
0.50	#35	48.2
0.25	#60	29.3
0.10	#140	18.1
0.053	#270	15.1
0.02	20 um	9.0
0.005	5 um	6.5
0.002	2 um	4.6

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 22.8

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 11

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	51,508.60	>20,000	
Flagellates	6,434,66	>20,000	Low
Ciliates	155.44	<579	
Nutrient Cycling Capacity from Microbial Activity	100-150 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	891.30	>300	
Fungal Biomass	1,753.76	>1,500	
Hyphal Diameter	4.00	>2.5	
Location 11 0-12"			
CEC	12.1	>10	
PH	5.7	6.5-7.0	
OM	4.5	4-8%	
Soluble Salts	0.15	<0.6	
Sand	71.50%		
Silt	21.90%		
Clay	6.60%		
Clay, Silt, VF Sand	35.50%		
Lead	36.2	<22	High
Location 11 12"-24"			
CEC	9.5	>10	
PH	5.8	6.5-7.0	
OM	3.9	4-8%	
Soluble Salts	0.16	<0.6	
Sand	69.80%		
Silt	22.50%		
Clay	7.70%		
Clay, Silt, VF Sand	36.10%		
Lead	59.1	<22	High
Location 11 24"-36"			
CEC	6.1	>10	
PH	6.5	6.5-7.0	
OM	2.3	4-8%	
Soluble Salts	0.07	<0.6	
Sand	70.10%		
Silt	21.30%		
Clay	8.60%		
Clay, Silt, VF Sand	35.30%		
Lead	35.1	<22	High

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11900
Unique ID: Cambridge Loc 11
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.89	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	66.47	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	1,753.76	µg/g	> 1,500.00	Good fungal biomass. -
Hyphal Diameter	4.00	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	23.01	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	891.30	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	1.97		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.04		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.03		> 0.10	Low bacterial activity, foods may be required.
AF:AB	2.89		5.00 to 10.00	Fungal dominated, becoming more fungal.
Protozoa (Protists)				
Flagellates	6,434.66	number/g	> 20,000.00	Lacking species diversity.
Amoebae	51,508.60	number/g	> 20,000.00	
Ciliates	155.44	number/g	< 579.00	
Nitrogen Cycling Potential	100-150	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	2.41	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	1.59	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.18	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.65	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	18.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11900
Unique ID: Cambridge Loc 11
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Acrobeloides	0.35	number/g	Bacterial Feeders	
Cephalobus	0.41	number/g	Bacterial Feeders	
Heterocephalobus	0.29	number/g	Bacterial Feeders	
Panagrolaimus	0.53	number/g	Bacterial Feeders	
Filenchus	0.18	number/g	Fungal/Root Feeders	
Heterodora	0.18	number/g	Root Feeders	Cyst nematode
Xiphinema	0.47	number/g	Root Feeders	Dagger nematode

UMass Extension

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Amherst, MA 01003
Phone: (413) 545-2311
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #11 0-12"
Order Number: 40085
Lab Number: S180904-402
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.7		**Cation Exch. Capacity, meq/100g**	12.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	8.2	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	5.7	4-14	Calcium Base Saturation	26	50-80
Potassium (K)	111	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	632	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	66	50-120	**Scoop Density, g/cc**	0.99	
Sulfur (S)	8.7	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.5	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.15	<0.6
Manganese (Mn)	5.1	1.1-6.3			
Zinc (Zn)	14.6	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	16.3	2.7-9.4			
Aluminum (Al)	79	<75			
Lead (Pb)	36.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
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University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 11 0-12"
Order Number: 40264
Lab Number: X180914-113
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	71.5
Silt	0.002-0.05	21.9
Clay	<0.002	6.6
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	12.7
Coarse	0.5-1.0	16.2
Medium	0.25-0.5	20.2
Fine	0.10-0.25	15.5
Very Fine	0.05-0.10	7.0
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	10.3
Medium	0.005-0.02	7.7
Fine	0.002-0.005	3.9

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	81.0
1.00	#18	70.7
0.50	#35	57.6
0.25	#60	41.3
0.10	#140	28.7
0.053	#270	23.1
0.02	20 um	14.7
0.005	5 um	8.5
0.002	2 um	5.3

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 19.0

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

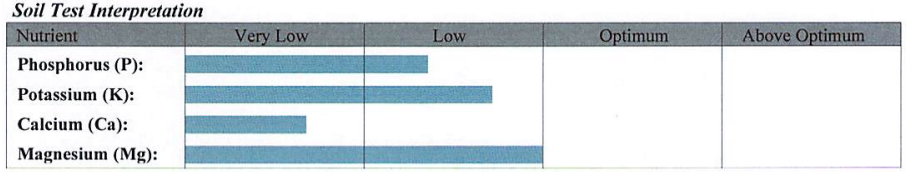
Sample Information:
Sample ID: Cambridge Loc #11 12-24"
Order Number: 40085
Lab Number: S180904-403
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.8		**Cation Exch. Capacity, meq/100g**	9.5	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	7.3	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.7	4-14	Calcium Base Saturation	17	50-80
Potassium (K)	86	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	330	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	51	50-120	**Scoop Density, g/cc**	0.97	
Sulfur (S)	13.4	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.9	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.16	<0.6
Manganese (Mn)	4.1	1.1-6.3			
Zinc (Zn)	10.9	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	22.0	2.7-9.4			
Aluminum (Al)	94	<75			
Lead (Pb)	59.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 11 12-24"
Order Number: 40264
Lab Number: X180914-114
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	69.8
Silt	0.002-0.05	22.5
Clay	<0.002	7.7

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	8.8
Coarse	0.5-1.0	16.6
Medium	0.25-0.5	22.9
Fine	0.10-0.25	15.6
Very Fine	0.05-0.10	5.9

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	11.3
Medium	0.005-0.02	8.1
Fine	0.002-0.005	3.1

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	77.9
1.00	#18	71.0
0.50	#35	58.1
0.25	#60	40.3
0.10	#140	28.1
0.053	#270	23.5
0.02	20 um	14.7
0.005	5 um	8.4
0.002	2 um	6.0

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 22.1

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

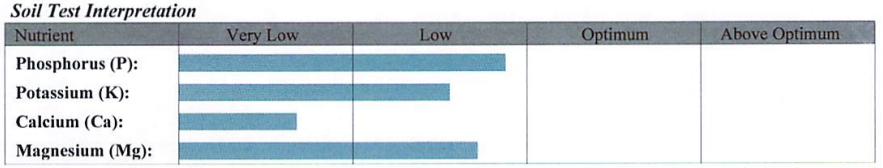
Sample Information:
Sample ID: Cambridge Loc #11 24-36"
Order Number: 40085
Lab Number: S180904-404
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.5		**Cation Exch. Capacity, meq/100g**	6.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.8	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.8	4-14	Calcium Base Saturation	29	50-80
Potassium (K)	79	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	349	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	43	50-120	**Scoop Density, g/cc**	1.11	
Sulfur (S)	6.1	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.3	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.07	<0.6
Manganese (Mn)	3.2	1.1-6.3			
Zinc (Zn)	16.5	1.0-7.6			
Copper (Cu)	0.8	0.3-0.6			
Iron (Fe)	9.2	2.7-9.4			
Aluminum (Al)	52	<75			
Lead (Pb)	35.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:

Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:

Sample ID: Cambridge Loc 11 24-36"
Order Number: 40264
Lab Number: X180914-115
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	70.1
Silt	0.002-0.05	21.3
Clay	<0.002	8.6
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	11.1
Coarse	0.5-1.0	17.9
Medium	0.25-0.5	29.9
Fine	0.10-0.25	5.8
Very Fine	0.05-0.10	5.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	4.6
Medium	0.005-0.02	12.3
Fine	0.002-0.005	4.4

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	74.4
1.00	#18	66.1
0.50	#35	52.8
0.25	#60	30.5
0.10	#140	26.3
0.053	#270	22.2
0.02	20 um	18.8
0.005	5 um	9.7
0.002	2 um	6.4

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 25.6

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 12

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	634.59	>20,000	Low
Flagellates	507.67	>20,000	Low
Ciliates	0.00	<11	
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	690.46	>300	
Fungal Biomass	266.59	>1,500	Low
Hyphal Diameter	3.50	>2.5	
Location 12 0-12"			
CEC	13	>10	
PH	5.5	6.5-7.0	
OM	4.6	4-8%	
Soluble Salts	0.04	<0.6	
Sand	58.30%		
Silt	31.60%		
Clay	10.00%		
Clay, Silt, VF Sand	47.00%		
Lead	9.1	<22	
Location 12 12"-24"			
CEC	12.6	>10	
PH	5.4	6.5-7.0	
OM	3.7	4-8%	
Soluble Salts	0.04	<0.6	
Sand	64.00%		
Silt	26.40%		
Clay	9.70%		
Clay, Silt, VF Sand	41.10%		
Lead	10.6	<22	
Location 12 24"-36"			
CEC	9.7	>10	
PH	4.8	6.5-7.0	
OM	2.4	4-8%	
Soluble Salts	0.05	<0.6	
Sand	71.50%		
Silt	18.70%		
Clay	9.70%		
Clay, Silt, VF Sand	34.20%		
Lead	4.3	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11901
Unique ID: Cambridge Loc 12
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.91	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	35.32	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	266.59	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.50	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	30.76	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	690.46	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.39		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.13		> 0.10	Good fungal activity.
AB:TB	0.04		> 0.10	Low bacterial activity, foods may be required.
AF:AB	1.15		5.00 to 10.00	Bacterial dominated, becoming more fungal.
Protozoa (Protists)				
Flagellates	507.67	number/g	> 20,000.00	Lacking species diversity.
Amoebae	634.59	number/g	> 20,000.00	
Ciliates	0.00	number/g	< 11.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.30	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.54	number/g	> 4.00	
Fungal	0.60	number/g	> 4.00	
Fungal/Root	0.15	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	21.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11901
Unique ID: Cambridge Loc 12
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.15	number/g	Bacterial Feeders	
Heterocephalobus	0.24	number/g	Bacterial Feeders	
Panagrolaimus	0.12	number/g	Bacterial Feeders	
Rhabditidae	0.03	number/g	Bacterial Feeders	
Aporcelaimium	0.42	number/g	Fungal Feeders	
Eudorylaimus	0.06	number/g	Fungal Feeders	
Pungentus	0.12	number/g	Fungal Feeders	
Aphelenchus	0.09	number/g	Fungal/Root Feeders	
Filenchus	0.06	number/g	Fungal/Root Feeders	

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

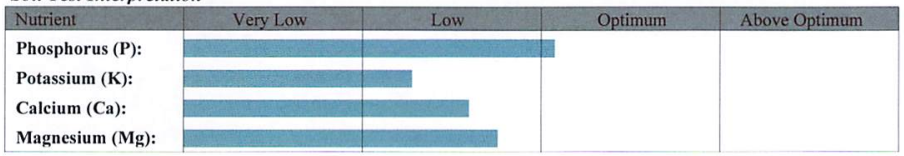
Sample Information:
Sample ID: Cambridge Loc #12 0-12"
Order Number: 40085
Lab Number: S180904-405
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.5		**Cation Exch. Capacity, meq/100g**	13.0	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	8.5	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.9	4-14	Calcium Base Saturation	30	50-80
Potassium (K)	64	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	794	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	44	50-120	**Scoop Density, g/cc**	1.07	
Sulfur (S)	14.8	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.6	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.04	<0.6
Manganese (Mn)	3.7	1.1-6.3			
Zinc (Zn)	15.8	1.0-7.6			
Copper (Cu)	0.7	0.3-0.6			
Iron (Fe)	12.3	2.7-9.4			
Aluminum (Al)	94	<75			
Lead (Pb)	9.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 12 0-12"
Order Number: 40264
Lab Number: X180914-116
Received: 9/14/2018
Reported: 9/25/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	58.3
Silt	0.002-0.05	31.6
Clay	<0.002	10.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.2
Coarse	0.5-1.0	13.1
Medium	0.25-0.5	16.5
Fine	0.10-0.25	14.1
Very Fine	0.05-0.10	5.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	14.9
Medium	0.005-0.02	14.1
Fine	0.002-0.005	2.5

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	74.6
1.00	#18	67.8
0.50	#35	58.0
0.25	#60	45.7
0.10	#140	35.1
0.053	#270	31.1
0.02	20 um	19.9
0.005	5 um	9.4
0.002	2 um	7.5

USDA Textural Class: sandy loam

Gravel Content: (%) **25.4**

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

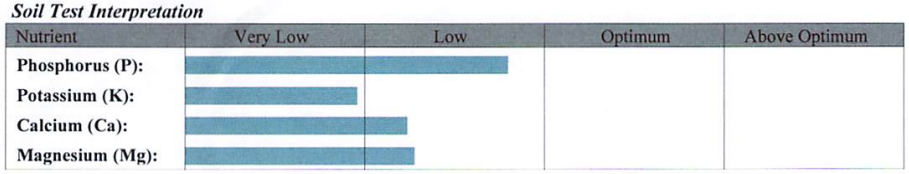
Sample Information:
Sample ID: Cambridge Loc #12 12-24"
Order Number: 40085
Lab Number: S180904-406
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.4		**Cation Exch. Capacity, meq/100g**	12.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	9.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.6	4-14	Calcium Base Saturation	25	50-80
Potassium (K)	48	100-160	Magnesium Base Saturation	2	10-30
Calcium (Ca)	625	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	32	50-120	**Scoop Density, g/cc**	1.09	
Sulfur (S)	19.1	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.7	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.04	<0.6
Manganese (Mn)	3.0	1.1-6.3			
Zinc (Zn)	10.1	1.0-7.6			
Copper (Cu)	1.7	0.3-0.6			
Iron (Fe)	15.0	2.7-9.4			
Aluminum (Al)	106	<75			
Lead (Pb)	10.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 12 12-24"
Order Number: 40424
Lab Number: X180921-101
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	64.0
Silt	0.002-0.05	26.4
Clay	<0.002	9.7
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	10.7
Coarse	0.5-1.0	15.1
Medium	0.25-0.5	20.2
Fine	0.10-0.25	12.9
Very Fine	0.05-0.10	5.0
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	12.7
Medium	0.005-0.02	10.2
Fine	0.002-0.005	3.5

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	86.1
1.00	#18	76.9
0.50	#35	63.8
0.25	#60	46.4
0.10	#140	35.3
0.053	#270	31.0
0.02	20 um	20.1
0.005	5 um	11.3
0.002	2 um	8.3

USDA Textural Class: coarse sandy loam

Gravel Content: (%) **13.9**

UMass Extension

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Soil Test Report

Prepared For:
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PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

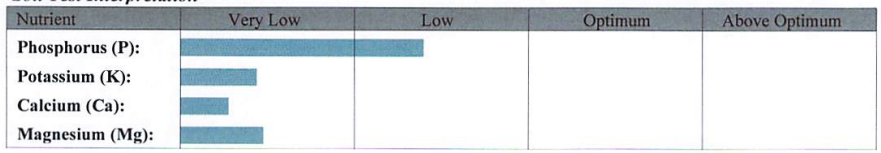
Sample Information:
Sample ID: Cambridge Loc #12 24-36"
Order Number: 40085
Lab Number: S180904-407
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	4.8		**Cation Exch. Capacity, meq/100g**	9.7	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	8.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.8	4-14	Calcium Base Saturation	7	50-80
Potassium (K)	23	100-160	Magnesium Base Saturation	1	10-30
Calcium (Ca)	132	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	12	50-120	**Scoop Density, g/cc**	1.32	
Sulfur (S)	56.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.4	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.05	<0.6
Manganese (Mn)	3.4	1.1-6.3			
Zinc (Zn)	2.7	1.0-7.6			
Copper (Cu)	1.5	0.3-0.6			
Iron (Fe)	23.3	2.7-9.4			
Aluminum (Al)	139	<75			
Lead (Pb)	4.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:

Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:

Sample ID: Cambridge Loc 12 24-36"
Order Number: 40424
Lab Number: X180921-102
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	71.5
Silt	0.002-0.05	18.7
Clay	<0.002	9.7
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.3
Coarse	0.5-1.0	16.9
Medium	0.25-0.5	22.3
Fine	0.10-0.25	17.3
Very Fine	0.05-0.10	5.8
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	8.4
Medium	0.005-0.02	8.1
Fine	0.002-0.005	2.2

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	76.9
1.00	#18	69.8
0.50	#35	56.8
0.25	#60	39.6
0.10	#140	26.4
0.053	#270	21.9
0.02	20 um	15.4
0.005	5 um	9.2
0.002	2 um	7.5

USDA Textural Class: coarse sandy loam

Gravel Content: (%) **23.1**

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 13

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	14,417.26	>20,000	Low
Flagellates	5,94.05	>20,000	Low
Ciliates	60.32	< 204	
Nutrient Cycling Capacity from Microbial Activity	75-100 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	834.49	>300	
Fungal Biomass	258.25	>1,500	Low
Hyphal Diameter	3.25	>2.5	
Location 13 0-12"			
CEC	7.3	>10	
PH	6.2	6.5-7.0	
OM	2.3	4-8%	
Soluble Salts	0.08	<0.6	
Sand	82.40%		
Silt	11.20%		
Clay	6.40%		
Clay, Silt, VF Sand	20.60%		
Lead	6.7	<22	
Location 13 12"-24"			
CEC	6.5	>10	
PH	6.4	6.5-7.0	
OM	2.1	4-8%	
Soluble Salts	0.1	<0.6	
Sand	82.50%		
Silt	11.60%		
Clay	5.90%		
Clay, Silt, VF Sand	21.20%		
Lead	11.1	<22	
Location 13 24"-36"			
CEC	5.1	>10	
PH	6.7	6.5-7.0	
OM	1.7	4-8%	
Soluble Salts	0.05	<0.6	
Sand	83.00%		
Silt	11.40%		
Clay	5.60%		
Clay, Silt, VF Sand	19.80%		
Lead	6.5	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11902
Unique ID: Cambridge Loc 13
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.96	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	11.81	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	258.25	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.25	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	34.13	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	834.49	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.31		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.05		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.04		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.35		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	5,984.05	number/g	> 20,000.00	Lacking species diversity.
Amoebae	14,417.26	number/g	> 20,000.00	
Ciliates	60.32	number/g	< 204.00	
Nitrogen Cycling Potential	75-100	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.72	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.74	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.23	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.74	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	19.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11902
Unique ID: Cambridge Loc 13
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.16	number/g	Bacterial Feeders	
Eumonhystera	0.16	number/g	Bacterial Feeders	
Heterocephalobus	0.16	number/g	Bacterial Feeders	
Plectus	0.27	number/g	Bacterial Feeders	
Aphelenchus	0.12	number/g	Fungal/Root Feeders	
Filenchus	0.12	number/g	Fungal/Root Feeders	
Pratylenchus	0.51	number/g	Root Feeders	Lesion nematode
Xiphinema	0.23	number/g	Root Feeders	Dagger nematode

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

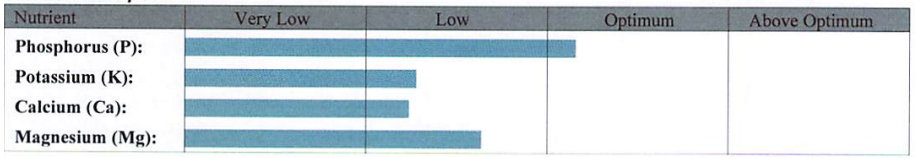
Sample Information:
Sample ID: Cambridge Loc #13 0-12"
Order Number: 40085
Lab Number: S180904-408
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.2		**Cation Exch. Capacity, meq/100g**	7.3	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.7	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	5.5	4-14	Calcium Base Saturation	43	50-80
Potassium (K)	63	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	622	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	41	50-120	**Scoop Density, g/cc**	1.34	
Sulfur (S)	9.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.3	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	4.5	1.1-6.3			
Zinc (Zn)	3.8	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	5.5	2.7-9.4			
Aluminum (Al)	30	<75			
Lead (Pb)	6.7	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 13 0-12"
Order Number: 40424
Lab Number: X180921-103
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	82.4
Silt	0.002-0.05	11.2
Clay	<0.002	6.4

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	25.1
Coarse	0.5-1.0	27.2
Medium	0.25-0.5	17.6
Fine	0.10-0.25	9.5
Very Fine	0.05-0.10	3.0

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	4.7
Medium	0.005-0.02	5.4
Fine	0.002-0.005	1.1

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	64.4
1.00	#18	48.3
0.50	#35	30.8
0.25	#60	19.4
0.10	#140	13.3
0.053	#270	11.4
0.02	20 um	8.3
0.005	5 um	4.8
0.002	2 um	4.1

USDA Textural Class: gravelly loamy coarse sand

Gravel Content: (%) 35.6

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

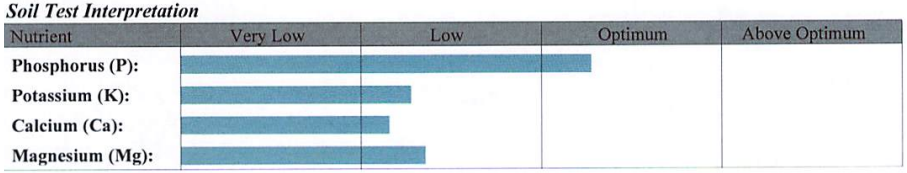
Sample Information:
Sample ID: Cambridge Loc #13 12-24"
Order Number: 40085
Lab Number: S180904-409
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.4		**Cation Exch. Capacity, meq/100g**	6.5	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	6.8	4-14	Calcium Base Saturation	45	50-80
Potassium (K)	63	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	587	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	34	50-120	**Scoop Density, g/cc**	1.28	
Sulfur (S)	7.7	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.1	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.10	<0.6
Manganese (Mn)	3.3	1.1-6.3			
Zinc (Zn)	2.3	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	4.7	2.7-9.4			
Aluminum (Al)	24	<75			
Lead (Pb)	11.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 13 12-24"
Order Number: 40424
Lab Number: X180921-104
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	82.5
Silt	0.002-0.05	11.6
Clay	<0.002	5.9
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	19.1
Coarse	0.5-1.0	28.1
Medium	0.25-0.5	20.8
Fine	0.10-0.25	10.9
Very Fine	0.05-0.10	3.7
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	5.4
Medium	0.005-0.02	4.9
Fine	0.002-0.005	1.3

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	69.7
1.00	#18	56.4
0.50	#35	36.8
0.25	#60	22.4
0.10	#140	14.8
0.053	#270	12.2
0.02	20 um	8.4
0.005	5 um	5.0
0.002	2 um	4.1

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 30.3

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

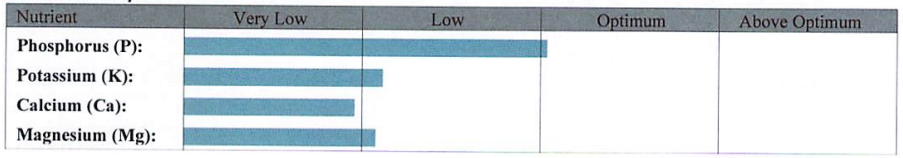
Sample Information:
Sample ID: Cambridge Loc #13 24-36"
Order Number: 40085
Lab Number: S180904-410
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.7		**Cation Exch. Capacity, meq/100g**	5.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	2.4	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.3	4-14	Calcium Base Saturation	46	50-80
Potassium (K)	55	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	474	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	27	50-120	**Scoop Density, g/cc**	1.26	
Sulfur (S)	9.6	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.7	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.05	<0.6
Manganese (Mn)	3.0	1.1-6.3			
Zinc (Zn)	1.1	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	4.2	2.7-9.4			
Aluminum (Al)	35	<75			
Lead (Pb)	6.5	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 13 24-36"
Order Number: 40424
Lab Number: X180921-105
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	83.0
Silt	0.002-0.05	11.4
Clay	<0.002	5.6
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	20.4
Coarse	0.5-1.0	26.9
Medium	0.25-0.5	22.2
Fine	0.10-0.25	10.7
Very Fine	0.05-0.10	2.8
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	4.1
Medium	0.005-0.02	5.9
Fine	0.002-0.005	1.4

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	72.1
1.00	#18	57.4
0.50	#35	38.1
0.25	#60	22.0
0.10	#140	14.3
0.053	#270	12.3
0.02	20 um	9.3
0.005	5 um	5.1
0.002	2 um	4.1

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 27.9

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 14

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	2,248.17	>20,000	Low
Flagellates	290.86	>20,000	Low
Ciliates	14.70	<25	
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	810.20	>300	
Fungal Biomass	424.07	>1,500	Low
Hyphal Diameter	3.25	>2.5	
Location 14 0-12"			
CEC	9.4	>10	
PH	5.7	6.5-7.0	
OM	2.9	4-8%	
Soluble Salts	0.08	<0.6	
Sand	77.70%		
Silt	16.40%		
Clay	5.90%		
Clay, Silt, VF Sand	26.80%		
Lead	16.9	<22	
Location 14 12"-24"			
CEC	5.9	>10	
PH	5.6	6.5-7.0	
OM	1.7	4-8%	
Soluble Salts	0.08	<0.6	
Sand	80.60%		
Silt	12.10%		
Clay	7.30%		
Clay, Silt, VF Sand	22.90%		
Lead	13.4	<22	
Location 14 24"-36"			
CEC	4.7	>10	
PH	5.4	6.5-7.0	
OM	1.4	4-8%	
Soluble Salts	0.16	<0.6	
Sand	87.40%		
Silt	7.00%		
Clay	5.60%		
Clay, Silt, VF Sand	15.10%		
Lead	9.1	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11903
Unique ID: Cambridge Loc 14
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.95	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	19.89	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	424.07	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.25	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	17.25	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	810.20	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.52		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.05		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.02		> 0.10	Low bacterial activity, foods may be required.
AF:AB	1.15		5.00 to 10.00	Bacterial dominated, becoming more fungal.
Protozoa (Protists)				
Flagellates	290.86	number/g	> 20,000.00	Lacking species diversity.
Amoebae	2,248.17	number/g	> 20,000.00	
Ciliates	14.70	number/g	< 25.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.83	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.38	number/g	> 4.00	
Fungal	0.19	number/g	> 4.00	
Fungal/Root	0.06	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.19	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	63.00	%	> 40	Normal colonization.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11903
Unique ID: Cambridge Loc 14
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Acrobeles	0.06	number/g	Bacterial Feeders	
Cephalobus	0.17	number/g	Bacterial Feeders	
Eucephalobus	0.09	number/g	Bacterial Feeders	
Panagrolaimus	0.06	number/g	Bacterial Feeders	
Aporcelaimium	0.11	number/g	Fungal Feeders	
Epidorylaimus	0.09	number/g	Fungal Feeders	
Ditylenchus	0.06	number/g	Fungal/Root Feeders	Stem & Bulb nematode
Paratylenchus	0.11	number/g	Root Feeders	Pin nematode
Xiphinema	0.09	number/g	Root Feeders	Dagger nematode

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

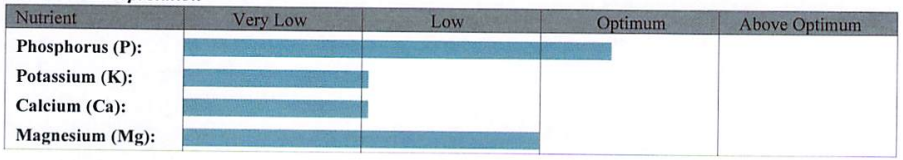
Sample Information:
Sample ID: Cambridge Loc #14 0-12"
Order Number: 40085
Lab Number: S180904-411
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.7		**Cation Exch. Capacity, meq/100g**	9.4	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	6.2	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	7.8	4-14	Calcium Base Saturation	28	50-80
Potassium (K)	52	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	522	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	51	50-120	**Scoop Density, g/cc**	1.23	
Sulfur (S)	8.2	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.9	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	2.5	1.1-6.3			
Zinc (Zn)	7.8	1.0-7.6			
Copper (Cu)	1.3	0.3-0.6			
Iron (Fe)	7.0	2.7-9.4			
Aluminum (Al)	44	<75			
Lead (Pb)	16.9	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Phone: (413) 545-2311
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website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 14 0-12"
Order Number: 40424
Lab Number: X180921-106
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	77.7
Silt	0.002-0.05	16.4
Clay	<0.002	5.9

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	13.4
Coarse	0.5-1.0	20.6
Medium	0.25-0.5	25.1
Fine	0.10-0.25	14.2
Very Fine	0.05-0.10	4.5

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	9.7
Medium	0.005-0.02	5.6
Fine	0.002-0.005	1.1

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	79.8
1.00	#18	69.1
0.50	#35	52.7
0.25	#60	32.7
0.10	#140	21.4
0.053	#270	17.8
0.02	20 um	10.1
0.005	5 um	5.6
0.002	2 um	4.7

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 20.2

UMass Extension

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161 Holdsworth Way
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

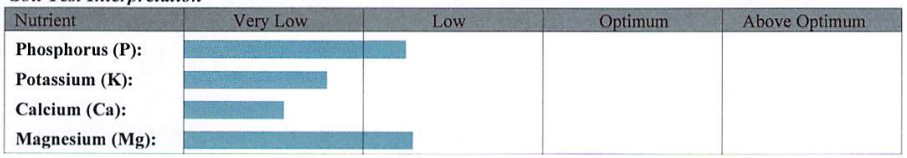
Sample Information:
Sample ID: Cambridge Loc #14 12-24"
Order Number: 40085
Lab Number: S180904-413
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.6		**Cation Exch. Capacity, meq/100g**	5.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.2	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.5	4-14	Calcium Base Saturation	24	50-80
Potassium (K)	41	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	282	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	32	50-120	**Scoop Density, g/cc**	1.28	
Sulfur (S)	9.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.7	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	1.2	1.1-6.3			
Zinc (Zn)	3.1	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	6.8	2.7-9.4			
Aluminum (Al)	57	<75			
Lead (Pb)	13.4	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 14 12-24"
Order Number: 40424
Lab Number: X180921-107
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	80.6
Silt	0.002-0.05	12.1
Clay	<0.002	7.3
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.1
Coarse	0.5-1.0	19.5
Medium	0.25-0.5	33.3
Fine	0.10-0.25	15.2
Very Fine	0.05-0.10	3.5
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	6.0
Medium	0.005-0.02	4.5
Fine	0.002-0.005	1.6

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	86.7
1.00	#18	78.8
0.50	#35	61.9
0.25	#60	33.0
0.10	#140	19.8
0.053	#270	16.8
0.02	20 um	11.6
0.005	5 um	7.7
0.002	2 um	6.3

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 13.3

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161 Holdsworth Way
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Amherst, MA 01003
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #14 24-36"
Order Number: 40085
Lab Number: S180904-414
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.3		**Cation Exch. Capacity, meq/100g**	4.7	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.4	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.3	4-14	Calcium Base Saturation	23	50-80
Potassium (K)	31	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	221	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	19	50-120	**Scoop Density, g/cc**	1.32	
Sulfur (S)	14.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.4	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.16	<0.6
Manganese (Mn)	1.2	1.1-6.3			
Zinc (Zn)	1.8	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	6.4	2.7-9.4			
Aluminum (Al)	60	<75			
Lead (Pb)	9.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 15

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Protozoa			
Amoeba	514.51	>20,000	Low
Flagellates	4,769.31	>20,000	Low
Ciliates	64.87	<53	High
Nutrient Cycling Capacity from Microbial Activity	25-50 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	1,006.02	>300	
Fungal Biomass	484.59	>1,500	Low
Hyphal Diameter	3.50	>2.5	
Location 15 0-12"			
CEC	10.2	>10	
PH	5.3	6.5-7.0	
OM	3.3	4-8%	
Soluble Salts	0.06	<0.6	
Sand	71.40%		
Silt	20.20%		
Clay	8.30%		
Clay, Silt, VF Sand	33.10%		
Lead	13.5	<22	
Location 15 12"-24"			
CEC	5.7	>10	
PH	5.7	6.5-7.0	
OM	1.5	4-8%	
Soluble Salts	0.05	<0.6	
Sand	80.40%		
Silt	12.90%		
Clay	6.80%		
Clay, Silt, VF Sand	24.10%		
Lead	11.7	<22	
Location 15 24"-36"			
CEC	5.1	>10	
PH	5.4	6.5-7.0	
OM	1.3	4-8%	
Soluble Salts	0.05	<0.6	
Sand	83.00%		
Silt	10.90%		
Clay	6.10%		
Clay, Silt, VF Sand	19.40%		
Lead	7.6	<22	

UMass Extension

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University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 14 24-36"
Order Number: 40424
Lab Number: X180921-108
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	87.4
Silt	0.002-0.05	7.0
Clay	<0.002	5.6

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	13.9
Coarse	0.5-1.0	24.8
Medium	0.25-0.5	34.6
Fine	0.10-0.25	11.6
Very Fine	0.05-0.10	2.5

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	2.3
Medium	0.005-0.02	3.6
Fine	0.002-0.005	1.2

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	78.5
1.00	#18	67.6
0.50	#35	48.1
0.25	#60	20.9
0.10	#140	11.8
0.053	#270	9.9
0.02	20 um	8.1
0.005	5 um	5.3
0.002	2 um	4.4

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 21.5

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11905
Unique ID: Cambridge Loc 15
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.89	N/A	0.45 to 0.85	Within normal moisture levels.
Active Fungi	27.91	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	484.59	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.50	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	43.72	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	1,006.02	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.48		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.06		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.04		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.64		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	4,769.31	number/g	> 20,000.00	High ciliate numbers indicate possible anaerobic conditions.
Amoebae	514.51	number/g	> 20,000.00	
Ciliates	64.87	number/g	< 53.00	
Nitrogen Cycling Potential	25-50	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	3.10	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	1.67	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.19	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	1.24	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	14.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11905
Unique ID: Cambridge Loc 15
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Acrobeles	0.56	number/g	Bacterial Feeders	
Prismatolaimus	0.74	number/g	Bacterial Feeders	
Rhabditidae	0.37	number/g	Bacterial Feeders	
Aphelenchus	0.19	number/g	Fungal/Root Feeders	
Gracilacus	0.31	number/g	Root Feeders	Pin nematode
Paratylenchus	0.50	number/g	Root Feeders	Pin nematode
Scutellonema	0.19	number/g	Root Feeders	
Xiphinema	0.25	number/g	Root Feeders	Dagger nematode

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

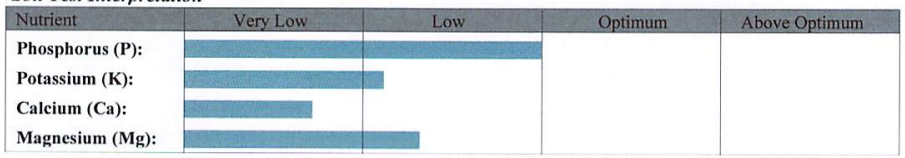
Sample Information:
Sample ID: Cambridge Loc #15 0-12"
Order Number: 40085
Lab Number: S180904-415
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.3		**Cation Exch. Capacity, meq/100g**	10.2	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	8.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.1	4-14	Calcium Base Saturation	17	50-80
Potassium (K)	56	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	351	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	33	50-120	**Scoop Density, g/cc**	1.05	
Sulfur (S)	12.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.3	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	2.3	1.1-6.3			
Zinc (Zn)	4.1	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	10.2	2.7-9.4			
Aluminum (Al)	108	<75			
Lead (Pb)	13.5	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambrirdge Loc 15 0-12"
Order Number: 40424
Lab Number: X180921-109
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	71.4
Silt	0.002-0.05	20.2
Clay	<0.002	8.3

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	10.8
Coarse	0.5-1.0	16.4
Medium	0.25-0.5	24.4
Fine	0.10-0.25	15.3
Very Fine	0.05-0.10	4.6

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	10.9
Medium	0.005-0.02	7.7
Fine	0.002-0.005	1.7

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	82.9
1.00	#18	73.9
0.50	#35	60.3
0.25	#60	40.1
0.10	#140	27.5
0.053	#270	23.7
0.02	20 um	14.7
0.005	5 um	8.3
0.002	2 um	6.9

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 17.1

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #15 12-24"
Order Number: 40085
Lab Number: S180904-416
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.7		**Cation Exch. Capacity, meq/100g**	5.7	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.2	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.8	4-14	Calcium Base Saturation	20	50-80
Potassium (K)	39	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	232	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	28	50-120	**Scoop Density, g/cc**	1.31	
Sulfur (S)	9.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.5	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.05	<0.6
Manganese (Mn)	0.7	1.1-6.3			
Zinc (Zn)	1.4	1.0-7.6			
Copper (Cu)	0.6	0.3-0.6			
Iron (Fe)	5.5	2.7-9.4			
Aluminum (Al)	72	<75			
Lead (Pb)	11.7	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 15 12-24"
Order Number: 40424
Lab Number: X180921-110
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	80.4
Silt	0.002-0.05	12.9
Clay	<0.002	6.8

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	9.0
Coarse	0.5-1.0	20.6
Medium	0.25-0.5	31.3
Fine	0.10-0.25	15.1
Very Fine	0.05-0.10	4.4

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	6.2
Medium	0.005-0.02	5.3
Fine	0.002-0.005	1.4

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	77.7
1.00	#18	70.7
0.50	#35	54.7
0.25	#60	30.4
0.10	#140	18.6
0.053	#270	15.2
0.02	20 um	10.4
0.005	5 um	6.3
0.002	2 um	5.3

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 22.3

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #15 24-36"
Order Number: 40085
Lab Number: S180904-417
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.4		**Cation Exch. Capacity, meq/100g**	5.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.3	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.5	4-14	Calcium Base Saturation	11	50-80
Potassium (K)	33	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	113	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	16	50-120	**Scoop Density, g/cc**	1.24	
Sulfur (S)	13.2	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.3	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.05	<0.6
Manganese (Mn)	0.9	1.1-6.3			
Zinc (Zn)	0.4	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	6.2	2.7-9.4			
Aluminum (Al)	89	<75			
Lead (Pb)	7.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

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Amherst, MA 01003
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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 15 24-36"
Order Number: 40424
Lab Number: X180921-111
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	83.0
Silt	0.002-0.05	10.9
Clay	<0.002	6.1

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	8.6
Coarse	0.5-1.0	22.6
Medium	0.25-0.5	37.4
Fine	0.10-0.25	12.1
Very Fine	0.05-0.10	2.4

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	5.2
Medium	0.005-0.02	4.6
Fine	0.002-0.005	1.1

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	77.6
1.00	#18	70.9
0.50	#35	53.4
0.25	#60	24.4
0.10	#140	15.0
0.053	#270	13.2
0.02	20 um	9.1
0.005	5 um	5.6
0.002	2 um	4.8

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 22.4

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 16

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	3,399.61	>20,000	
Flagellates	16,995.62	>20,000	
Ciliates	170.41	<204	
Nutrient Cycling Capacity from Microbial Activity	75-100 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	948.23	>300	
Fungal Biomass	1,631.55	>1,500	
Hyphal Diameter	4.00	>2.5	
Location 16 0-12"			
CEC	6.9	>10	
PH	7.3	6.5-7.0	
OM	3.5	4-8%	
Soluble Salts	0.05	<0.6	
Sand	76.30%		
Silt	19.20%		
Clay	4.60%		
Clay, Silt, VF Sand	33.10%		
Lead	4.1	<22	
Location 16 12"-24"			
CEC	4.8	>10	
PH	7.5	6.5-7.0	
OM	2.8	4-8%	
Soluble Salts	0.06	<0.6	
Sand	75.70%		
Silt	18.90%		
Clay	5.40%		
Clay, Silt, VF Sand	29.20%		
Lead	6.3	<22	
Location 16 24"-36"			
CEC	2.4	>10	
PH	7.5	6.5-7.0	
OM	1.5	4-8%	
Soluble Salts	0.06	<0.6	
Sand	78.30%		
Silt	16.60%		
Clay	5.10%		
Clay, Silt, VF Sand	32.00%		
Lead	6.8	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11906
Unique ID: Cambridge Loc 16
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.82	N/A	0.45 to 0.85	Within normal moisture levels.
Active Fungi	69.81	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	1,631.55	µg/g	> 1,500.00	Good fungal biomass. -
Hyphal Diameter	4.00	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	37.05	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	948.23	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	1.72		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.04		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.04		> 0.10	Low bacterial activity, foods may be required.
AF:AB	1.88		5.00 to 10.00	Fungal dominated, becoming more fungal.
Protozoa (Protists)				
Flagellates	16,995.62	number/g	> 20,000.00	Lacking species diversity.
Amoebae	3,399.61	number/g	> 20,000.00	
Ciliates	170.41	number/g	< 204.00	
Nitrogen Cycling Potential	75-100	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.24	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.76	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.12	number/g	< 1.00	
Predatory	0.36	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	Processing	%	> 40	Low colonization, foods may be required. -
ECTO	Processing	%	> 40	
Ericoid	Processing	%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11906
Unique ID: Cambridge Loc 16
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Heterocephalobus	0.36	number/g	Bacterial Feeders	
Prismatolaimus	0.20	number/g	Bacterial Feeders	
Rhabditidae	0.20	number/g	Bacterial Feeders	
Tylenchus	0.12	number/g	Fungal/Root Feeders	
Mylonchulus	0.36	number/g	Predatory	

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161 Holdsworth Way
University of Massachusetts
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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #16 0-12"
Order Number: 40085
Lab Number: S180904-418
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.3		**Cation Exch. Capacity, meq/100g**	6.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.8	4-14	Calcium Base Saturation	61	50-80
Potassium (K)	54	100-160	Magnesium Base Saturation	37	10-30
Calcium (Ca)	841	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	310	50-120	**Scoop Density, g/cc**	0.97	
Sulfur (S)	6.0	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.5	
Boron (B)	0.3	0.1-0.5	Soluble Salts (1:2), dS/m	0.05	<0.6
Manganese (Mn)	2.1	1.1-6.3			
Zinc (Zn)	7.2	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	3.3	2.7-9.4			
Aluminum (Al)	19	<75			
Lead (Pb)	4.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 16 0-12"
Order Number: 40424
Lab Number: X180921-112
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	76.3
Silt	0.002-0.05	19.2
Clay	<0.002	4.6
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	11.5
Coarse	0.5-1.0	17.4
Medium	0.25-0.5	19.5
Fine	0.10-0.25	18.5
Very Fine	0.05-0.10	9.3
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	12.9
Medium	0.005-0.02	4.4
Fine	0.002-0.005	1.8

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	73.7
1.00	#18	65.2
0.50	#35	52.4
0.25	#60	38.0
0.10	#140	24.3
0.053	#270	17.5
0.02	20 um	8.0
0.005	5 um	4.7
0.002	2 um	3.4

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 26.3

UMass Extension

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161 Holdsworth Way
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Amherst, MA 01003
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e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

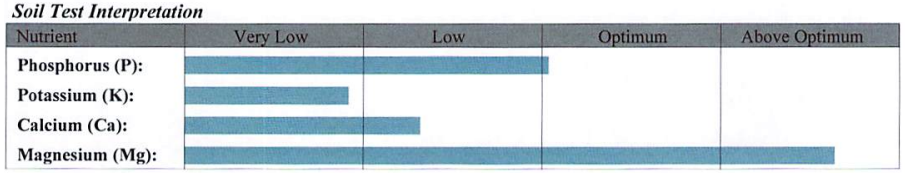
Sample Information:
Sample ID: Cambridge Loc #16 12-24"
Order Number: 40085
Lab Number: S180904-419
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.5		**Cation Exch. Capacity, meq/100g**	4.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.6	4-14	Calcium Base Saturation	68	50-80
Potassium (K)	46	100-160	Magnesium Base Saturation	29	10-30
Calcium (Ca)	653	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	173	50-120	**Scoop Density, g/cc**	1.08	
Sulfur (S)	6.4	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.8	
Boron (B)	0.5	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	1.9	1.1-6.3			
Zinc (Zn)	9.2	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	4.2	2.7-9.4			
Aluminum (Al)	27	<75			
Lead (Pb)	6.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 16 12-24"
Order Number: 40424
Lab Number: X180921-113
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	75.7
Silt	0.002-0.05	18.9
Clay	<0.002	5.4
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	14.1
Coarse	0.5-1.0	18.0
Medium	0.25-0.5	21.1
Fine	0.10-0.25	17.6
Very Fine	0.05-0.10	4.9
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	10.8
Medium	0.005-0.02	6.1
Fine	0.002-0.005	2.0

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	73.2
1.00	#18	62.9
0.50	#35	49.8
0.25	#60	34.3
0.10	#140	21.4
0.053	#270	17.8
0.02	20 um	9.8
0.005	5 um	5.4
0.002	2 um	4.0

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 26.8

UMass Extension

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Amherst, MA 01003
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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

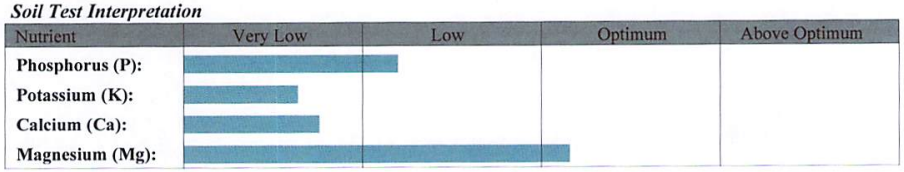
Sample Information:
Sample ID: Cambridge Loc #16 24-36"
Order Number: 40085
Lab Number: S180904-420
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.5		**Cation Exch. Capacity, meq/100g**	2.4	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	2.4	4-14	Calcium Base Saturation	76	50-80
Potassium (K)	32	100-160	Magnesium Base Saturation	20	10-30
Calcium (Ca)	373	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	61	50-120	**Scoop Density, g/cc**	1.13	
Sulfur (S)	4.8	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.5	
Boron (B)	0.3	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	2.3	1.1-6.3			
Zinc (Zn)	5.2	1.0-7.6			
Copper (Cu)	0.6	0.3-0.6			
Iron (Fe)	5.0	2.7-9.4			
Aluminum (Al)	32	<75			
Lead (Pb)	6.8	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 16 24-36"
Order Number: 40424
Lab Number: X180921-114
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	78.3
Silt	0.002-0.05	16.6
Clay	<0.002	5.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	9.0
Coarse	0.5-1.0	13.2
Medium	0.25-0.5	21.2
Fine	0.10-0.25	24.6
Very Fine	0.05-0.10	10.3
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	9.0
Medium	0.005-0.02	5.4
Fine	0.002-0.005	2.2

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	77.4
1.00	#18	70.5
0.50	#35	60.3
0.25	#60	43.8
0.10	#140	24.8
0.053	#270	16.8
0.02	20 um	9.8
0.005	5 um	5.6
0.002	2 um	3.9

USDA Textural Class: loamy sand

Gravel Content: (%) 22.6

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 17

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	299.41	>20,000	Low
Flagellates	1,498.13	>20,000	Low
Ciliates	0.00	<18	
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	700.95	>300	
Fungal Biomass	280.18	>1,500	Low
Hyphal Diameter	3.50	>2.5	
Location 17 0-12"			
CEC	10	>10	
PH	6.1	6.5-7.0	
OM	4.7	4-8%	
Soluble Salts	0.08	<0.6	
Sand	59.80%		
Silt	30.90%		
Clay	9.30%		
Clay, Silt, VF Sand	46.00%		
Lead	4.3	<22	
Location 17 12"-24"			
CEC	6.6	>10	
PH	6.1	6.5-7.0	
OM	2.5	4-8%	
Soluble Salts	0.06	<0.6	
Sand	73.70%		
Silt	19.00%		
Clay	7.30%		
Clay, Silt, VF Sand	32.40%		
Lead	4	<22	
Location 17 24"-36"			
CEC	19.8	>10	
PH	5.5	6.5-7.0	
OM	3.1	4-8%	
Soluble Salts	0.19	<0.6	
Sand	71.50%		
Silt	19.50%		
Clay	9.00%		
Clay, Silt, VF Sand	32.90%		
Lead	979.6	<22	High

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11907
Unique ID: Cambridge Loc 17
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.93	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	14.14	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	280.18	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.50	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	14.31	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	700.95	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.40		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.05		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.02		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.99		5.00 to 10.00	Bacterial dominated, likely to remain bacterial.
Protozoa (Protists)				
Flagellates	1,498.13	number/g	> 20,000.00	Lacking species diversity.
Amoebae	299.41	number/g	> 20,000.00	
Ciliates	0.00	number/g	< 18.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	2.44	number/g	> 10.00	Low numbers, but good diversity.
Bacterial	1.14	number/g	> 4.00	
Fungal	0.38	number/g	> 4.00	
Fungal/Root	0.27	number/g	< 1.00	
Predatory	0.22	number/g	> 2.00	
Root	0.43	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	7.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Nematode Detail

Report Sent:
Sample #: 03-11907
Unique ID: Cambridge Loc 17
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.65	number/g	Bacterial Feeders	
Eucephalobus	0.11	number/g	Bacterial Feeders	
Rhabditidae	0.38	number/g	Bacterial Feeders	
Aporcelaimium	0.38	number/g	Fungal Feeders	
Filenchus	0.27	number/g	Fungal/Root Feeders	
Pratylenchus	0.43	number/g	Root Feeders	Lesion nematode
Mylonchulus	0.22	number/g	Predatory	

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #17 0-12"
Order Number: 40085
Lab Number: S180904-421
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.1		**Cation Exch. Capacity, meq/100g**	10.0	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	6.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.0	4-14	Calcium Base Saturation	26	50-80
Potassium (K)	70	100-160	Magnesium Base Saturation	3	10-30
Calcium (Ca)	524	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	35	50-120	**Scoop Density, g/cc**	1.04	
Sulfur (S)	7.2	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.7	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.08	<0.6
Manganese (Mn)	3.8	1.1-6.3			
Zinc (Zn)	3.9	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	17.2	2.7-9.4			
Aluminum (Al)	90	<75			
Lead (Pb)	4.3	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
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University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 17 0-12"
Order Number: 40424
Lab Number: X180921-115
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	59.8
Silt	0.002-0.05	30.9
Clay	<0.002	9.3

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	7.1
Coarse	0.5-1.0	11.7
Medium	0.25-0.5	17.8
Fine	0.10-0.25	17.4
Very Fine	0.05-0.10	5.8

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	18.5
Medium	0.005-0.02	10.3
Fine	0.002-0.005	2.1

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	77.5
1.00	#18	72.0
0.50	#35	63.0
0.25	#60	49.1
0.10	#140	35.7
0.053	#270	31.1
0.02	20 um	16.8
0.005	5 um	8.8
0.002	2 um	7.2

USDA Textural Class: sandy loam

Gravel Content: (%) 22.5

UMass Extension

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161 Holdsworth Way
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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

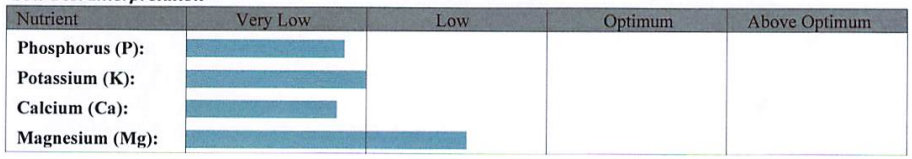
Sample Information:
Sample ID: Cambridge Loc #17 12-24"
Order Number: 40085
Lab Number: S180904-422
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.1		**Cation Exch. Capacity, meq/100g**	6.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	1.7	4-14	Calcium Base Saturation	32	50-80
Potassium (K)	50	100-160	Magnesium Base Saturation	5	10-30
Calcium (Ca)	421	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	39	50-120	**Scoop Density, g/cc**	1.24	
Sulfur (S)	5.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.5	
Boron (B)	0.0	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	2.2	1.1-6.3			
Zinc (Zn)	8.8	1.0-7.6			
Copper (Cu)	0.9	0.3-0.6			
Iron (Fe)	9.0	2.7-9.4			
Aluminum (Al)	62	<75			
Lead (Pb)	4.0	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

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Amherst, MA 01003
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website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 17 12-24"
Order Number: 40424
Lab Number: X180921-116
Received: 9/21/2018
Reported: 9/26/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	73.7
Silt	0.002-0.05	19.0
Clay	<0.002	7.3
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	14.2
Coarse	0.5-1.0	22.1
Medium	0.25-0.5	18.1
Fine	0.10-0.25	13.2
Very Fine	0.05-0.10	6.1
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	11.2
Medium	0.005-0.02	5.8
Fine	0.002-0.005	2.0

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	72.5
1.00	#18	62.2
0.50	#35	46.2
0.25	#60	33.1
0.10	#140	23.5
0.053	#270	19.1
0.02	20 um	11.0
0.005	5 um	6.7
0.002	2 um	5.3

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 27.5

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #17 24-36"
Order Number: 40085
Lab Number: S180904-424
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	5.5		**Cation Exch. Capacity, meq/100g**	19.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	7.6	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	5.8	4-14	Calcium Base Saturation	58	50-80
Potassium (K)	77	100-160	Magnesium Base Saturation	2	10-30
Calcium (Ca)	2295	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	58	50-120	**Scoop Density, g/cc**	1.11	
Sulfur (S)	49.2	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.1	
Boron (B)	0.2	0.1-0.5	Soluble Salts (1:2), dS/m	0.19	<0.6
Manganese (Mn)	4.5	1.1-6.3			
Zinc (Zn)	132.7	1.0-7.6			
Copper (Cu)	115.2	0.3-0.6			
Iron (Fe)	10.6	2.7-9.4			
Aluminum (Al)	48	<75			
Lead (Pb)	979.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

Soil and Plant Nutrient Testing Laboratory
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University of Massachusetts
Amherst, MA 01003
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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 17 24-36"
Order Number: 40600
Lab Number: X180928-101
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	71.5
Silt	0.002-0.05	19.5
Clay	<0.002	9.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	17.4
Coarse	0.5-1.0	18.6
Medium	0.25-0.5	19.6
Fine	0.10-0.25	11.6
Very Fine	0.05-0.10	4.4
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	7.9
Medium	0.005-0.02	9.3
Fine	0.002-0.005	2.3

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	62.8
1.00	#18	51.9
0.50	#35	40.3
0.25	#60	28.0
0.10	#140	20.6
0.053	#270	17.9
0.02	20 um	12.9
0.005	5 um	7.1
0.002	2 um	5.6

USDA Textural Class: gravelly coarse sandy loam

Gravel Content: (%) 37.2

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 18

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	1,518.06	>20,000	Low
Flagellates	1,555.09	>20,000	Low
Ciliates	477.97	<31	High
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	856.00	>300	
Fungal Biomass	64.39	>1,500	Low
Hyphal Diameter	2.50	>2.5	
Location 18 0-12"			
CEC	3.6	>10	
PH	7.2	6.5-7.0	
OM	4.4	4-8%	
Soluble Salts	0.29	<0.6	
Sand	70.50%		
Silt	22.50%		
Clay	7.00%		
Clay, Silt, VF Sand	36.60%		
Lead	12.8	<22	
Location 18 12"-24"			
CEC	7.8	>10	
PH	6.5	6.5-7.0	
OM	3	4-8%	
Soluble Salts	0.09	<0.6	
Sand	68.50%		
Silt	22.10%		
Clay	9.30%		
Clay, Silt, VF Sand	36.00%		
Lead	39.1	<22	High
Location 18 24"-36"			
CEC	5.5	>10	
PH	6.3	6.5-7.0	
OM	2.1	4-8%	
Soluble Salts	0.35	<0.6	
Sand	62.30%		
Silt	25.30%		
Clay	12.40%		
Clay, Silt, VF Sand	44.70%		
Lead	10.1	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11908
Unique ID: Cambridge Loc 18
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.89	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	2.51	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	64.39	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	2.50	µm	> 2.50	Good balance of fungi. -
Active Bacteria	17.26	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	856.00	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.08		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.04		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.02		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.15		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	1,555.09	number/g	> 20,000.00	High ciliate numbers indicate possible anaerobic conditions.
Amoebae	1,518.06	number/g	> 20,000.00	
Ciliates	477.97	number/g	< 31.00	
Nitrogen Cycling Potential	<25	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	0.38	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.28	number/g	> 4.00	
Fungal	0.00	number/g	> 4.00	
Fungal/Root	0.00	number/g	< 1.00	
Predatory	0.07	number/g	> 2.00	
Root	0.04	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	9.00	%	> 40	Low colonization, foods may be required. -
ECTO		%	> 40	
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11908
Unique ID: Cambridge Loc 18
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Butlerius	0.04	number/g	Bacterial Feeders	
Cephalobus	0.16	number/g	Bacterial Feeders	
Heterocephalobus	0.05	number/g	Bacterial Feeders	
Rhabditidae	0.03	number/g	Bacterial Feeders	
Meloidogyne	0.04	number/g	Root Feeders	Root-Knot nematode
Clarkus	0.07	number/g	Predatory	

UMass Extension

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University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

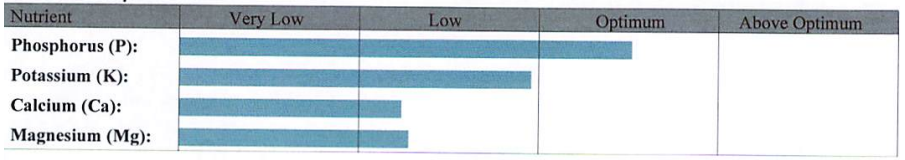
Sample Information:
Sample ID: Cambridge Loc #18 0-12"
Order Number: 40085
Lab Number: S180904-425
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.2		**Cation Exch. Capacity, meq/100g**	3.6	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	9.2	4-14	Calcium Base Saturation	86	50-80
Potassium (K)	97	100-160	Magnesium Base Saturation	7	10-30
Calcium (Ca)	611	1000-1500	Potassium Base Saturation	7	2.0-7.0
Magnesium (Mg)	32	50-120	**Scoop Density, g/cc**	0.99	
Sulfur (S)	10.7	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	4.4	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.29	<0.6
Manganese (Mn)	4.4	1.1-6.3			
Zinc (Zn)	4.7	1.0-7.6			
Copper (Cu)	4.8	0.3-0.6			
Iron (Fe)	12.2	2.7-9.4			
Aluminum (Al)	69	<75			
Lead (Pb)	12.8	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 18 0-12"
Order Number: 40600
Lab Number: X180928-102
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	70.5
Silt	0.002-0.05	22.5
Clay	<0.002	7.0
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.9
Coarse	0.5-1.0	16.4
Medium	0.25-0.5	22.0
Fine	0.10-0.25	17.1
Very Fine	0.05-0.10	7.1
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	12.6
Medium	0.005-0.02	6.9
Fine	0.002-0.005	3.0

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	73.6
1.00	#18	67.8
0.50	#35	55.7
0.25	#60	39.6
0.10	#140	26.9
0.053	#270	21.7
0.02	20 um	12.5
0.005	5 um	7.3
0.002	2 um	5.2

USDA Textural Class: sandy loam

Gravel Content: (%) 26.4

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc #18 12 24"
Order Number: 40085
Lab Number: S180904-426
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.5		**Cation Exch. Capacity, meq/100g**	7.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	9.6	4-14	Calcium Base Saturation	42	50-80
Potassium (K)	95	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	660	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	41	50-120	**Scoop Density, g/cc**	1.04	
Sulfur (S)	7.6	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.0	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.09	<0.6
Manganese (Mn)	1.7	1.1-6.3			
Zinc (Zn)	1.8	1.0-7.6			
Copper (Cu)	0.5	0.3-0.6			
Iron (Fe)	3.4	2.7-9.4			
Aluminum (Al)	45	<75			
Lead (Pb)	39.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation

Nutrient	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

UMass Extension

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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 18 12-24"
Order Number: 40600
Lab Number: X180928-103
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	68.5
Silt	0.002-0.05	22.1
Clay	<0.002	9.3
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	8.6
Coarse	0.5-1.0	15.5
Medium	0.25-0.5	23.8
Fine	0.10-0.25	16.0
Very Fine	0.05-0.10	4.6
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	7.5
Medium	0.005-0.02	11.8
Fine	0.002-0.005	2.8

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	65.7
1.00	#18	60.0
0.50	#35	49.9
0.25	#60	34.2
0.10	#140	23.7
0.053	#270	20.7
0.02	20 um	15.7
0.005	5 um	8.0
0.002	2 um	6.1

USDA Textural Class: gravelly sandy loam

Gravel Content: (%) 34.3

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

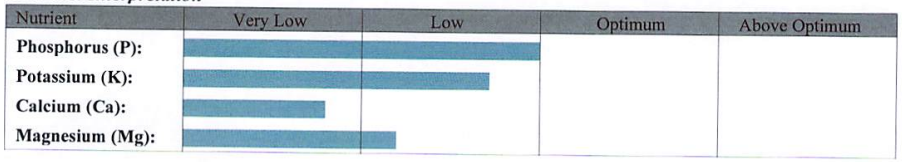
Sample Information:
Sample ID: Cambridge Loc #18 24-36"
Order Number: 40085
Lab Number: S180904-427
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.3		**Cation Exch. Capacity, meq/100g**	5.5	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.1	4-14	Calcium Base Saturation	37	50-80
Potassium (K)	87	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	407	1000-1500	Potassium Base Saturation	4	2.0-7.0
Magnesium (Mg)	30	50-120	**Scoop Density, g/cc**	1.00	
Sulfur (S)	7.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.1	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.35	<0.6
Manganese (Mn)	1.8	1.1-6.3			
Zinc (Zn)	1.4	1.0-7.6			
Copper (Cu)	0.3	0.3-0.6			
Iron (Fe)	3.8	2.7-9.4			
Aluminum (Al)	72	<75			
Lead (Pb)	10.1	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 18 24-36"

Order Number: 40600
Lab Number: X180928-104
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction

Main Fractions	Size (mm)	Percent
Sand	0.05-2.0	62.3
Silt	0.002-0.05	25.3
Clay	<0.002	12.4

Sand Fractions	Size (mm)	Percent
Very Coarse	1.0-2.0	8.0
Coarse	0.5-1.0	13.4
Medium	0.25-0.5	17.6
Fine	0.10-0.25	16.4
Very Fine	0.05-0.10	7.0

Silt Fractions	Size (mm)	Percent
Coarse	0.02-0.05	13.7
Medium	0.005-0.02	8.3
Fine	0.002-0.005	3.4

Percent of Whole Sample Passing

Size (mm)	Sieve #	Whole Sample % of Sample Passing
2.00	#10	77.9
1.00	#18	71.7
0.50	#35	61.3
0.25	#60	47.6
0.10	#140	34.8
0.053	#270	29.4
0.02	20 um	18.7
0.005	5 um	12.3
0.002	2 um	9.6

USDA Textural Class: sandy loam

Gravel Content: (%) 22.1

4 of 10

Sample ID: Cambridge Loc 18 24-36"

Lab N

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 19

	EXISTING CONDITION	DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	4,776.17	>20,000	Low
Flagellates	2,875.45	>20,000	Low
Ciliates	14.54	<77	
Nutrient Cycling Capacity from Microbial Activity	25-50 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	670.86	>300	
Fungal Biomass	411.82	>1,500	Low
Hyphal Diameter	3.50	>2.5	
Location 19 0-12"			
CEC	7	>10	
PH	6.7	6.5-7.0	
OM	3.1	4-8%	
Soluble Salts	0.04	<0.6	
Sand	74.60%		
Silt	18.00%		
Clay	7.40%		
Clay, Silt, VF Sand	29.60%		
Lead	8.5	<22	
Location 19 12"-24"			
CEC	18.9	>10	
PH	7.8	6.5-7.0	
OM	2.1	4-8%	
Soluble Salts	0.13	<0.6	
Sand	75.60%		
Silt	16.80%		
Clay	7.70%		
Clay, Silt, VF Sand	29.80%		
Lead	17.2	<22	
Location 19 24"-36"			
CEC	30.8	>10	
PH	8.4	6.5-7.0	
OM	1.9	4-8%	
Soluble Salts	0.14	<0.6	
Sand	77.10%		
Silt	15.00%		
Clay	7.90%		
Clay, Silt, VF Sand	27.10%		
Lead	25	<22	High

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11909
Unique ID: Cambridge Loc 19
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.96	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	27.39	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	411.82	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.50	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	19.20	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	670.86	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.61		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.07		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.03		> 0.10	Low bacterial activity, foods may be required.
AF:AB	1.43		5.00 to 10.00	Bacterial dominated, becoming more fungal.
Protozoa (Protists)				
Flagellates	2,875.45	number/g	> 20,000.00	Lacking species diversity.
Amoebae	4,776.17	number/g	> 20,000.00	
Ciliates	14.52	number/g	< 77.00	
Nitrogen Cycling Potential	25-50	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.02	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.30	number/g	> 4.00	
Fungal	0.45	number/g	> 4.00	
Fungal/Root	0.15	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.11	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	8.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11909
Unique ID: Cambridge Loc 19
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.08	number/g	Bacterial Feeders	
Rhabditidae	0.23	number/g	Bacterial Feeders	
Aporcelaimus	0.15	number/g	Fungal Feeders	
Eudorylaimus	0.30	number/g	Fungal Feeders	
Aphelenchus	0.15	number/g	Fungal/Root Feeders	
Heterodora	0.11	number/g	Root Feeders	Cyst nematode

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

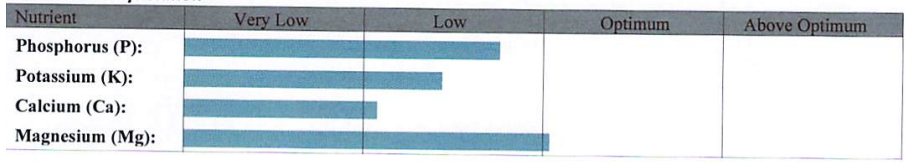
Sample Information:
Sample ID: Cambridge Loc #19 0-12"
Order Number: 40085
Lab Number: S180904-428
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.7		**Cation Exch. Capacity, meq/100g**	7.0	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.7	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	3.6	4-14	Calcium Base Saturation	39	50-80
Potassium (K)	73	100-160	Magnesium Base Saturation	6	10-30
Calcium (Ca)	546	1000-1500	Potassium Base Saturation	3	2.0-7.0
Magnesium (Mg)	52	50-120	**Scoop Density, g/cc**	1.25	
Sulfur (S)	6.5	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.1	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.04	<0.6
Manganese (Mn)	1.1	1.1-6.3			
Zinc (Zn)	11.9	1.0-7.6			
Copper (Cu)	1.1	0.3-0.6			
Iron (Fe)	6.1	2.7-9.4			
Aluminum (Al)	46	<75			
Lead (Pb)	8.5	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 19 0-12"
Order Number: 40600
Lab Number: X180928-105
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	74.6
Silt	0.002-0.05	18.0
Clay	<0.002	7.4
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	10.9
Coarse	0.5-1.0	19.0
Medium	0.25-0.5	27.9
Fine	0.10-0.25	12.6
Very Fine	0.05-0.10	4.2
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	11.4
Medium	0.005-0.02	4.8
Fine	0.002-0.005	1.8

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	77.9
1.00	#18	69.4
0.50	#35	54.6
0.25	#60	32.9
0.10	#140	23.0
0.053	#270	19.8
0.02	20 um	10.9
0.005	5 um	7.1
0.002	2 um	5.7

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 22.1

UMass Extension

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

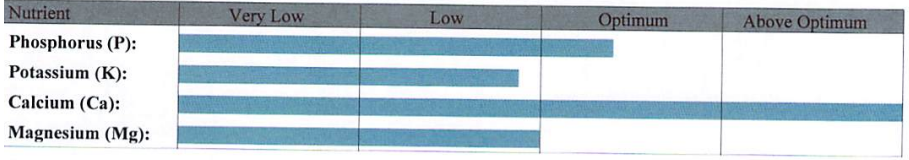
Sample Information:
Sample ID: Cambridge Loc #19 12-24"
Order Number: 40085
Lab Number: S180904-429
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	7.8		**Cation Exch. Capacity, meq/100g**	18.9	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	7.8	4-14	Calcium Base Saturation	97	50-80
Potassium (K)	94	100-160	Magnesium Base Saturation	2	10-30
Calcium (Ca)	3656	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	50	50-120	**Scoop Density, g/cc**	1.34	
Sulfur (S)	37.8	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	2.1	
Boron (B)	0.2	0.1-0.5	Soluble Salts (1:2), dS/m	0.13	<0.6
Manganese (Mn)	2.6	1.1-6.3			
Zinc (Zn)	10.6	1.0-7.6			
Copper (Cu)	2.5	0.3-0.6			
Iron (Fe)	6.8	2.7-9.4			
Aluminum (Al)	34	<75			
Lead (Pb)	17.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 19 12-24"
Order Number: 40600
Lab Number: X180928-106
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	75.6
Silt	0.002-0.05	16.8
Clay	<0.002	7.7
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	16.2
Coarse	0.5-1.0	18.8
Medium	0.25-0.5	20.0
Fine	0.10-0.25	15.3
Very Fine	0.05-0.10	5.3
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	9.2
Medium	0.005-0.02	5.4
Fine	0.002-0.005	2.1

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	56.2
1.00	#18	47.0
0.50	#35	36.5
0.25	#60	25.3
0.10	#140	16.7
0.053	#270	13.7
0.02	20 um	8.5
0.005	5 um	5.5
0.002	2 um	4.3

USDA Textural Class: gravelly coarse sandy loam

Gravel Content: (%) 43.8

UMass Extension

Soil and Plant Nutrient Testing Laboratory
203 Paige Laboratory
161 Holdsworth Way
University of Massachusetts
Amherst, MA 01003
Phone: (413) 545-2311
e-mail: soiltest@umass.edu
website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

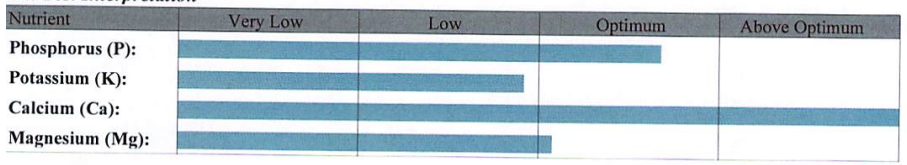
Sample Information:
Sample ID: Cambridge Loc #19 24-36"
Order Number: 40085
Lab Number: S180904-430
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	8.4		**Cation Exch. Capacity, meq/100g**	30.8	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	0.0	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	10.9	4-14	Calcium Base Saturation	98	50-80
Potassium (K)	96	100-160	Magnesium Base Saturation	1	10-30
Calcium (Ca)	6025	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	55	50-120	**Scoop Density, g/cc**	1.36	
Sulfur (S)	72.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	1.9	
Boron (B)	0.4	0.1-0.5	Soluble Salts (1:2), dS/m	0.14	<0.6
Manganese (Mn)	4.0	1.1-6.3			
Zinc (Zn)	11.0	1.0-7.6			
Copper (Cu)	4.0	0.3-0.6			
Iron (Fe)	14.7	2.7-9.4			
Aluminum (Al)	36	<75			
Lead (Pb)	25.0	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 19-24-36"
Order Number: 40600
Lab Number: X180928-107
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	77.1
Silt	0.002-0.05	15.0
Clay	<0.002	7.9
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	19.3
Coarse	0.5-1.0	20.3
Medium	0.25-0.5	20.2
Fine	0.10-0.25	13.1
Very Fine	0.05-0.10	4.2
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	7.7
Medium	0.005-0.02	5.5
Fine	0.002-0.005	1.8

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	39.6
1.00	#18	32.0
0.50	#35	23.9
0.25	#60	15.9
0.10	#140	10.7
0.053	#270	9.1
0.02	20 um	6.0
0.005	5 um	3.8
0.002	2 um	3.1

USDA Textural Class: gravelly coarse sandy loam

Gravel Content: (%) 60.4

F2 ENVIRONMENTAL DESIGN LLC

TEST RESULTS

Location 20

	EXISTING CONDITION	*DESIRABLE RANGE*	*COMMENTS*
Biology			
Protozoa			
Amoeba	4,993.48	>20,000	Low
Flagellates	30,058.42	>20,000	
Ciliates	49.87	<351	
Nutrient Cycling Capacity from Microbial Activity	100-150 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	571.98	>300	
Fungal Biomass	387.37	>1,500	Low
Hyphal Diameter	3.25	>2.5	
Location 20 0-12"			
CEC	12.4	>10	
PH	6	6.5-7.0	
OM	5.4	4-8%	
Soluble Salts	0.09	<0.6	
Sand	66.00%		
Silt	22.00%		
Clay	12.10%		
Clay, Silt, VF Sand	49.60%		
Lead	3.7	<22	
Location 20 12"-24"			
CEC	9.1	>10	
PH	6.2	6.5-7.0	
OM	3.8	4-8%	
Soluble Salts	0.07	<0.6	
Sand	69.50%		
Silt	23.40%		
Clay	7.10%		
Clay, Silt, VF Sand	36.80%		
Lead	2.6	<22	
Location 20 24"-36"			
CEC	7	>10	
PH	6.5	6.5-7.0	
OM	2.7	4-8%	
Soluble Salts	0.06	<0.6	
Sand	76.30%		
Silt	17.60%		
Clay	6.10%		
Clay, Silt, VF Sand	30.20%		
Lead	2.2	<22	

Soil Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11910
Unique ID: Cambridge Loc 20
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.92	N/A	0.45 to 0.85	Add organic matter to build soil structure, increase water holding capacity.
Active Fungi	21.91	µg/g	> 150.00	Fungal activity low, foods may be required. -
Total Fungi	387.37	µg/g	> 1,500.00	Low fungal biomass, foods and biology may be required. -
Hyphal Diameter	3.25	µm	> 2.50	Disease suppressive fungi likely present. -
Active Bacteria	23.37	µg/g	> 30.00	Bacterial activity low, foods may be required.
Total Bacteria	571.98	µg/g	> 300.00	Good bacterial biomass. -
Actinobacteria	0.00	µg/g		
Organism Biomass Ratios				
TF:TB	0.68		5.00 to 10.00	Too bacterial for indicated plant.
AF:TF	0.06		> 0.10	Low fungal activity, foods may be required.
AB:TB	0.04		> 0.10	Low bacterial activity, foods may be required.
AF:AB	0.94		5.00 to 10.00	Bacterial dominated, becoming more bacterial.
Protozoa (Protists)				
Flagellates	30,058.42	number/g	> 20,000.00	Lacking species diversity.
Amoebae	4,993.48	number/g	> 20,000.00	
Ciliates	49.87	number/g	< 351.00	
Nitrogen Cycling Potential	100-150	lbs/acre		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	1.55	number/g	> 10.00	Low numbers, low diversity. Root feeding nematodes are present. Improving soil structure, introducing predatory nematodes and increasing mycorrhizal colonization can help suppress root feeders.
Bacterial	0.46	number/g	> 4.00	
Fungal	0.92	number/g	> 4.00	
Fungal/Root	0.17	number/g	< 1.00	
Predatory	0.00	number/g	> 2.00	
Root	0.00	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO		%	> 40	-
ECTO	29.00	%	> 40	Low colonization, foods may be required.
Ericoid		%	> 40	
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Soil Notes:
Varied irrigation method

Nematode Detail

Report prepared for:
F2 Environmental Design
Eric T. Fleisher
PO Box 292
null
Pottersville, NJ 07979 USA

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent:
Sample #: 03-11910
Unique ID: Cambridge Loc 20
Plant: trees
Season: summer
Invoice Number: 4688
Sample Recieved: 06 Sep 2018

 # per gram
Classified by type and identified to genus.
If section is blank, no nematodes identified.

SOIL FOODWEB NEW YORK
17 Clinton St.
Center Moriches, NY 11934 United States
631-750-1553
soilfoodwebny@aol.com
http://soilfoodwebnewyork.com

Nematode Genus	number/g	Units	Group	Common Name
Cephalobus	0.29	number/g	Bacterial Feeders	
Rhabditidae	0.17	number/g	Bacterial Feeders	
Aporcelaimus	0.35	number/g	Fungal Feeders	
Eudorylaimus	0.40	number/g	Fungal Feeders	
Paraxonchium	0.17	number/g	Fungal Feeders	
Aphelenchus	0.17	number/g	Fungal/Root Feeders	

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website: soiltest.umass.edu

Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

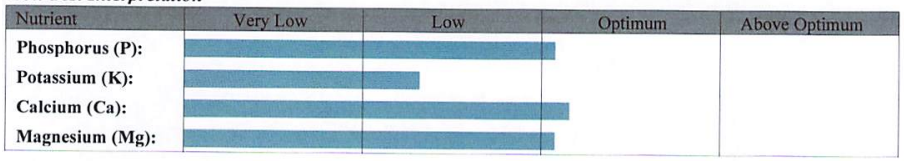
Sample Information:
Sample ID: Cambridge Loc #20 0-12"
Order Number: 40085
Lab Number: S180904-431
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.0		**Cation Exch. Capacity, meq/100g**	12.4	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	6.4	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.9	4-14	Calcium Base Saturation	44	50-80
Potassium (K)	66	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	1076	1000-1500	Potassium Base Saturation	1	2.0-7.0
Magnesium (Mg)	56	50-120	**Scoop Density, g/cc**	1.08	
Sulfur (S)	11.2	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	5.4	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.09	<0.6
Manganese (Mn)	4.8	1.1-6.3			
Zinc (Zn)	7.0	1.0-7.6			
Copper (Cu)	0.7	0.3-0.6			
Iron (Fe)	8.9	2.7-9.4			
Aluminum (Al)	78	<75			
Lead (Pb)	3.7	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 20 0-12"
Order Number: 40600
Lab Number: X180928-108
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	66.0
Silt	0.002-0.05	22.0
Clay	<0.002	12.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	7.6
Coarse	0.5-1.0	14.4
Medium	0.25-0.5	17.2
Fine	0.10-0.25	11.2
Very Fine	0.05-0.10	15.5
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	13.4
Medium	0.005-0.02	6.7
Fine	0.002-0.005	2.0

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	80.5
1.00	#18	74.4
0.50	#35	62.8
0.25	#60	48.9
0.10	#140	39.9
0.053	#270	27.4
0.02	20 um	16.6
0.005	5 um	11.3
0.002	2 um	9.7

USDA Textural Class: sandy loam

Gravel Content: (%) 19.5

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

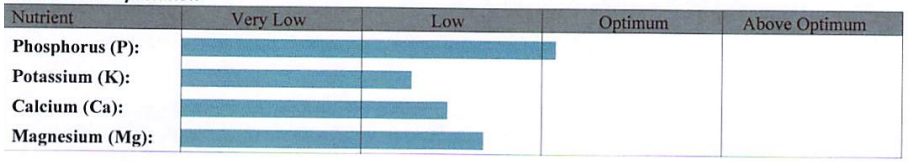
Sample Information:
Sample ID: Cambridge Loc #20 12-24"
Order Number: 40085
Lab Number: S180904-432
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.2		**Cation Exch. Capacity, meq/100g**	9.1	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	4.9	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	4.6	4-14	Calcium Base Saturation	40	50-80
Potassium (K)	63	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	734	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	42	50-120	**Scoop Density, g/cc**	1.14	
Sulfur (S)	9.9	>10	**Optional tests**		
Micronutrients *			Soil Organic Matter (LOI), %	3.8	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.07	<0.6
Manganese (Mn)	3.2	1.1-6.3			
Zinc (Zn)	3.8	1.0-7.6			
Copper (Cu)	0.4	0.3-0.6			
Iron (Fe)	7.2	2.7-9.4			
Aluminum (Al)	72	<75			
Lead (Pb)	2.6	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

Sample Information:
Sample ID: Cambridge Loc 20 12-24"
Order Number: 40600
Lab Number: X180928-109
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	69.5
Silt	0.002-0.05	23.4
Clay	<0.002	7.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	11.9
Coarse	0.5-1.0	17.7
Medium	0.25-0.5	18.8
Fine	0.10-0.25	14.9
Very Fine	0.05-0.10	6.3
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	13.1
Medium	0.005-0.02	7.6
Fine	0.002-0.005	2.6

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	77.9
1.00	#18	68.6
0.50	#35	54.8
0.25	#60	40.2
0.10	#140	28.6
0.053	#270	23.7
0.02	20 um	13.5
0.005	5 um	7.6
0.002	2 um	5.6

USDA Textural Class: coarse sandy loam

Gravel Content: (%) 22.1

UMass Extension

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Soil Test Report

Prepared For:
Andrea Fillippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1957

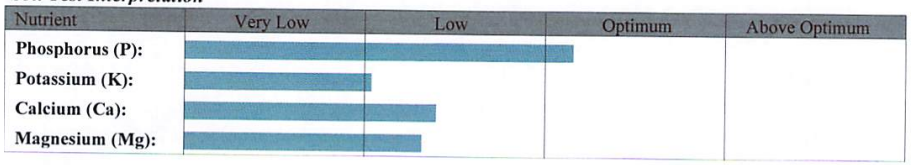
Sample Information:
Sample ID: Cambridge Loc #20 24-36"
Order Number: 40085
Lab Number: S180904-433
Area Sampled:
Received: 9/4/2018
Reported: 9/13/2018

Results

Analysis	*Value Found*	*Optimum Range*	*Analysis*	*Value Found*	*Optimum Range*
Soil pH (1:1, H2O)	6.5		**Cation Exch. Capacity, meq/100g**	7.0	
Modified Morgan extractable, ppm			**Exch. Acidity, meq/100g**	3.1	
Macronutrients			**Base Saturation, %**		
Phosphorus (P)	5.5	4-14	Calcium Base Saturation	49	50-80
Potassium (K)	51	100-160	Magnesium Base Saturation	4	10-30
Calcium (Ca)	692	1000-1500	Potassium Base Saturation	2	2.0-7.0
Magnesium (Mg)	33	50-120	**Scoop Density, g/cc**	1.16	
Sulfur (S)	8.2	>10	**Optional tests**		
*Micronutrients **			Soil Organic Matter (LOI), %	2.7	
Boron (B)	0.1	0.1-0.5	Soluble Salts (1:2), dS/m	0.06	<0.6
Manganese (Mn)	3.1	1.1-6.3			
Zinc (Zn)	3.6	1.0-7.6			
Copper (Cu)	0.3	0.3-0.6			
Iron (Fe)	5.7	2.7-9.4			
Aluminum (Al)	54	<75			
Lead (Pb)	2.2	<22			

* *Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.*

Soil Test Interpretation



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Particle Size Analysis - Comprehensive

Prepared For:
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908-413-1957

Sample Information:
Sample ID: Cambridge Loc 20 24-36"
Order Number: 40600
Lab Number: X180928-110
Received: 9/28/2018
Reported: 10/9/2018

USDA Size Fraction		
Main Fractions	**Size (mm)**	**Percent**
Sand	0.05-2.0	76.3
Silt	0.002-0.05	17.6
Clay	<0.002	6.1
Sand Fractions	**Size (mm)**	**Percent**
Very Coarse	1.0-2.0	15.2
Coarse	0.5-1.0	20.5
Medium	0.25-0.5	19.2
Fine	0.10-0.25	14.8
Very Fine	0.05-0.10	6.5
Silt Fractions	**Size (mm)**	**Percent**
Coarse	0.02-0.05	9.2
Medium	0.005-0.02	6.9
Fine	0.002-0.005	1.6

Percent of Whole Sample Passing		
Size (mm)	**Sieve #**	**Whole Sample % of Sample Passing**
2.00	#10	77.3
1.00	#18	65.6
0.50	#35	49.7
0.25	#60	34.8
0.10	#140	23.4
0.053	#270	18.4
0.02	20 um	11.3
0.005	5 um	5.9
0.002	2 um	4.7

USDA Textural Class: loamy coarse sand

Gravel Content: (%) 22.7

F2 CAMBRIDGE SOIL SAMPLING LOCATIONS DATA

	Cambridge Urban Tree Canopy																								
	Data Collected by F2 Environmental Design					Horizon	Horizon	Horizon																	
#	Site Location	Photo ID	Summary of 5 Sample Locations per site	Latitude	Longitude	0-12	12-24	24-36	Visual Description	Environmental Conditions	Air Temperature	Relative Humidity	Wind Conditions	Pit	Park	Tree Type	Old or Young	Healthy/Alive / Dead	Irrigation	Drainage	Compaction	Soil Moisture	Soil Temp	Based on observation Sand or Clay	Photos Taken
1	Massachusetts Ave & Columbus Ave	#1MACA_																							
2	Alewife Linear Park, off Massachusetts Ave	#2ALP_																							
3	Cambridgepark Drive	#3CPD_																							
4	Fresh Pond, off Concord Ave, between Wheeler and Faucet	#4FPOCA_																							
5	Danehy Park Sherman St entrance, 2nd parking lot entrance	#5DP_																							
6	Massachusetts Ave between Milton Street and Russel Street	#6MAMSRS_																							
7	Concord Ave, between Donnell St, Appleton St, and Royal St	#7CABBPL_																							
8	Fayerweather St between Brattle and Resevoir	#8FSBSRS_																							
9	Massachusetts Ave between Prentiss and Garfield	#9MAPG_																							
10	Cambridge Common Park, Between Waterhouse and Garden Street	#10CCP_																							
11	Hew St, between Western Ave and Calendar St	#11HSWACS_																							
12	DCR, Magazine Beach, between Magazine St and Overpass	#12DCRMB_																							
13	Corner of Pearl and Henry, between Tufts St and Glenwood Ave	#13PHS_																							
14	Tremont St, between Garden St and Broadway	#14TS_																							
15	Sennot Park, Corner of Broadwat and Norfolk St	#15SP_																							
16	Massachusetts Ave at Blanche St, between State and Landsdowne St	#16MABSS_																							
17	Munroe St, between 5th and 3rd St	#17MS_																							
18	Spring St, between Fifth St and Sciarappa St	#18SPOSS_																							
19	First St and Binney St, between Edwin H Land Blvd and 1st St	#19FSBS_																							
20	Education St in North Point between Museum Way and North Pt Blvd	#20ESNP_																							
1	**Massachusetts Ave & Columbus Ave**	**#1MACA_**	**Very dry, inconsistent material, very compacted**																						
	Sample 1 - Maple & Oak trees, dry partially mowed, a lot of utilities crossing this park			42.400657	-71.135873	**0-12**			Somewhat moist, dry side, loam with fair amount of silt	10:24	93		slight breeze		Park	Maple & Oak	Old	Alive			Very Compacted	More Moisture	80	Silt & Clay	yes
	Begonias and hosta in a bed at beginning of park,						**12-24**		Compaction layer at 24", Dry, sandy loam													Dry			
								24-36	24" hitting compaction layer, lumps of compacted soil, silt and clay, more clay lower you go.							Begonia & Hosta					Very Compacted			Silt & Clay	
	Sample 2 -between 2 oaks and 1 maple 50' tal, 24" cal			42.400565	-71.136069	**0-12**			Very very dry, super compacted, sandy loam high in silt	10:40					Park	Maple & Oak	Old	Alive			Very Compacted	Extremely Dry	82	Silty Loam	yes
							12-24		Hit a rock in this level, so dry, barely can dig in the soil													Extremely Dry			
								24-36	Lots of stones, extremely dry all the way down													Extremely Dry			
	Sample 3 -In area not mowed			42.400463	-71.136174	**0-12**			High grass, Extremely dry sandy loam	10:55			slight breeze		Park	Grass		Alive			Compacted	Extremely Dry	76	Sandy Loam	yes
							12-24		Hit a rock in this level, so dry, barely can dig in the soil													Extremely Dry			
								24-36	Hit rock at 24" - so could not take any samples from this depth																
	Sample 4 - North of an Oak, South of walkway			42.40064	-71.136033	**0-12**			Mowed area by sidewalk, terribly compacted silty loam	11:27			slight breeze		Park	Oak	Old	Alive			Compacted	Dry	84	Silty Loam	
							12-24		Hit a rock in this level, so dry, barely can dig in the soil													Extremely Dry			
								24-36	Lots of stones, extremely dry all the way down	11:40												Extremely Dry			
	Sample 5 - North of Oak and walkway			42.400623	-71.13618	**0-12**			Mowed area by sidewalk, terribly compacted silty loam				slight breeze		Park	Oak	Old	Alive			Compacted	Dry	84	Silty Loam	
							12-24		Hit a rock in this level, so dry, barely can dig in the soil													Extremely Dry			
								24-36	Lots of stones, extremely dry all the way down													Extremely Dry			
2	**Alewife Linear Park, off Massachusetts Ave**	**#2ALP_**	**Compacted, Dry**																						
	Sample 1 South side between yews and ash trees, can not get past 20", Compacted			42.397815	-71.131352	**0-12**			Very dry, silty loam	8:42 AM	80		no breeze, flags are not flying	Beds		Ash & Yews		Healthy/Alive			Compacted	Extremely Dry	76	Silty Loam	yes
	Use to be a railroad in 19th c, then became extention of the red line from Harvard to Alewife						**12-24**		Very dry, silty loam, can not get past 20", might be hitting the roof of the subway.													Extremely Dry		Silty Loam	
	Sample 2			42.397809	-71.131418	**0-12**			Very dry, silty loam					Beds		Ash & Yews		Healthy/Alive				Extremely Dry	80	Silty Loam	
							12-24		Very dry, silty loam, can not get past 20", might be hitting the roof of the subway.													Extremely Dry		Silty Loam	
	Sample 3			42.397832	-71.13138	**0-12**			Very dry, silty loam					Beds		Ash		Healthy/Alive				Extremely Dry	78	Silty Loam	
							12-24		Very dry, silty loam, can not get past 20", might be hitting the roof of the subway.													Extremely Dry		Silty Loam	
	Sample 4 40' ash growing in 20" depth of soil ontop of subway			42.397734	71.131207	**0-12**			Very dry, silty loam					Beds		Ash	Old	Healthy/Alive				Extremely Dry	77	Silty Loam	
							12-24		Very dry, silty loam, can not get past 20", might be hitting the roof of the subway.													Extremely Dry		Silty Loam	
	Sample 5			42.397852	-71.131223	**0-12**			Very dry, silty loam					Beds		Ash		Healthy/Alive				Extremely Dry	79	Silty Loam	
							12-24		Very dry, silty loam, can not get past 20", might be hitting the roof of the subway.													Extremely Dry		Silty Loam	
3	**Cambridgepark Drive**	**#3CPD_**	**Inconsistent soil, poor drainage, getting wetter going down**																						
	Sample 1 - Maple Tree Half dead, half of bark gone/damaged			42.394892	-71.144066	**0-12**			Tree will die soon,severe bark damage, sandy loam, extremely dry	12:00	103		slight breeze	Pit		Maple		1/2 dead			not compacted, but could only go to 24"	Extremely Dry	86	Sandy Loam	yes
							12-24		Getting wet as we go down													More Moisture			
								24-36	Wet, sandy loam													Very Wet		Sandy Loam	
	Sample 2 - Maple dying, yellow leaves, damaged bark, planted too high			42.394654	-71.143958	**0-12**			Extremely Dry, Sandy Loam, Leaves turning yellow, irrigation line evident, planted too high and damaged bark.	12:05			slight breeze	Pit		Maple		Dying				Extremely Dry	92	Sandy Loam	yes
							12-24		Getting wetter													More Moisture		Sandy Loam	
								24-36	Hit too much rock only went down to 28"															Rocks	
	Sample 3 - Maple tree suffering, yellow leaves with brown edge, bark not bad, roots exposed			42.394661	-71.143893	**0-12**			Extremely Dry, Sandy Loam, Leaves turning yellow, Roots exposed, planted too high	12:17			slight breeze	Pit		Maple		Dying				Extremely Dry	86	Sandy Loam	yes
							12-24		Getting wetter													More Moisture		Sandy Loam	
								24-36	Very wet - could only go to 30" hit rock													Very Wet		Rocks	
	Sample 4 - Maple tree suffering, yellow leaves with brown edge, bark not bad, roots exposed, no sign of irrigation			42.394626	-71.143823	**0-12**			Extremely dry sandy loam.Planted high, see roots, no irrigation, leaves browning at the edges, not happy	12:27			slight breeze	Pit		Maple		Dying				Extremely Dry	86	Sandy Loam	yes
							12-24		Getting wetter, Hitting rocks at 21", can not dig down any further													More Moisture		Rocks	
								24-36	Hit rock so could not take any samples from this depth															Rocks	
	Sample 5 -Maple tree mostly dead, only a few leaves left, planted high, no irrigation			42.394753	-71.143646	**0-12**			Tree Dead, 20 leaves left. Extremely dry sandy loam.Planted high, see roots, no irrigation, leaves browning at the edges, not happy	12:45			slight breeze	Pit		Maple		1/2 dead				Extremely Dry	86	Sandy Loam	yes
							12-24		Hit rocks at 24"													Extremely Dry		Rocks	
	Next maple tree lost all its bark							**24-36**	Hit rock so could not take any samples from this depth															Rocks	

Cambridge Urban Tree Canopy

Data Collected by F2 Environmental Design

#	Site Location	Photo ID	Summary of 5 Sample Locations per site	Latitude	Longitude	Horizon 0-12	Horizon 12-24	Horizon 24-36	Visual Description	Environmental Conditions	Air Temperature	Relative Humidity	Wind Conditions	Pit	Park	Tree Type	Old or Young	Healthy/Alive / Dead	Irrigation	Drainage	Compaction	Soil Moisture	Soil Temp	Based on observation Sand or Clay	Photos Taken
4	**Fresh Pond, off Concord Ave, between Wheeler and Faucet**	**#4FPOCA_**	**Nice soil gradation, Nice soil all around**																						
	Sample 1 - in the woods, just enter the park, before the gate hope the side barriers and in 30'			42.388513	-71.144628	**0-12**			Sandy loam, top 6" had the most loam, progressively sandier as we go down, nice moisture. Perfect more moisture at the top, as you go down and it gets sandier it also has less moisture - perfect, smelled very good	2:50	107		slight breeze		Park/Woods	Woods		Healthy			No compaction, rocks at 24"	good moisture	70	Sandy Loam	yes
							12-24		Sandier, Rocks at 24"															Sandier Loam	
								24-36	Sandier,nice texture, less moisture,															Sandier Loam	
	Sample 2 - nice leave matter on the forest floor, amazing tall sycamore and ash trees			42.388827	-71.144711	**0-12**			Loamy, 6" -good amount of organic matter, 6" we are hitting sand	3:13			slight breeze		Park/Woods	Sycamore	Old	Healthy				good moisture	67	Sandy Loam	
							12-24		Sandier but can only get down to 24"															Sandier Loam	
								24-36	Rocks at 24" - used post hole digger to get down past the 24" w the rocks															Rocks	
	Sample 3 - nice leave matter on the forest floor, amazing tall sycamore and ash trees			42.388692	-71.144963	**0-12**			Loamy, 6" -good amount of organic matter, 6" we are hitting sand						Park/Woods	Sycamore & Ash	Old	Healthy						Sandy Loam	
							12-24		Sandier but can only get down to 24"															Sandier Loam	
								24-36	Rocks at 24" - used post hole digger to get down past the 24" w the rocks															Rocks	
	Sample 4 - nice leave matter on the forest floor, amazing tall sycamore and ash trees			42.388538	-71.14494	**0-12**			Loamy, 6" -good amount of organic matter, 6" we are hitting sand						Park/Woods	Sycamore & Ash	Old	Healthy						Sandy Loam	
							12-24		Sandier but can only get down to 24"															Sandier Loam	
								24-36	Rocks at 24" - used post hole digger to get down past the 24" w the rocks															Rocks	
	Sample 5 - Amazing sycamore 4' diameter, lots of exfoliating bark on the forest floor			42.388563	-71.144999	**0-12**			Loamy, 6" -good amount of organic matter, 6" we are hitting sand						Park/Woods	Sycamore & Ash	Old	Healthy						Sandy Loam	
							12-24		Sandier but can only get down to 24"															Sandier Loam	
								24-36	Rocks at 24" - used post hole digger to get down past the 24" w the rocks															Rocks	
									Incredible large sycamore 4' diameter, bark everywhere on the forest floor																
5	**Danehy Park Sherman St entrance, 2nd parking lot entrance**	**#5DP_**	**Very compacted soils**																						
	Sample 1 Park on landfill which closed in the 70's, capped at 22" below the surface of the park soil			42.388701	-71.134339	**0-12**			Compacted, good level of moisture, 2.5" of root growth on turf, Sandy loam in the top 6", then sand	Hot	96	Humid	Breeze		Park	lawn					Very Compacted	Good moisture	78	Sandy Loam	yes
							12-24		Sandy, 21" hitting stone, was able to get to 24" w post hole digger but no further															Sand	
								24-36	Concrete at 22-24" -no samples																
	Sample 2 - sample taken around the maple trees and picnic table			42.38863	-71.134627	**0-12**			Compacted, good level of moisture, 2.5" of root growth on turf, Sandy loam in the top 6", then sand						Park	Maple	Young				Good moisture		Sandy Loam	
							12-24		Sand															Sand	
								24-36	Concrete at 22-24" -no samples																
	Sample 3 -			42.388669	-71.13487	**0-12**			Loamy top 4-6", below that is sand						Park	lawn					Good moisture		Sandy Loam	
							12-24		Sand															Sand	
								24-36	Concrete at 22-24" -no samples																
	Sample 4			42.388506	-71.134781	**0-12**			Loamy top 4-6", below that is sand						Park	lawn					Good moisture		Sandy Loam	
							12-24		Sand															Sand	
								24-36	Concrete at 22-24" -no samples																
	Sample 5			42.388511	-71.13461	**0-12**			Loamy top 4-6", below that is sand						Park	lawn					Good moisture		Sandy Loam	
							12-24		Sand															Sand	
								24-36	Concrete at 22-24" -no samples																
6	**Massachusetts Ave between Milton and Russel**	**#6MAMSRS_**	**Too wet, getting very wet in lower horizon, anaerobic**																						
6:49pm	**Sample 1** -In Front fof Waxing the City, Elm 4" cal, cracked trunk at 12", no waterbag			42.392461	-71.124783	**0-12**			Sandy Loam w silt, pocket of sand at 10", Dry	Dark Street Lights	88	Humid	slight breeze	Tree Pit		Elm		Damaged/Crack Trunk			Compaction is not bad	Dry	80	Sandy Loam	yes
							12-24		Sandy Loam with considerable amount of silt		88	Humid	slight breeze											Sandy Loam	
								24-36	Sandier		88	Humid	slight breeze											Sandier Loam	
	Sample 2 - Between Waxing the City and Rockler Hardware			42.392295	-71.124795	**0-12**			Weeds at base, Elm, No Tree Bag, Seeing roots, Sandy Loam, Not Dry	Dark Street Lights	88	Humid	slight breeze	Tree Pit		Elm		Alive			Compaction is not bad	Moisture	80	Sandy Loam	yes, site
							12-24		Sandy Loam but getting wetter		88	Humid	slight breeze									More Moisture		Sandy Loam	
								24-36	Sandy, wet, smelling anaerobic		88		slight breeze									Very Wet		Sandier Loam	
	Sample 3 - Just in front of the corner of Rockler Hardware			42.392367	-71.124589	**0-12**			Weeds at base, Elm, No Tree Bag, Seeing roots, Sandy Loam, Not Dry					Tree Pit		Elm		Alive				Moisture		Sandy Loam	
							12-24		Sandy, Getting Wetter													More Moisture		Sandy Loam	
								24-36	Sandy, wet, smelling anaerobic													Very Wet		Sandier Loam	
	Sample 4 - In front of Super Cuts Hair salon, Elm Dead, no leaves			42.392183	-71.124586	**0-12**			Tree is dead, might be an elm, weeds, dry, sandy loam	Pitch Black				Tree Pit		Elm		Dead			Compaction is not bad	Dry	80	Sandy Loam	yes seve
							12-24		Dry Sandy loam													Dry		Sandy Loam	
								24-36	Sandy, getting wetter, smelling anaerobic													Very Wet		Sandier Loam	
	Sample 5 -								No more Tree wells to do on this side of street, too many utilities on the other side of the street							0									
7	**Concord Ave, between Donnell St, Appleton St, and Royal St**	**#7CABBPL_**	**Very compacted, inconsistent soil profile, getting heavier going deeper**																						
	Sample 1 Honey locust tree pit , mulch, very dry w/gravel. Trees look healthy on the street			42.383013	-71.132543	**0-12**			Sandy Loam w high percentage of gravel , extremely dry, very compacted. Can only dig into 12"					Pit		Honey Locust		Alive			Very Compacted	Extremely Dry	90	Sandy Loam + Gravel	
							12-24		No sample																
								24-36	No sample																
	Sample 2 Honey locust tree pit , mulch, very dry w/gravel. Trees look healthy on the street			42.38309	-71.132463	**0-12**			Sandy Loam w high percentage of gravel , extremely dry, very compacted.	Hot and Humid	91	Humid	tiny breeze	Pit		Honey Locust		Alive			Very Compacted	Extremely Dry	84	Sandy Loam	yes of e
							12-24		Sandy Loam, getting into clay - cake like, more moisture													More Moisture		Sandy Loam + Clay	yes of c
								24-36	Clay soil, Not to wet but sticky													Moisture		Clay	
	Sample 3 Honey locust tree pit , mulch, very dry w/gravel. Trees look healthy on the street			42.382995	-71.132085	**0-12**			Sandy Loam w high percentage of gravel , extremely dry, very compacted. Can only dig into 12" Extremely compacted. Hardto get the compaction meter in at all					Pit		Honey Locust		Alive			Very Compacted	Moisture	86	Sandy Loam + Gravel	yes
							12-24		Sandy Loam, getting into clay - cake like, more moisture													Moisture		Sandy Loam + Clay	
								24-36	Clay soil, Not to wet but sticky													More Moisture		Clay	
	Sample 4 Maple, looks healthy but soil is very dry on the top 12"			42.383061	-71.132441	**0-12**			Sandy Loam w high percentage of gravel , extremely dry, very compacted.					Pit		Maple		Alive			Very Compacted	E		Sandy Loam + Gravel	
							12-24		Sandy Loam, getting into clay - cake like, more moisture													Moisture		Sandy Loam + Clay	
								24-36	Clay soil, Not to wet but sticky													More Moisture		Clay	
	Sample 5 Tilia Cordata, Dry w gravel/1/2 mulch 1/2 permeable mat			42.383296	-71.132669	**0-12**			Sandy Loam w high percentage of gravel , extremely dry, very compacted.					Pit		Tilia Cordata		Alive			Very Compacted	E		Sandy Loam + Gravel	
							12-24		Sandy Loam, getting into clay - cake like, more moisture													Moisture		Sandy Loam + Clay	
								24-36	Clay soil, Not too wet but sticky													More Moisture		Clay	
8	**Fayerweather St between Brattle and Resevoir**	**#8FSBSRS_**	**Poor drainage soils very wet at 24" to 36" depth**																						
	Sample 1 - Honey Locust 30" cal, grass below			42.377888	-71.137608	**0-12**			Sandy, Dry	Hot and Humid	81	Humid	Still	Long Bed w pervious sidewalk by tree		Honey Locust	30"	Healthy			Not to compacted but rocky	Dry	80	Sand	yes

	Cambridge Urban Tree Canopy																								
	Data Collected by F2 Environmental Design					Horizon	Horizon	Horizon																	
#	Site Location	Photo ID	Summary of 5 Sample Locations per site	Latitude	Longitude	0-12	12-24	24-36	Visual Description	Environmental Conditions	Air Temperature	Relative Humidity	Wind Conditions	Pit	Park	Tree Type	Old or Young	Healthy/Alive / Dead	Irrigation	Drainage	Compaction	Soil Moisture	Soil Temp	Based on observation Sand or Clay	Photos Taken
							12-24		Sandy, Dry, Rocky - stones and some concrete													Dry		Sand + Rocks	
								24-36	Sandy, Gravel, Stones - can only go down 31" hit a big rock													Dry		Sand + Rocks	
	Sample 2 - North of Honey Locust in lawn - not good root growth of lawn			42.378041	-71.137713	0-12			Low organic matter, surprised not finding roots, Sandy, Dry					Long Bed w pervious sidewalk by tree		Honey Locust		Healthy				Dry		Sandy Loam	
							12-24		Sandy, Rocky, Roots we are hitting do not look healthy													Dry		Sand + Rocks	
								24-36	If this is structural soil - it has rocks that are too big													Dry			
	Sample 3 - South of Ginkgo tree in lawn - root growth of grass is not good			42.378277	-71.137674	0-12			Sandy, Hit RC (reclaimed maccadam at 12")	Hot and Humid			Still	Long Bed w pervious sidewalk by tree		Ginkgo		Healthy			Not compacted till you hit the RC	Dry	80	Sand, Silt + Clay at 20"	yes
							12-24		No Sample - could not dig down further																
								24-36	No Sample - could not dig down further																
	Sample 4 - North of Ginkgo tree , sample in lawn -root growth of grass not good, 3"			42.378347	-71.137677	0-12			Sandy	Hot and Humid			Still	Long Bed w pervious sidewalk by tree		Gingko	3"	Healthy			Not compacted till you hit the RC	Dry	80	Sand	yes
							12-24		Pure Gravel at 18"													Dry		Gravel	
								24-36	24" hit wet silty material, like riverbed, does not have an anaerobic odor, totally saturated at 36"													Dry till 36" it is totally saturated xxx		Gravel	
	Sample 5 - Katura tree, - Recently planted, 2.5 cal, mulch, concrete sidewalk			42.378247	-71.137538	0-12			Sandy Soil Dry	Hot and Humid			Still	Long Bed w pervious sidewalk by tree		Katsura	2.5"	Healthy			Not compacted till you hit silt and gravel, suppose to be structural soil, butt his is not meeting spec	Dry	80	Sandy Loam	yes
							12-24		Hitting Silty soil, Terrible soil at 20"													Moisture		Silt	
								24-36	Getting wetter and heavier as we go down													More Moisture		Silt & Clay at 20"	
9	Massachusetts Ave between Prentiss and Garfield	#9MAPG_	Extremely compacted and dry																						
5:40pm	Sample 1 - In front of yellow house			42.384265	-71.119606	0-12			Tree Pit 45x66, Dry, Compacted, Sandy Loam, Very Compacted	Dusk, getting a bit cooler	95	Humid	slight breeze	Tree Pit		Oak		Alive			Very Compacted	Dry	86	Sandy Loam	
							12-24		Tree Pit 45x66, Dry, Compacted, Sandy Loam		95	Humid	slight breeze								Very Compacted	Dry		Sandy Loam	
								24-36	Tree Pit 45x66, Dry, Compacted, Sandy Loam		95	Humid	slight breeze								Very Compacted	Dry		Sandy Loam	
	Sample 2 - In front of Caldwell Banker Residential Broker			42.38419	-71.11957	0-12			Tree Pit Pin Oak Dry, Compacted, Sandy Loam		95	Humid	slight breeze	Tree Pit		Oak		Alive			Very Compacted	Dry		Sandy Loam	
							12-24		Tree Pit Pin Oak Dry, Compacted, Sandy Loam		95	Humid	slight breeze								Very Compacted	Dry		Sandy Loam	
								24-36	Tree Pit 46x140"Pin Oak Dry, Compacted, Sandy Loam, only to 26" - lots of red marks on the sidewalk west side of Mass Ave		95	Humid	slight breeze								Very Compacted	Dry		Sandy Loam	yes
	Sample 3 -In front of Junior Auto and as No Tree but a shoot of some tree coming back			42.384116	-71.119333	0-12			Sandy & Silty Loam		95	Humid	slight breeze	Tree Pit		No Tree		Dead				Very Dry		Sandier Loam	
							12-24		Sandy & Silty Loam - Soil falls out of probe - it is so dry		95	Humid	slight breeze									Extremely Dry		Sandier Loam	
								24-36	Sandy & Silty Loam, hit concrete at 30"		95	Humid	slight breeze									Extremely Dry			
	Sample 4 - In front of University Wine Shop			42.384386	-71.119335	0-12			Very Dry, Silty, Fine, Honey Locust (Gleditsia Triacanthos) Water bag on it		95	Humid	slight breeze	Tree Pit		Honey Locust		Alive				Very Dry	90		yes seve
							12-24		So dry it falls out of the soil probe		95	Humid	slight breeze									Extremely Dry			
								24-36	Dry, Sandy, hit concrete at 30"		95	Humid	slight breeze									Extremely Dry		Sand	
	Sample 5								No sample taken because no more tree wells to do																
10	Between Waterhouse and Garden Street -	#10CCP_	Nice Profile Texturally																						
4:00pm	Sample 1 - Mass Ave, Watertown Street			42.377679	-71.120529	0-12			hitting rocks and roots, seams to be a subtantial amount of organic matter	Clear, Intense Heat, Dry Soil	102	Humid	slight breeze		Lawn	Lawn		Healthy			Compacted	Dry	82	Sandy Loam	yes
							12-24		less organic at 18", silt		102	Humid	slight breeze											Sandy Loam	yes
								24-36	Sandy		102	Humid	slight breeze											Sandy Loam	yes
	Sample 2			42.377425	-71.120315	0-12			Sandy loam, nice quality of soil, very compacted		102	Humid	slight breeze		Lawn			Healthy			Very Compacted	Dry	78	Sandy Loam	
							12-24		Sandy loam, nice quality of soil, dry, rock stuck in probe, 20" it started to get sandier		102	Humid	slight breeze											Sandy Loam	
								24-36	Sandy, Nice course sand		102	Humid	slight breeze											Sandy Loam	
	Sample 3			42.377178	-71.120284	0-12			Nice organic matter, typical sandy loam		102	Humid	slight breeze		Lawn			Healthy			Not Compacted		80	Sandy Loam	
							12-24		Org loam, Pocket of sand at 15"		102	Humid	slight breeze											Sandier Loam	
								24-36	Sandier at 24", nice course sand, stone at 30"		102	Humid	slight breeze											Sand	
	Sample 4			42.377012	-71.120517	0-12			Typical sandy loam,a little moisture, tending toward dry, Compaction starting 8" down		102	Humid	slight breeze		Lawn			Healthy			Compacted	little moisture	77.5	Sandy Loam	yes in T
							12-24		Typical sandy loam, a bit more sand at 22"		102	Humid	slight breeze											Sandier Loam	
								24-36	Very sandy		102	Humid	slight breeze											Sand	yes w b
	Sample 5			42.376957	-71.120294	0-12			Typical sandy loam		102	Humid	slight breeze		Lawn			Healthy			Not So Compacted			Sandy Loam	
							12-24		Start hitting sand at 14"		102	Humid	slight breeze											Sandier Loam	
								24-36	sandy but more moisture		102	Humid	slight breeze									More Moisture		Sand	
11	Hew St, between Western Ave and Calendar St	#11HSWACS_	Good soil moisture going down. Fairly nice consistent sandy loam. Some nice healthy trees																						
	Sample 1 - Maple tree , 4x12' tree pit, concret sidewalks, Dieback on two of the three major limbs, tree is failing			42.364927	-71.112594	0-12			Sandy Loam, very dry	Hot and Humid			Little breeze	Pit, black macadam sidewalk by tree		Maple					Not compacted	Very Dry	80	Sandy Loam	yes
							12-24		Sandy Loam, very dry, hit a large stone at 22"													Very Dry		Sandy Loam	
								24-36	No sample taken - Hit rocky compacted area																
	Sample 2 - Sumac tree 18" cal, dry			42.36527	-71.112938	0-12			Top 6" dry, then 6-12 has more moisture, Sandy loam	Hot and Humid			Little breeze			Sumac	Amazing Old	large trees,large canopy stretched over the road			Not compacted	Dry	88	Sandy Loam	yes
							12-24		Sandy loam, nice roots, some moisture													Moisture		Sandy Loam	
								24-36	Hitting roots at 29",silty clay sticky, more moisture, can not dig down further													More Moisture		Silt & Clay	
	Sample 3 - Sumac tree 24" cal, dry, tree pit 3x9', macadam rest of sidewalk			42.36521	-71.11277	0-12			Gravel and stone dust					Pit		Sumac					Dry		Gravel	
							12-24		Gravel, Sandy, dry, Can only dig to 18"	Hot and Humid			Little breeze								Compacted	Dry	80	Gravel and sand	yes
								24-36	No sample taken - Hit rocky compacted area																
	Sample 4			42.36522	-71.112809	0-12			Sandy loam, nice roots, some mycorhizsel development,Top dry some moisture at 6"													Dry		Sandy Loam	
							12-24		Sandy Loam a little bit of moisture,	Hot and Humid			Little breeze								Not compacted	Moisture	80	Sandy Loam	
								24-36	Sandy Loam, very dry, w chunks of macadam at 29"													Very Dry		Sandy Loam + Macadam	
	Sample 5			None taken					No sample taken - Hit rocky compacted area																

	Cambridge Urban Tree Canopy																									
	Data Collected by F2 Environmental Design					Horizon	Horizon	Horizon																		
#	Site Location	Photo ID	Summary of 5 Sample Locations per site	Latitude	Longitude	0-12	12-24	24-36	Visual Description	Environmental Conditions	Air Temperature	Relative Humidity	Wind Conditions	Pit	Park	Tree Type	Old or Young	Healthy/Alive / Dead	Irrigation	Drainage	Compaction	Soil Moisture	Soil Temp	Based on observation Sand or Clay	Photos Taken
12	**DCR, Magazine Beach, between Magazine St and Overpass**	**#12DCRMB_**	**Very compacted sandy dry soils**																						
	Sample 1 -West of Carpinus grove and closer to oak tree, cooler spot, less dry, nice breeze			42.355875	-71.114685	**0-12**			Sandy loam, good moisture slightly on the dry side, oaks look great	Cooler under the trees			Breeze		Park	Carpinus	Young	Alive	None		Very Compacted	Moisture	76	Sandy Loam	Yes
	Highly compacted in the entire area. Barely can get compaction meter down 2"						**12-24**		Sandy loam but at 22-24 a sandier texture,															Sandy Loam	
								24-36																Sandier Loam	
	Sample 2 - In between Carpinus grove, Could not get compaction meter in 2" of soil			42.355604	-71.114608	**0-12**			Sandy loam but drier,high percentage of rocks, very compacted, carpinus trees look alright				Breeze		Park	Carpinus	Young	Alive	None		Very Compacted	Dry	76	Sandy Loam + Rocks	Yes
							12-24		Sandier and drier, high percentage of rocks													Very Dry		Sandy Loam + Rocks	
								24-36	So many rock, hard to go past 28", at 36" hit a very dry silt - feels like powder													Extremely Dry		Rocks	
	Sample 3 - By walkway and oak tree 36" diameter, Could not get compaction meter in 2" of soil			42.355605	-71.114632	**0-12**			Closer to walkway and oak tree, Highly compacted here but entire area, dry, sandy loam				Breeze		Park	Oak	Old	Alive	None		Very Compacted	Dry	78	Sandy Loam	
							12-24		Sandier and drier, high percentage of rocks													Very Dry		Sandy Loam	
								24-36	So many rock, hard to go past 28", at 36" hit a very dry silt - feels like powder													Extremely Dry		Rocks	
	Sample 4 - By park bench, lots of acorns, close to amazing sycamore 5' diameter			42.355772	-71.114748	**0-12**			Closer to walkway and oak tree, Highly compacted here but entire area, dry, sandy loam						Park	Sycamore	Old	Alive	None			Dry	78	Sandy Loam	
							12-24		Sandier and drier, high percentage of rocks													Very Dry		Sandy Loam + Rocks	
								24-36	So many rock, hard to go past 28", at 36" hit a very dry silt - feels like powder													Extremely Dry		Rocks + Silt	
	Sample 5 - by the walkway, highly compacted and dry			42.355858	-71.114626	**0-12**			Closer to walkway and oak tree, Highly compacted here but entire area, dry, sandy loam						Park	Oak & Lawn	Old		None			Dry	78	Sandy Loam	
							12-24		Sandier and drier, high percentage of rocks													Very Dry		Sandy Loam + Rocks	
								24-36	So many rock, hard to go past 28", at 36" hit a very dry silt - feels like powder,													Extremely Dry		Rocks + Silt	
13	**Corner of Pearl and Henry, between Tufts St and Glenwood Ave**	**#13PHS_**	**Compacted sandy dry soils**																						
	Sample 1 Newly planted cherry water bags on each of the stakes 2.5" caliper			42.356744	-71.111194	**0-12**			Sandy loam	Hot and humid	89	Humid	slight breeze	Pit		Cherry	Young	Alive	Water Bags on 2 stakes		Compacted	Extremely Dry	82	Sandy Loam	yes
	Tree pit is						**12-24**		Gravel at 18-24"													Extremely Dry		Gravel	
								24-36	Course Sand													Extremely Dry		Course Sand	
	Sample 2 Maple Tree 5-6" caliper, very dry and flagging, weed in bed, no water bag but snow fencing around tree			42.356732	-71.11158	**0-12**			Very sandy dry loam , Maple Tree which is flagging		89	Humid	slight breeze	Pit		Maple	Young	Flagging	Snow Fence		Compacted	Extremely Dry		Sandy Loam	yes
							12-24		Sandy and dry													Extremely Dry		Sandier Loam	
								24-36	Sandy and dry													Extremely Dry		Course Sand	
	Sample 3 Mature Maple tree,18" caliper, snow fence and 2x4 around trunk, old mulch			42.356676	-71.111297	**0-12**			Sandy and extremely dry		89	Humid	slight breeze	Pit		Maple	Mature	Alive	Snow Fence		Compacted	Extremely Dry	92	Course Sand	yes
							12-24		Sandy and extremely dry that it falls out of digger													Extremely Dry		Course Sand	
								24-36	So dry & sandy that we are having troubles getting it out because if falls out of the digger													Extremely Dry		Course Sand	
	Sample 4 Cherry 8" cal, snow fence, black mulch			42.356594	-71.111209	**0-12**			Extremely dry All sand w pebbles, No organic matter		89	Humid	slight breeze	Pit		Cherry	8"	Alive	Snow Fence		Compacted	Extremely Dry	82	Course Sand	yes
							12-24		Sand													Extremely Dry		Course Sand	
								24-36	Sand													Extremely Dry		Course Sand	
	Sample 5 Maple 8" cal Flagging, snow fence, no mulch, planted in straight course sand, no organic matter at all, totally compacted			42.35684	-71.111102	**0-12**			Extremely dry, planted in only course sand, no mulch		89	Humid	slight breeze	Pit		Maple	8"	Flagging	Snow Fence		Very Compacted	Extremely Dry	80	Course Sand	yes
							12-24		Extremely dry, planted in only course sand													Extremely Dry		Course Sand	
								24-36	Extremely dry, planted in only course sand													Extremely Dry		Course Sand	
14	**Tremont St, between Garden St and Broadway**	**#14TS_**	**Very dry compacted soils**																						
	Sample 1 - Honey Locust 12"cal , tiny pit 3x5 and no mulch, surrounded by brick walkways			42.369315	-71.099756	**0-12**			Extremely Dry, Sand	Clouds with pockets of blue sky			Breeze	Pit		Honey Locust	12"	Alive	None		Compacted	Extremely dry	79	Sand	Yes
							12-24		Sand, very dry													Extremely dry		Sand	
								24-36	Sand, very dry													Extremely dry		Sand	
	Sample 2 - Tilia 12" cal, tiny pit, no much, brick sidewalks			42.36923	-71.099502	**0-12**			Extremely Dry, Sand	Clouds with pockets of blue sky			Breeze	Pit		Tilia	12"	Alive	None		Compacted	Extremely dry	79	Sand	Yes
							12-24		Sand, very dry													Extremely dry		Sand	
								24-36	Sand, very dry													Extremely dry		Sand	
	Sample 0 - No tree in this pit but there are a few perennials, in front of Temple, see wire basket in the hole			42.369493	-71.099695	**0-12**			No samples taken because they backfilled with another soil					Pit		No tree/ Perennials									
	Sample 3 - Tilia cordata, no mulch, bad pruning around elec lines			42.369719	-71.09927	**0-12**			Extremely Dry, Sandy loam	Clouds			Breeze	Pit		Tilia cordata					Compacted	Extremely dry	80	Sand	Yes
							12-24		Sand, very dry													Extremely dry		Sand	
								24-36	Sand, very dry													Extremely dry		Sand	
	Sample 4 - Tilia cordata, no mulch			42.369801	-71.099354	**0-12**			Extremely Dry, Sandy loam	Clouds			Breeze	Pit		Tilia cordata					Compacted	Extremely dry	82	Sand	Yes
							12-24		Sand, very dry													Extremely dry		Sand	
								24-36	Sand, very dry													Extremely dry		Sand	
	Sample 5 - Tilia cordata, no mulch			42.369809	-71.099273	**0-12**			Extremely Dry, Sandy loam	Clouds			Breeze	Pit		Tilia cordata					Compacted	Extremely dry	80	Sand	Yes
							12-24		Sand, very dry													Extremely dry		Sand	
								24-36	Sand, very dry													Extremely dry			
15	**Sennott Park, Corner of Broadway and Norfolk St**	**#15SP_**	**Nice soil profile going down through profile. Some nice trees - a great oak**																						
	Sample 1 - Under a Tilia cordata,18" cal, looks healthy, new mulch, very compacted			42.368622	-71.099416	**0-12**			Tilia cordata, hit red tape a 12", moved over 12", Sandy loam, dry, Hitting sand at 18"	Clouds and blue sky, nice Temp	84		No breeze	Pit		Tilia Cordata	18"	Alive	None		Compacted	Dry	76	Sandy Loam	yes
							12-24		Sandy and dry													Dry		Sandier Loam	
								24-36	All sand													Dry		Sand	
	Sample 2 - In the lawn behind the bench and roses			42.368509	-71.099342	**0-12**			Sandy loam	Clouds and blue sky	80		No breeze		Park	Lawn			None		Compacted	good moisture leve	80	Sandy Loam	Yes
							12-24		Hitting straight sand at 20"													Good moisture level		Sandy Loam	
								24-36	More moisture still sandy	Cloudy	80		Breeze								Compacted	good moisture leve	76	Sand	Yes
	Sample 3 - Under a spectacular oak but 17' outside of the mulch area			42.368466	-71.099447	**0-12**			Sandy Loam, Hitting sand at 10"						Park	Oak	17"	Alive	None					Sandy Loam	
	Biochar mixed into mulch under oak						**12-24**		At 12" hit straight sand with 3/8" gravel															Sand + Gravel	
								24-36	Course Sand															Course Sand	
	Sample 4 - Between a Amelanchier and Tilia Cordata by the sidewalk			42.36842	-71.099095	**0-12**			Sandy loam	Clouds with pockets of blue sky			Breeze		Park	Amelanchier & Tilia		Alive	None		Compacted	Dry	78	Sandy Loam	Yes
							12-24		Hit Sand at 18"													Dry		Sand	
								24-36	Course Sand													Dry		Course Sand	
	Sample 5 - Under Tilia by the street and corner of the park entance			42.368674	-71.099355	**0-12**			Under Tilia by the street and corner of the park entance, hitting sand at 12"	Clouds with pockets of blue sky			Breeze	Pit		Tilia		Alive	None		Compacted	Dry	76	Sandy Loam	Yes
							12-24		Sandy and dry													Dry		Sand	
								24-36	Sandy and dry													Dry		Course Sand	
16	**Massachusetts Ave at Blanche St, between State and Landsdowne St**	**#16MABSS_**	**Soil getting heavier down through the profile, implying less drainage**																						
	Sample 1 - Elm, 10" cal, one grate loose in front of 290			42.362337	-71.098289	**0-12**			Sandy Loam, very dry	Cooling down, clouds rolling in, might rain	86		Breeze	Pit/Grate		Elm	10"	Alive				Very dry	77	Sandy Loam	Yes
							12-24		Total sand at 20", dry some moisture													Dry		Sand	
								24-36	Sandy moist but kind of the dry side													Dry		Sand	

	Cambridge Urban Tree Canopy																								
	Data Collected by F2 Environmental Design					Horizon	Horizon	Horizon																	
#	Site Location	Photo ID	Summary of 5 Sample Locations per site	Latitude	Longitude	0-12	12-24	24-36	Visual Description	Environmental Conditions	Air Temperature	Relative Humidity	Wind Conditions	Pit	Park	Tree Type	Old or Young	Healthy/Alive / Dead	Irrigation	Drainage	Compaction	Soil Moisture	Soil Temp	Based on observation Sand or Clay	Photos Taken
	Sample 2 - Elm, 10" cal, one grate loose in front of 282			42.362117	-71.098203	**0-12**			Sandy Loam, very dry	Cooling down, clouds rolling in, might rain	86		Breeze	Pit/Grate		Elm	10"	Alive				Dry	80	Sandy Loam	Yes
							12-24		Sandy loam,															Sandy Loam	
								24-36	at 24" hitting some clay															Clay	
	Sample 3 - Tree pit but no tree, recently removed tree			42.362235	-71.098205	**0-12**			Sandy Loam, dry		84		Breeze	Pit/Grate		Gone		Dead				Dry	89	Sandy Loam	Yes
	Two tree pits next to each other with no trees- why are they dying						**12-24**		Sandy loam, getting moisture as you go down.22-30" was all gravel	Cooling down, clouds rolling in, might rain												Moisture		Sandy Loam	
								24-36	22-30" was gravel, 30-36" was clay and gravel material															Clay and Gravel	
	Sample 4 - Tree pit w no tree, looks lilke a sandy material			42.362357	-71.098579	**0-12**			Sandy loam, higher organic than usual, not that dry	Cloudy	84		Slight breeze	Pit/Grate		Gone		Dead				Not that dry	86	Sandy Loam	Yes
							12-24		At 20" we are hitting a heavier material															Clay	
								24-36	24" hitting a heavier clay like material, Silty layer at 34"															Silt + Clay	
	Sample 5 - No more accessable tree pits. Grates could not be opened								NO SAMPLES TAKEN																
17	**Munroe St, between 5th and 3rd St**	**#17MS_**	**A lot of deliterious material, construction debris, rocks, etc.**																						
	Sample 1 - Next to an Oak tree, 20" cal, in lawn w root depth to 4"			42.365257	-71.083741	**0-12**			Sandy loam, lot of rocks , getting into a sand	Cool, Morning, Clouds and blue sky	69	No humidity			Lawn	Oak	20"	Alive				Dry	72	Sandy Loam	Yes
							12-24		Sand Dry but some moiture													Dry		Sandy Loam	
								24-36	Hitting RC and mystery white stuff, below 24" seeing construction debris													Dry		Gravel	
	Sample 2 - Honey Locust, 7" cal, Black mulch, tree pit 4.5x7, Very Compacted			42.365123	-71.083884	**0-12**			Sandy loam, very dry	Clouds and Blue sky	69	No humidit	Light breeze	Pit		Honey Locust	7"	Alive			Very Compacted	Very Dry	70	Sandy Loam	Yes
							12-24		Sandy loam, very dry												Very Compacted	Very Dry		Sandy Loam	
								24-36	Sandy loam, very dry and rocks, 30" hit too much rocks, below . In tree pits, soil is consistantly sandy and very dry, no construction debris												Very Compacted	Very Dry		Sandy Loam + Rocks	
	Sample 3 - Honey Locust, 7" cal, Black mulch, tree pit 4.5x7, too much mulch, planted too high, Very Compacted			42.365395	-71.083756	**0-12**			Sandy loam, very dry	Clouds and Blue sky	69	No humidit	Light breeze	Pit		Honey Locust	7"	Alive			Very Compacted	Very Dry	74	Sandy Loam	Yes
							12-24		Sandy loam, very dry, more stone at 20"												Very Compacted	Very Dry		Sandy Loam + Rocks	
								24-36	Sandy loam, very dry and rocks, 30" hit too much rocks, below . In tree pits, soil is consistantly sandy and very dry, construction debris at 24", broken up tile												Very Compacted	Very Dry		Sandy Loam + Rocks	
	Sample 4 - Honey Locust, 7" cal, Black mulch, tree pit 4.5x7, Very Compacted			42.365153	-71.083997	**0-12**			Sandy loam, very dry	Clouds and Blue sky	69	No humidit	Light breeze	Pit		Honey Locust	7"	Alive			Very Compacted	Very Dry	74	Sandy Loam	Yes
							12-24		Sandy loam, very dry, more stone at 20"												Very Compacted	Very Dry		Sandy Loam + Rocks	
								24-36	Sandy loam, very dry and rocks, 30" hit too much rocks, below . In tree pits, soil is consistantly sandy and very dry, construction debris at 24", broken up tile												Very Compacted	Very Dry		Sandy Loam + Rocks	
	Sample 5 - Maple tree 12" cal, lawn,Very Compacted			42.365297	-71.083663	**0-12**			Sandy loam, lot of rocks , getting into a sand, moisture levels are higher	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze		Lawn	Maple	12"	Alive			Very Compacted	Moisture	72	Sandy Loam	Yes
							12-24		Sand more moisture												Very Compacted	Moisture		Sandy Loam + Rocks	
								24-36	Hitting RC and mystery white stuff, below 24" seeing construction debris												Very Compacted			Gravel	
18	**Spring St, between Fifth St and Sciarappa St**	**#18SPOSS_**	**Heavier soils**																						
	Sample 1- Maple tree, 24" cal, no mulch			42.369338	-71.082828	**0-12**			Heavy loam	Dusk	75	Not humid	Light breeze			Maple	24"	Alive			Compacted	Moisture	80	Sandy Loam	Yes
							12-24		Heavy loam, more silt and clay															Sandy Loam + Silt + Clay	
								24-36	Heavy loam, more silt and clay,															Sandy Loam + Silt + Clay	
	Sample 2- Sumac 6" cal , Filter fabric with mulch over it			42.369201	-71.08275	**0-12**			Heavy loam with a lot of gravel	Dark			Light breeze			Sumac	6"	Alive			Compacted	Dry	82	Sandy Loam + Gravel	Yes
							12-24		Heavy loam, more silt and clay w more gravel															Sandy Loam + Silt + Clay	
								24-36	Heavy loam, more silt and clay w more gravel,															Sandy Loam + Silt + Clay	
	Sample 3- Carpinus 4" cal, weeds, no mulch			42.369221	-71.082459	**0-12**			Very Dry and Sandy loam	Dark			Light breeze			Carpinus	4"	Alive			Compacted	Very Dry	80	Sandy Loam	yes but
							12-24		Drier													Extremely dry			
								24-36	Dry													Extremely dry			
	Sample 4- Sumac 8" cal, no mulch, healthy			42.36924	-71.082227	**0-12**			Very Dry and Sandy loam	Dark			Light breeze			Sumac	8"	Alive			Compacted	Very Dry	80	Sandy Loam	Too dar
							12-24		Drier													Extremely dry			
								24-36	Dry													Extremely dry			
	Sample 5								No sample take Not able to get into another tree pit																
19	**First St and Binney St, between Edwin H Land Blvd and 1st St**	**#19FSBS_**	**Very dry compacted soils**																						
	Sample 1 - in the median, under the oak tree, Very Compacted			42.365079	-71.077163	**0-12**			Very, very dry, silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze	Median		Oak		2 Alive, 1 Flagging			Very Compacted	Extremely dry	80	Silty Loam	Yes
	3 oaks - 2 alright but third is flagging						**12-24**		Very, very dry, silty loam - and hitting large rocks and debris												Very Compacted	Extremely dry		Silty Loam	
								24-36	Could not dig further because of utility lines																
	Sample 2 Maple, Very Compacted			42.365344	-71.077411	**0-12**			Very, very dry, silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze	Median		Maple		Alive			Very Compacted	Extremely dry	80	Silty Loam	Yes
							12-24		Very, very dry, silty loam - and hitting large rocks and debris												Very Compacted	Extremely dry		Silty Loam	
								24-36	Could not dig further because of utility lines																
	Sample 3 Oaks 15" cal, weeds, no mulch, Very Compacted			42.365143	-71.078055	**0-12**			Good Moisture, silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze	Median		Oaks	15"	Alive			Very Compacted	Extremely dry	80	Silty Loam	Yes
							12-24		Very, very dry, silty loam - and hitting large rocks and debris												Very Compacted	Extremely dry		Silty Loam	
								24-36	Could not dig further because of utility lines																
	Sample 4 Oak12' cal begonias below and lawn, Very Compacted			42.365178	-71.077921	**0-12**			Very, very dry, silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze	Median		Oak		Alive			Very Compacted	Extremely dry	80	Silty Loam	Yes
							12-24		Very, very dry, silty loam - and hitting large rocks and debris												Very Compacted	Extremely dry		Silty Loam	
								24-36	Could not dig further because of utility lines																
	Sample 5 - Oak 15" cal begonias below and lawn, Very Compacted			42.364915	-71.077743	**0-12**			Very, very dry, silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze	Median		Oak	15"	Alive			Very Compacted	Extremely dry	80	Silty Loam	Yes
							12-24		Very, very dry, silty loam - and hitting large rocks and debris												Very Compacted	Extremely dry		Silty Loam	
								24-36	Could not dig further because of utility lines																

	Cambridge Urban Tree Canopy																									
	Data Collected by F2 Environmental Design					Horizon	Horizon	Horizon																		
#	Site Location	Photo ID	Summary of 5 Sample Locations per site	Latitude	Longitude	0-12	12-24	24-36	Visual Description	Environmental Conditions	Air Temperature	Relative Humidity	Wind Conditions	Pit	Park	Tree Type	Old or Young	Healthy/Alive / Dead	Irrigation	Drainage	Compaction	Soil Moisture	Soil Temp	Based on observation Sand or Clay	Photos Taken
20	**Education St in North Point between Museum Way and North Pt Blvd**	**#20ESNP_**	**Good moisture level going down through the soil**																						
	Sample 1 - Maple tree, mulched, irrigation pop up heads on the edge of the bed, Very Compacted			42.369742	-71.071007	**0-12**			Very dry sandy silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze	Pit		Maple		Alive	Pop up Head		**Very Compacted**	Extremely dry	73	Sandy Silty loam	Yes
							12-24		Very dry sandy silty loam													Extremely dry		Sandy Silty loam	
								24-36	Very dry sandy silty loam to 30" then hit concrete													Extremely dry		Sandy Silty loam	
	Sample 2 - Maple tree, mulched, irrigation pop up heads on the edge of the bed, Very Compacted			42.369386	-71.070761	**0-12**			Very dry sandy silty loam	Cool, Morning, Clouds and blue sky	69	No humidit	Light breeze		Park	Maple		Alive	Pop up Head		**Very Compacted**	Extremely dry	73	Sandy Silty loam	
							12-24		Very dry sandy silty loam													Extremely dry		Sandy Silty loam	
								24-36	Very dry sandy silty loam to 30" then hit concrete													Extremely dry		Sandy Silty loam	
	Sample 3 - Maple in tree pit w grate, mulched, aeration pipe			42.369402	-71.070829	**0-12**			Dry and sandier loam	Cool, Morning, Clouds and blue sky	69	No humidit	Windy	Pit		Maple		Alive	Aeration pipe		Not Compacted	Dry	77	Sandy Loam	Yes
							12-24		Sandy and a bit more moisture													Moisture		Sandy Loam	
								24-36	Sandy and a bit more moisture													Moisture		Sandy Loam	
	Sample 4 - Sycamore 4" cal, w water bags on two stakes, strap is too tight on trunk, should be loosened			42.369826	-71.070589	**0-12**			Sandy loam w moisture	Cool, Morning, Clouds and blue sky	70	No humidit	Windy	Pit		Sycamore	4"	Alive	Water Bag on Stakes		Not Compacted	Moisture	75	Sandy Loam	yes
							12-24		Sandy loam w moisture													Moisture		Sandy Loam	
								24-36	Sandier loam w moisture													Moisture		Sandy Loam	
	Sample 5 - Sycamore 4" cal, w water bags on two stakes, straps are fine			42.36969	-71.070351	**0-12**			Sandy loam w moisture	Cool, Morning, Clouds and blue sky	70	No humidit	Windy	Pit		Sycamore	4"	Alive	Water Bag on Stakes		Not Compacted	Moisture	75	Sandy Loam	yes
							12-24		Sandy loam w moisture													Moisture		Sandy Loam	
								24-36	Sandier loam w moisture													Moisture		Sandy Loam	

APPENDIX I: CANOPY LOSS INVESTIGATIONS

APPLIED ECOLOGICAL SERVICES
SPECIALISTS IN ECOLOGICAL SCIENCE, RESTORATION, MANAGEMENT, AND RESEARCH
21938 MUSHTOWN RD • PRIOR LAKE, MN 55372 • (952) 447-1919

Memorandum

To: Matt Soule, Stephanie Hsia, Eric Kramer – Reed Hilderbrand

From: Brandon Moore, Kim Chapman – Applied Ecological Services

Re: Cambridge – Impervious Cover and Canopy Loss Analysis (Revised)

Date: April 30, 2019

Purpose

Analysis of tree canopy change in the City of Cambridge from 2009 to 2018 revealed that tree canopy had decreased over that period (Table 1). Development of private parcels was suggested as one cause of that decrease. An indicator of this loss would be the replacement of tree canopy by impervious cover in that same period. The City requested that Reed Hilderbrand (RH) and Applied Ecological Services (AES) investigate the question: Is there an association between an increase in impervious cover and decrease in tree canopy in the City? This would suggest that development, indicated by an increase in impervious cover, was a cause of canopy loss.

Table 1. Impervious cover & tree canopy cover in 2010 and 2018

Feature	Acres
2010 Impervious Cover	2,563.8
2018 Impervious Cover	2,604.4
City-Wide Change	*40.6*
2009 Tree Canopy Cover	1,219.7
2018 Tree Canopy Cover	1,056.3
City-Wide Change	*-163.4*

Methods

The question was answered by comparing the change in impervious cover over time at specific locations to the change in tree canopy cover over that same time period at the same locations. In other words, where impervious cover increased, was there a decrease in canopy cover?

AES obtained the 2009 canopy cover layer from the City of Cambridge and created the 2018 canopy cover layer from 2017-2018 aerial imagery. Impervious cover layers were obtained from Reed Hilderbrand for 2018 and the City of Cambridge for 2010. Both impervious cover datasets were natively a polygon ESRI shapefile and separated into classes of Impervious-Other, Impervious-Paved Surface, Impervious-Structure, and Impervious-Surface.

The two impervious datasets were joined together in ArcMap using the union tool, resulting in an impervious change layer in GIS. The following new fields were added to the impervious change layer:

- ImpTyp2010 (impervious cover type in 2010 as pavement or structure);
- ImpTyp2018 (impervious cover type in 2018 as pavement or structure);
- ImpervChan (equals a gain, loss, or no change in impervious type);
- ClassComb (combination of the ImpervChan and ImpTyp2018 fields);
- area2_ac (area of the resulting polygon in acres);
- area2_m2 (area of the resulting polygon in square meters).

The ImpervChan field was determined by comparing the ImpTyp2010 and ImpTyp2018 fields. A value of "No Change" was assigned if ImpTyp2010 and ImpTyp2018 were the same value. If ImpTyp2010 changed from "Pervious" to "Pavement" in ImpTyp2018 a value of "Gain" was assigned to the ImpervChan field. When the ImpTyp2010 changed from "Pavement" to "Pervious" in 2018, the ImpervChan field was set to "Loss". This resulted in three categories of impervious cover change from the 2010 to 2018 period: Gain, No Change, and Loss.

To determine the effect the change in impervious cover from 2010 to 2018 had on the change in tree canopy, the Tree Canopy Change layer was overlaid on the Impervious Change layer. The Tree Canopy Change layer had been created previously for the 2009-2018 period. The canopy extent layers for the beginning and ending years of the period were joined using the ArcMap Union tool. This resulted in the identification of three categories of tree canopy change: Gain, No Change, and Loss.

All instances of Gain in the Impervious Change layer were identified and all polygons from the Tree Canopy Change layer that touched the identified Impervious Change layer polygons were selected using the Select-By-Location ArcMap tool. This step identified all Tree Canopy Change layer polygons that were associated with a gain in the impervious cover. The total area in acres was then calculated for each change category, for example, "Canopy Gain + Increased Impervious Cover". This process was repeated for the No Change and Loss categories of the Impervious Change layer and the Tree Canopy Change layer. There were six change categories (Table 1).

In the development of this method, it was discovered that one of the analysis steps was open to processing error. It became necessary to add a step in which the "Gain", "Loss", or "No Change" polygons in the Tree Canopy Change layer were selected before using the Select-By-Location ArcMap tool, so that the Summary Statistics ArcMap tool included all tree canopy polygons. Unless this step is taken, overlaying Tree Canopy Gain with Impervious Cover does not select all Tree Canopy No Change polygons associated with an increase in impervious cover.

The character of the available impervious cover data and the GIS data processing mechanics overestimated acres of canopy change. One source of this error is in the impervious cover mapping, which appeared to be more accurate in the 2018 than in the 2010 GIS dataset. The 2010 and 2018

impervious cover layers often differed by only a small degree, producing more intersections of new impervious cover with tree canopy than would have occurred had the 2010 mapping been as accurate as the 2018. A typical situation occurred in a revision to an existing impervious area, such as a sidewalk or parking lot. Often the impervious cover polygon was enlarged slightly, presumably using more accurate aerial imagery and mapping techniques. This increased the likelihood that a gain in impervious cover would intersect a change in tree canopy cover.

To check whether this source of overestimate affected the study findings, AES analyzed canopy-impervious cover change after removing all polygons of impervious cover that were smaller than $6m^2$. The results of the analysis of the full dataset, discussed below, were not significantly different after the small polygons were removed, suggesting this source of error would not affect the overall conclusions drawn from the analysis.

A second source of error was due to the mechanics of the GIS analysis. Because a single polygon in the Tree Canopy Change layer may intersect multiple polygons of an Impervious Change layer, and because the entire Tree Canopy Change polygon is used to calculate the acreage of change, portions of Tree Canopy Change polygons may be counted more than once and used in the acreage totals for a change category. This double-counting of canopy acres in different impervious cover change categories likely affected all categories of change about the same due to the large number of polygons involved and their city-wide distribution.

A final source of error could result from the different starting year for impervious cover and canopy cover layers: 2010 versus 2009. The difference this single year made, however, is likely minimal given that development had virtually stopped in the 2008-2009 period during the Great Recession.

Findings

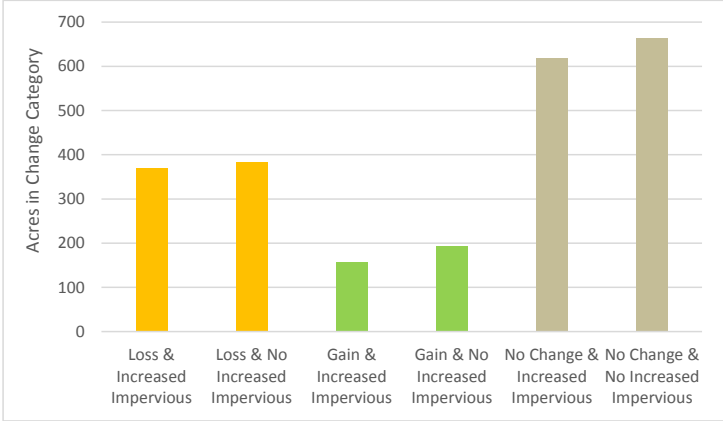
Tree canopy loss in the 2009-2018 period did not appear to be associated with changes in impervious cover (Table 2, Figure 1). The acres of canopy loss were about the same whether impervious cover increased or did not increase. Where impervious cover did not increase, the loss was 3 percent greater than where impervious cover had increased. Similarly, areas of no change in canopy cover did not differ much between locations where impervious cover had increased or not increased. Where there was no increase in impervious cover, the area of no change in tree canopy was 7 percent higher than where impervious cover had increased.

For locations showing a tree canopy gain, however, there was a noticeable difference between acres where impervious cover increased and where it did not. Where impervious cover did not increase, the tree canopy gain was 24 percent greater than where impervious cover increased.

Table 2. Acres in categories of canopy change with impervious cover change, 2009-2018

Change Category	Acres 2009-2018
Loss & Increased Impervious	370.6
Loss & No Increased Impervious	382.9
Gain & Increased Impervious	156.3
Gain & No Increased Impervious	193.6
No Change & Increased Impervious	619.6
No Change & No Increased Impervious	664.4

Figure 1. Acres in categories of canopy change with impervious cover change, 2009-2018



Discussion

Canopy Loss Not Obviously Associated with Impervious Cover Increase. From the findings, it is reasonable to conclude that tree canopy *loss* is not directly associated with increases in impervious cover, since canopy loss was about the same regardless of the change in impervious cover. Overall, impervious cover in Cambridge increased 1.6 percent from 2010 to 2018, while in the same period the city-wide tree canopy cover fell by 13.4 percent. If tree canopy loss were disproportionately due to new or expanded impervious cover, we would expect to see more acres of canopy loss associated with new and expanded impervious cover. This was not the case.

Certainly, development can reduce tree canopy cover, but the large decrease in tree canopy over a decade suggests that other factors are at work. A visual scan of air photos detected several large areas of new impervious cover where canopy loss had occurred between 2009 and 2018. This suggests that

large areas of new impervious cover might be associated with more canopy loss than small areas of new impervious cover.

On the other hand, impervious cover can increase without canopy loss; some 156 acres of expanded tree canopy were associated with impervious cover increases. Examples of this situation are where turf is paved to extend a parking lot or expand a basketball court, and no trees are affected.

More Canopy Gain Perhaps Associated with No Impervious Cover Increase. Tree canopy cover increased 24 percent more where impervious cover did not increase compared to where it did increase. This may suggest that where impervious cover is not modified, the tree canopy has a greater potential to grow without interruption, but it must be remembered that this analysis merely indicates correlation, not causation.

A reasonable follow-up to this analysis would be to identify parcels where a permit to construct a new building was issued by the City between 2009 and 2018. For these parcels, one would compare the aerial imagery of 2009 and 2018 and document canopy loss on those parcels where new buildings were constructed. This would provide a direct test of the idea that new development with buildings is one cause of tree canopy loss in the City.

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Memorandum

To: Matt Soule, Stephanie Hsia, Eric Kramer – Reed Hilderbrand

From: Brandon Moore, Kim Chapman – Applied Ecological Services

Re: Cambridge – Parcel Sale and Canopy Loss Analysis

Date: March 29, 2018 (Revised April 2019)

Purpose

Analysis of tree canopy change in the City of Cambridge from 2009 to 2018 revealed that tree canopy had decreased over that period. Development of private parcels was suggested as one cause of that decrease. An indicator of this loss would be the sale of a parcel and loss of tree canopy at the same time. The City requested that Reed Hilderbrand (RH) and Applied Ecological Services (AES) investigate the question: Is there an association between the sale of a parcel and a decrease in tree canopy in the City? A sale of a parcel could be a prelude to a development project and the loss of tree canopy.

Methods

The question was answered by comparing the change in ownership over a period of time to the change in tree canopy cover over that same period of time. Parcel data from January 1, 2015 through December 31, 2017 were obtained from Reed Hilderbrand using the City's Property Database. (AES removed records with erroneous dates and duplicate records, where evident.) While numerous fields existed in each database, parcel identification using Map-Lot was used to compare the parcel sales to tree canopy gain/loss. Any parcels exhibiting a change in ownership were retained for comparison with tree canopy change. This resulted in a total of 2,495 parcels in the City where ownership had changed.

The tree canopy area had been previously delineated for 2014 and 2018. Parcels where ownership had changed were intersected with the delineated tree canopy from 2014 and 2018. New fields are added to the GIS attribute table:

- Area_ac_14 (area in acres of the 2014 canopy),
- Area_ac_18 (area in acres of the 2014 canopy),
- LossGain (text field signifying a loss or gain in tree canopy area from 2014 to 2018),
- Perc_chang (the percent change in parcel tree canopy area).

The acres of canopy in each parcel was calculated for both the 2014 (area_ac_14) and 2018 (area_ac_18) tree canopy using the Calculate Geometry tool in ArcMap. Tree canopy was classified as a gain if the canopy area in 2018 was greater than in 2014, and a loss if the tree canopy area in 2018 was less than in 2014. A percent change from 2014-2018 was then computed using the parcel canopy area from 2014 and 2018.

Data were summarized to separate parcels with a significant loss or gain in tree canopy from those with minor or not change in canopy. A significant canopy loss was defined as a canopy loss of 10-100 percent in a parcel with 0.1 acres or more of tree canopy in 2014. The is equivalent to the loss of a medium-sized tree or more from 0.1 acres of canopy on a parcel. Significant canopy gain was defined as a 10-100 percent increase in canopy on a parcel with 0.1 acres or more of canopy in 2014.

There are limitations to the analysis. This analysis treated canopy losses and additions in a parcel as an overall loss or gain in that parcel. In addition, canopy loss on an unsold parcel next to one that was sold could affect the canopy on the parcel that was sold. Both factors thus introduce uncertainty in the interpretation of the findings.

Findings

There were 2,945 parcel sales records created from January 1, 2015 to December 31, 2017. In 2014 these parcels had a canopy area of 149 acres. In 2018 these same parcels had a canopy area of 127 acres, for an overall canopy loss of 22.3 acres from 2014-2018.

Of the nearly 3,000 parcels, only 179 had a significant canopy loss based on the criteria above (Table 1). The loss was 10.5 acres on these parcels, or 47 percent of the 2014-2018 loss. Given that 123.6 acres of canopy were lost City-wide in the 2014-2018 period, this represents only 8.5 percent of the canopy loss in the period. There were 1,100 parcels that also experienced canopy loss, but the significance of that loss on any one parcel was very small. All of them began with a canopy of less than 0.1 acres in 2014 and lost less than 10 percent of that canopy. However, the aggregate contribution of these many small losses to the total canopy loss on parcels that were sold (18.3 acres) was larger than on the few parcels where the loss was more significant. (Numbers in Table 1 do not add up to 22.3 acres due to rounding.)

Table 1. Acres in categories of canopy change with ownership change, 2014-2018

Change Category	No. Parcels	Acres Changed	% of City-Wide Canopy Loss
Significant Canopy Loss	179	10.5	8.5
Other Canopy Loss	1100	18.3	14.8
Significant Canopy Gain	29	2.9	2.4
Other Canopy Gain	313	4.1	3.3
No Canopy Change	1319	0.5	0.4

Discussion

Significant Canopy Loss Occurring on a Few Parcels. Nearly half of the 22.3 acres of tree canopy loss from 2014-2018 was associated with just a few parcels where ownership changed hands. This suggests that on parcels with at least 0.1 acres of tree canopy, activity on a relatively few parcels has a strong effect on overall canopy losses. The question of whether the loss occurring on these 179 parcels was due to development, rather than a new owner simply removing a tree, could be directly answering by comparing the 2014 and 2018 aerial photographs of the 179 parcels. Putting this loss in a City-wide context, however, it is clear that there are other, more dominant reasons for canopy loss. A full 82 percent of the canopy loss across the City occurred on parcels where the ownership did not change in the 2014-2018 period.

Aggregate Canopy Loss is Also Significant. At the same time, small amounts of canopy loss occurred on over a thousand parcels that were sold. This suggests that stemming canopy loss in the City requires more than working with individuals who are purchasing and developing properties. Helping all residents to retain their tree canopy would be a reasonable direction for taking action to reduce tree canopy loss in the City. Perhaps the 82 percent of loss that occurred on parcels that did not change ownership occurred in like fashion—that is, incremental canopy loss as a result of ongoing small changes that owners make to their properties combined with unintentional neglect in the care and replacement of trees on private property.

To assess potential causes of tree removals in Cambridge between 2009-2018, we asked three questions:

1. Is loss associated with an **increase in impervious area**?
   Compare impervious cover (2010-2018) and canopy change (2009-2018)

2. Is loss associated with **property sales**?
   Compare 2015-2017 parcel sales and canopy change (2014-2018)

3. What **other causes** are there for canopy loss?
   Undertake field investigation by visiting sites of loss.

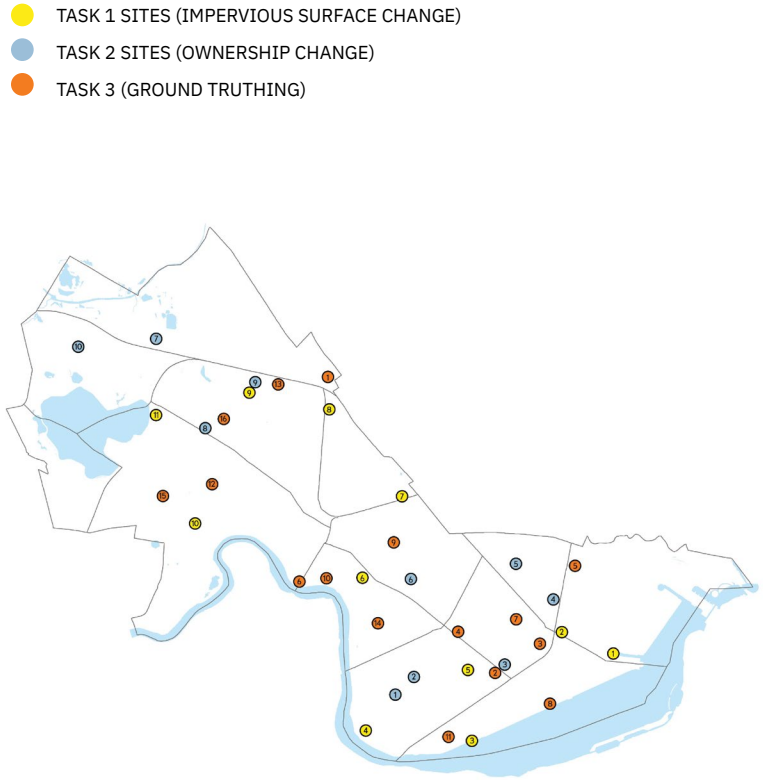


Figure 3.1: Canopy loss investigation sites in Cambridge

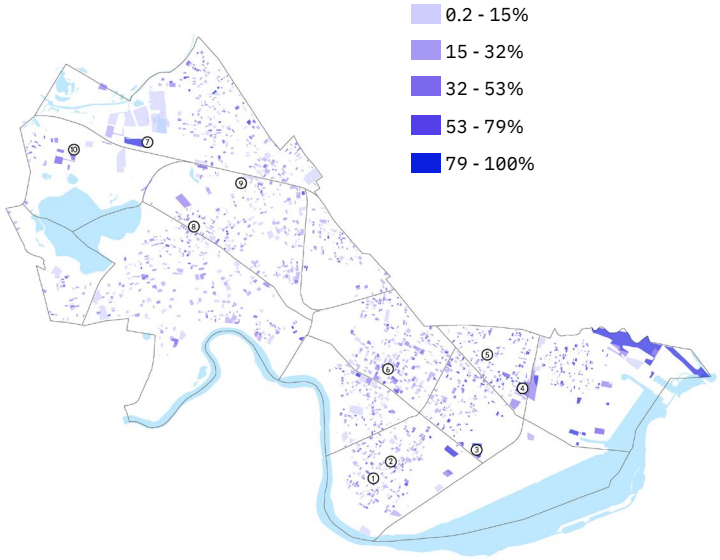


Figure 3.2: Percent canopy loss within parcels that changed ownership and show losses

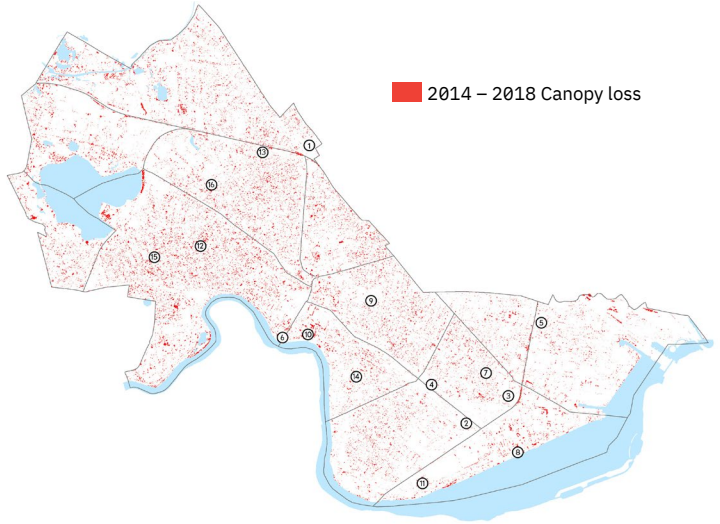
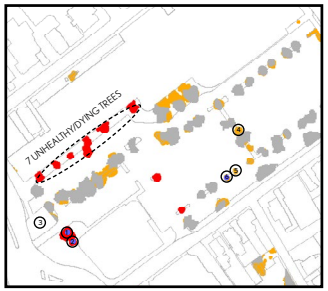


Figure 3.3: Tree canopy loss 2014 - 2018 and investigation sites

SITE 1:
LAND USE:

PORTER SQUARE PARKING LOT
COMMERCIAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: SEPTEMBER 2014

IMAGE: JUNE 2017

TREE 1 IS REPLACED BY A NEW TREE

MISSING TREE 5

UNHEALTHT/DYING TREES CLOSE TO THE BUILDING

SUMMARY:

Cause of loss: plaza construction, harsh soil condition

FIELD NOTES:

Tree 5,6 were removed due to parking lot rennovating construction in 2016. New trees were planted back, but the tree 5 died finally.

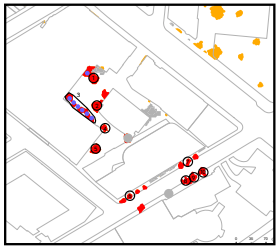
The trees very close to building are in poor health condition. The soil underneath might be compressed.

Tree 4 are removed for unkown reason.

Tree 1,2 have exsited for a long time and were protected during the plaza construction happened in 2015. However ,the two trees died in 2017. The tree 3 were newly planted in 2015 but died and removed in 2018.

SITE 2:
LAND USE:

NOVARTIS
COMMERCIAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

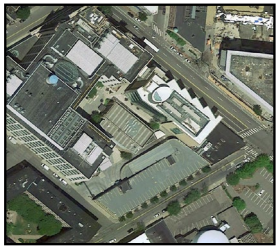
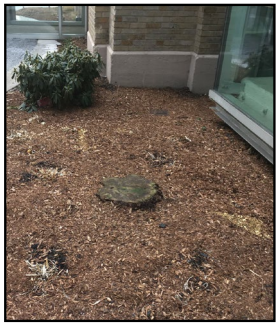


IMAGE: JUNE 2015

IMAGE: JUNE 2017

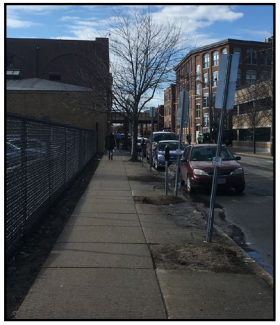
NEW TREE IN LOCATION OF THE REMOVED TREE



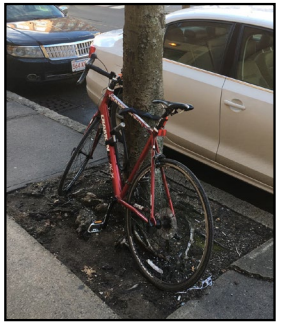
TREE STUMP

NEW SMALL TREES ON EAST FACADE (3)

TREES ARE VERY CLOSE TO UTILITY POLES



EMPTY TREE PITS

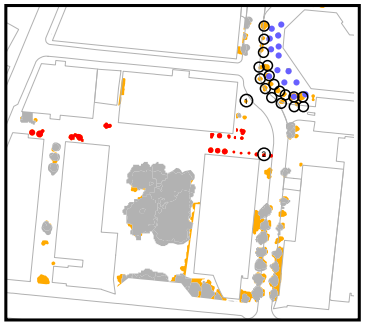


BIKE CHAINED TO A TREE

SUMMARY:
Ten trees were removed from the Novartis courtyard. Trees on Albany street are in poor condition including inadequate soil volume and the utility wires.

FIELD NOTES:
"The six trees (3) are in shade most of the day. Even if it is hard to tell from aerials or streetview, there were probably larger trees. They are replaced with very small trees, (5 of them are almost shrub size). Only one (1) of four other larger trees that were removed have been replaced by a new tree. There is a stump left of tree number (2).
Trees on Albany street are in poor condition and five of them are missing. The empty tree pits of the missing trees are still existing.
Trees on Northwest part of the street are in conflict with utility poles and wires. A bike was chained to one of the trees in front of the MIT Nuclear Reactor Lab."

SITE 3: TECHNOLOGY SQUARE
LAND USE: COMMERCIAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JUNE 2015

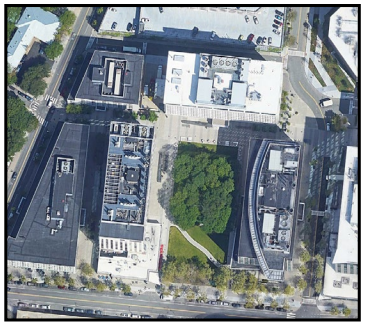


IMAGE: JUNE 2017

EMPTY PIT OF MISSING TREE

SALT IS COLLECTED ON EMPTY PIT

NEW TREES

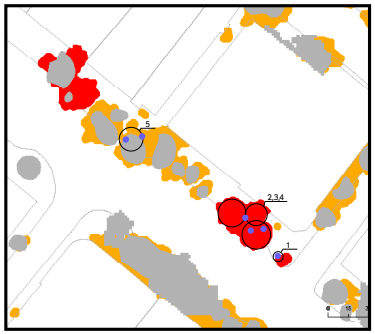
SUMMARY:
Only two trees are missing from the Technology Square. 17 trees were removed from Draper site and 14 new trees were planted.

FIELD NOTES:

"There was one empty pit on the tree grid. In Technology square, wwo trees are missing in total (1), (2). Five of them were replaced and they are very small. Even though trees have buds on them, they don't look very healthy. Some of them are tilted and some have short branches. Also, salt was collected on tree pits.

Draper site was cleared in early 2017, 17 trees were removed and 14 were planted closer to the building."

SITE 4: MASS AVE AND PEARL ST
LAND USE: ROW



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

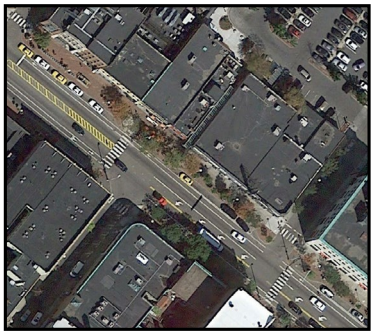


IMAGE: SEPTEMBER 2014

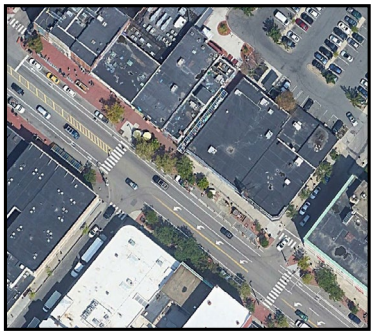


IMAGE: JUNE 2017

NEW TREES ON BRICK PAVEMENT AT MISSING TREE 1,2,3,4

NEW TREES AT THE MISSING TREE 5 LOCATION

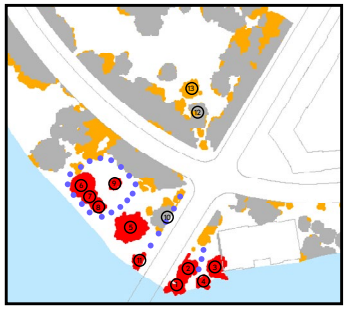
NEW TREE IN MISSING TREE 1 LOCATION

SUMMARY:
Trees are in harsh urban conditions because of foot traffic, soil compaction and inadequate soil volume.

FIELD NOTES:

"There are 5 missing trees on site and there are 6 new trees. New trees are in the traffic zone, so compaction on root system is possible. New trees are planted very close to each other. There is a pavement change on the sidewalk (concrete and brick paving) and new trees are on the permeable brick paving. Question- are the new trees planted on structural soil?"

SITE 6: CHARLES RIVER JFK BRIDGE
LAND USE: OPEN SPACE



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JUNE 2007

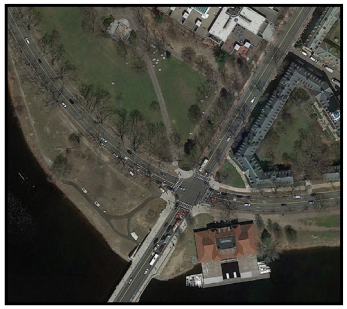


IMAGE: APRIL 2018

TREE 1,2,3,4 ARE REMOVED, THREE SMALL TREES ARE PLANTED

TREE 5,6,7,8 ARE REMOVED, 17 SMALL TREES ARE PLANTED AROUND

STUMP OF TREE 12

SUMMARY:

Cause of loss-
Bridge widening construction

FIELD NOTES:

The bridge was being widened and under construction during 2008-2018. The trees closed to the bridge had to be removed due to new structure. The site northwest to the bridge had been a service area during construction, so the trees 6,7,8,9 were cleared. However, from google historical earial photos, it shows that the tree 5 was protected at first, and then it died in 2015 and were removed finally. Tree 10 appears in the earial photo of 2018, but is found removed during site visit.

SITE 7: GREENE ROSE HERITAGE PARK
LAND USE: OPEN SPACE

CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

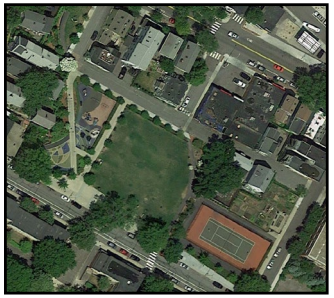


IMAGE: JUNE 2015

IMAGE: APRIL 2018

NEW TREES PLANTED CLOSE TO THE PATHWAY

NEW TREES ARE PLANTED ON TURF

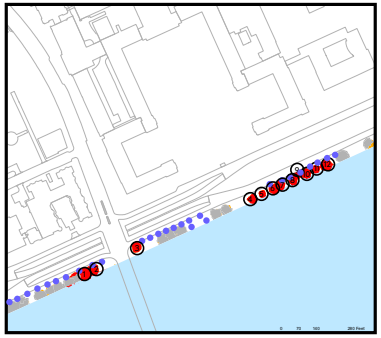
SUMMARY:

Trees are planted very close to the path and to each other.

FIELD NOTES:

"Red marked tree canopy areas generally look healthy with buds on them, except two trees that are missing.
There are 12 new trees on site. New trees are too close to the pathway. As a result, compaction is possible in the near future because of foot traffic. New trees are planted in turf. One of the new trees is very close to the light pole, utility work might have negative impact on roots.
There were compacted areas in the field. Hard to tell the exact location of the missing trees. At the spot where Tree2 is missing, there were irrigation pipes."

SITE 8: CHARLES RIVER, NEAR MIT
LAND USE: OPEN SPACE



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JULY 2014

IMAGE: JUNE 2017

HEALTHY TREES

MISSING TREES ON THE RIVERSIDE

NEW TREES

SUMMARY:

The site is a commonly used corridor by pedestrians and cyclers and because of that it needs shade trees however many trees were removed around late 2015.

FIELD NOTES:

"There were 12 missing trees in total along the river on the site. New trees are planted on the other side of the bike lane around 40 feet apart. 10 trees on west side of the bridge were removed. Large trees look healthy."

SITE 9: CAMBRIDGE PUBLIC LIBRARY
LAND USE: PUBLIC

CANOPY LOSS
REMAINING CANOPY
MISSING / DEAD TREES

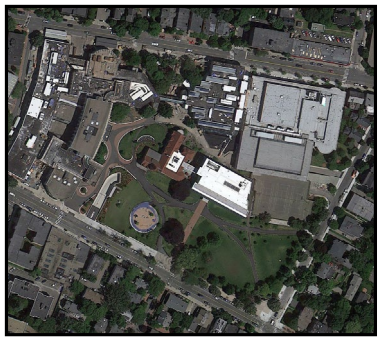


IMAGE: JUNE 2010

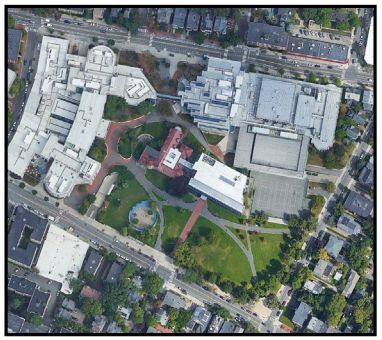


IMAGE: JUNE 2017

MISSING TREE 1

MISSING TREE 2

INCLINED UNHEALTHY TREES
(LOCATION 3)

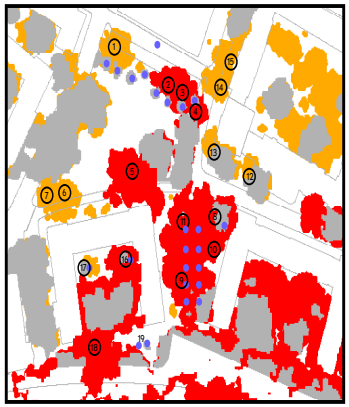
SUMMARY:

Cause of loss-
New building, undergound parking lot construction

FIELD NOTES:

The tree 1 was protected during site construction but died(removed) a year after the construction was done. The tree 1 locates very close to the underground parking lot, which might affect the soil volum and condition.

SITE 10: HARVARD WINTHROP HOUSE (1)
LAND USE: INSTITUTIONAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JUNE 2010

IMAGE: JUNE 2017

TREES 16,17 ARE REMOVED

NEW TREES ARE PLANTED AT LOCATION 19

TREE 8,9,10,11 ARE REMOVED, NEW TREES ARE PLANTED

TREE 1,2,3,4 WERE REMOVED DUE TO NEW PARKING LOT, NEW TREES ARE PLANTED

TREE 5 WAS REMOVED LEAVING BEHIND A SOAKED GROUND

CONSTRUCTION IN TIGHT SPACE, TREE 12,13 ARE REMOVED

SUMMARY:

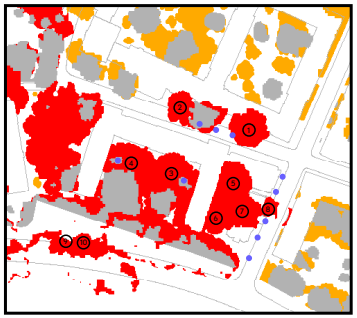
Cause of loss- Building construction, parking lot construction

FIELD NOTES:

During 2013-2019, there has been continuous construction works happening around this location. The trees 5,6,7 were removed because all the surrounding construction works have been using where they locate as service place, so there are also no trees planted back.

The other trees were removed due to the construction wotks directly.

SITE 10: HARVARD WINTHROP HOUSE (2)
LAND USE: INSTITUTIONAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JUNE 2010

IMAGE: JUNE 2017

TREE 1,2 ARE REMOVED, NEW TREES ARE PLANTED

TREE 3,4 ARE REMOVED DUE TO THE EXPA-SION PART OF BUILDING

TREE 8 IS REMOVED, NEW TREES ARE PLANTED ALONG SIDEWALK

SUMMARY:

Building expansion construction

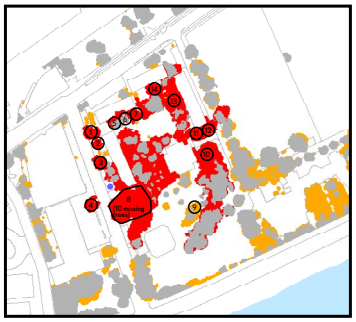
FIELD NOTES:

The trees 3,4 were removed in 2017 when the building expansion construction began. Trees 5,6,7,8 were removed from courtyard in 2015 due to new building construction and the courtyard is of hard surface now with no trees.

The tree 1,2 were also removed due to on-going construction.

trrs 9,10 dispeared for unkonwn reason.

SITE 11: MIT WESTGATE
LAND USE: INSTITUTIONAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JULY 2014

IMAGE: JUNE 2017

UNHEALTHY LOOKING TREES

MISSING TREES

PRUNED TREES

SUMMARY:

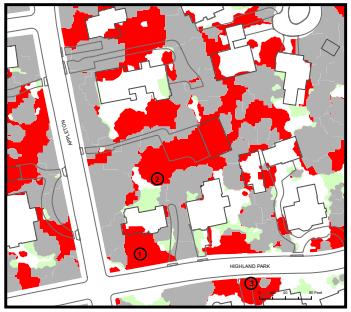
The likely cause of the loss is the reconstruction of some parts of the site.

FIELD NOTES:

"There are missing trees on both the street and the courtyard at MIT Westgate. A group of trees, possibly 10 trees were removed during a construction in early 2017. Some of the trees (1,2,3,4) were removed before the construction and others (10,11,12) were removed mid-late 2017. Some trees in the courtyard were removed in 2017 and 2018 for unknown reasons. There is only one new tree planted on the site.

Some trees on Audrey street look pruned and unhealthy. There are also trees that are pruned very poorlythat are close to the cuurent construction adjacent to the site."

SITE 12: APPLETON AND HIGHLAND PARK
LAND USE: RESIDENTIAL



CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JUNE 2015

IMAGE: APRIL 2018

AT LOCATION OF 1, TREES WERE REPLACED BY SHRUBS

AT LOCATION OF 2, TREES WERE REMOVED FOR NEW BUILDING AND LAWN.

TREE 3 WAS REMOVED FOR DRIVEWAY AND COVERED WITH NEW PAVING

SUMMARY:

Cause of loss:

1,2 : rennovation work of private property;
3 : poor tree condition; narrow driveway.

FIELD NOTES:

"At the spot where Tree 3 is missing, there is a pavement change on the driveway, which might indicate that the tree was removed on purpose of clearing the driveway. There're also 1-2 trees removed along the sidewalk which is narrow and of poor soil condition, but there is a signal on the ground saying that new trees will be planted at this location."

SITE 13: RICHDALE AND WALDEN
LAND USE: RESIDENTIAL

CANOPY LOSS
REMAINING CANOPY

IMAGE: JUNE 2010

IMAGE: JUNE 2017

SUMMARY:

Any conclusions from site visit - what was the likely cause of loss- poor tree condition, inadequate soil volume, land conversion, mature canopy decline, narrow sidewalk/ROW?

Industrial Land Use:
-contains 2% of City's total canopy (22 acres)
- industrial land use is experiencing a high mortality rate: 10.3% gross annual mortality rate between 2014-2018.

SITE 14: CAMBRIDGE HOUSING AUTHORITY
LAND USE: RESIDENTIAL

CANOPY LOSS
REMAINING CANOPY
NEW TREES
MISSING / DEAD TREES

IMAGE: JUNE 2010

IMAGE: JUNE 2017

TREE 1-4 WERE REMOVED FOR NEW TRASH BUILDINGS

NEW TREES PLANTED ALONG SIDEWALK

THE LOCATION OF TREE 5 IS IN POOR CONDITION

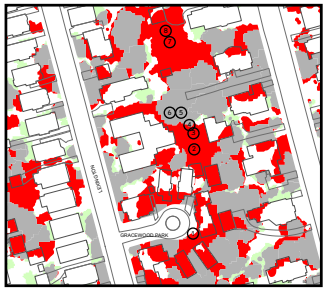
SUMMARY:

Cause of loss: 1-4 new building construction;
5 poor tree condition.

FIELD NOTES:

"There are 4 new trash stations built after 2010 which replaced the existing trees."

SITE 15: GRACEWOOD PARK
LAND USE: RESIDENTIAL



CANOPY LOSS
REMAINING CANOPY
MISSING / DEAD TREES

IMAGE: JUNE 2010

IMAGE: JUNE 2017

TREE 1 WAS REMOVED

TREES 2-6 WERE REMOVED FROM BACK-YARD

TREES 7-8 WERE TRMOVED FOR BACKYARD RENOVATION

SUMMARY:

Cause of loss: 1 intentional removal;
2-6 rennovation work of private property;
7-8 rennovation work of private property.

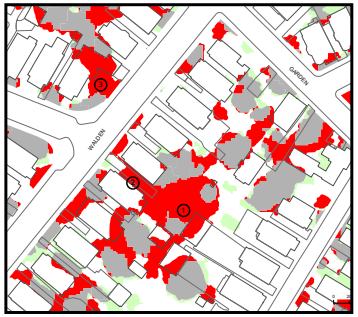
FIELD NOTES:

"The 1st photo: In the same area of tree 1, there are 3 mature trees that some of their branches are trimmed for shade reducing or dead branches cleaning.

The 2nd photo: The backyard belongs to an apartment which might require larger open space for tenants. But it might not be nessassary to remove all the 5 trees?

The 3rd photo: A private property rennovated its backyard with lawn landscape."

SITE 16: WALDEN AND GARDEN
LAND USE: RESIDENTIAL



CANOPY LOSS
REMAINING CANOPY
MISSING / DEAD TREES

IMAGE: APRIL 2008

IMAGE: APRIL 2018

TREE 1 WAS REMOVED FROM BACKYARD

TREE 2 WAS TRIMMED AND BOUND TO THE FENCE

TREE 3 WAS PROBABLY REPLACED BY LAWN (CANNOT FIND A REMAINING PART OF THE TREE)

SUMMARY:

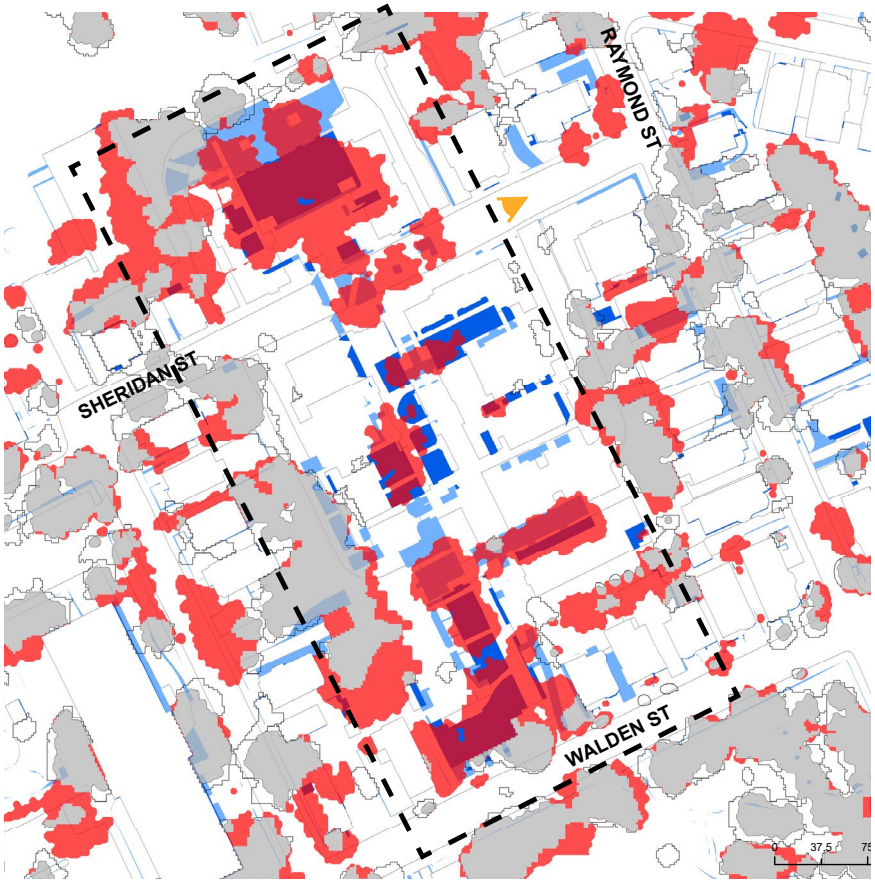
Cause of loss: 1 intentional removal;
2 narrow sidewalk, poor tree condition;
3 rennovation work of private property.

FIELD NOTES:

The Tree 1 seems very large and old. It is possible that the owner cut the tree because it was in poor health condition and dying.

NEW CONSTRUCTION

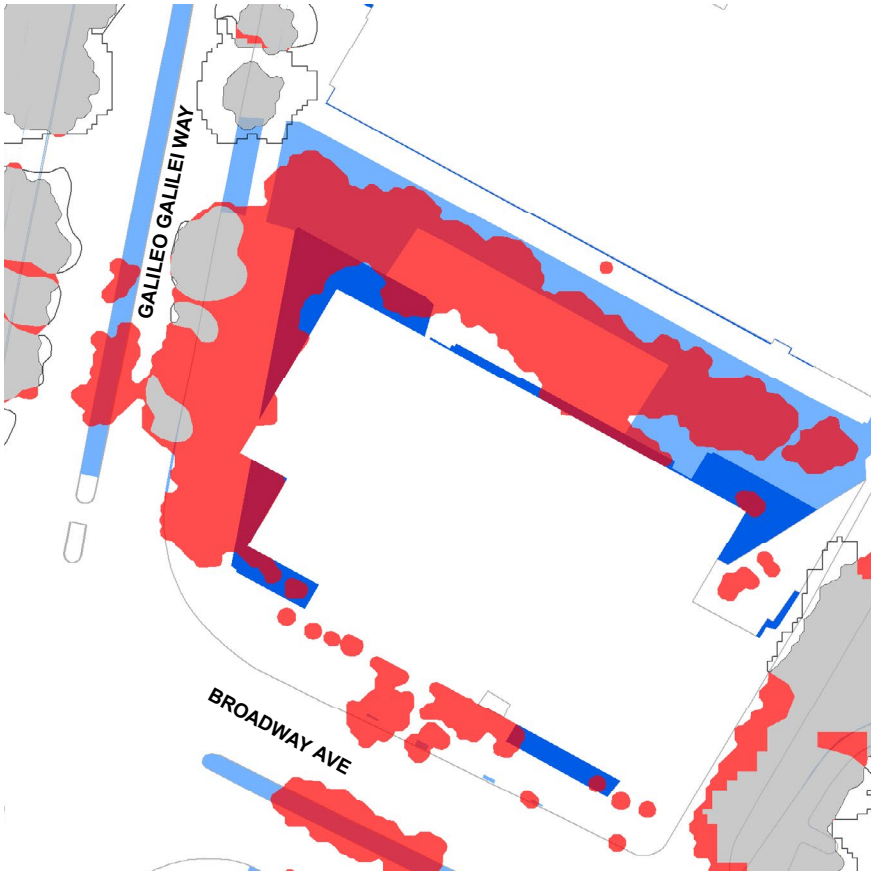
Tree removal is associated with a new development.
New structures and eliminating pervious surfaces affected the tree canopy.



Project type: Residential

NEW CONSTRUCTION

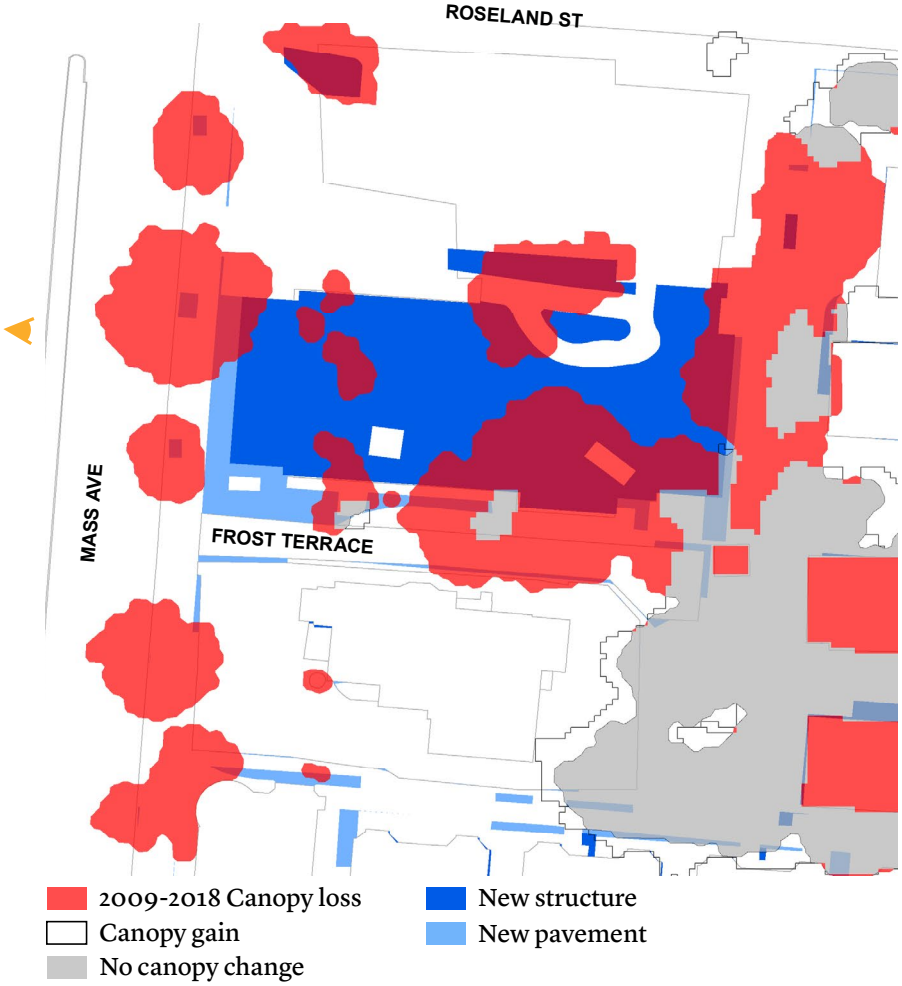
Tree removal is associated with construction of a new commercial building on Broadway Ave. Street design change also impacted trees in the median.



Project type: Commercial

NEW CONSTRUCTION

Tree removal from the green space on Mass Ave is associated with relocating the church



2010

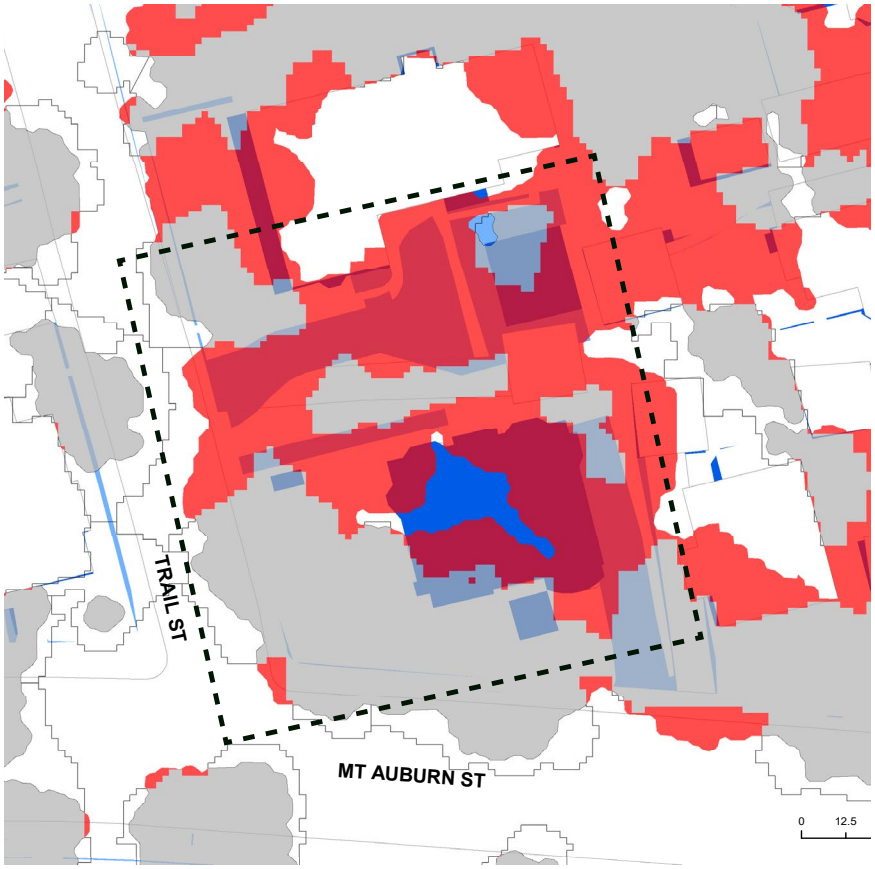
2018

Project type: Institutional, Lesley University

RENOVATION

Tree removal is associated with a yard renovation and new construction near Mt Auburn St.

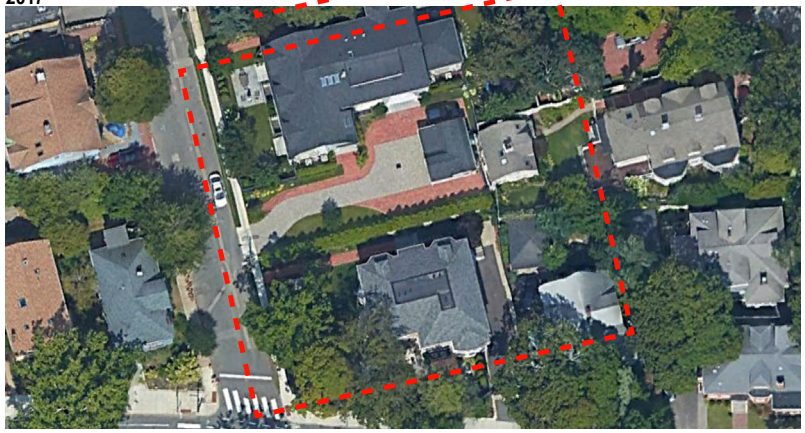
1



2009-2018 Canopy loss
Canopy gain
No canopy change
New structure
New pavement
Study area

2010

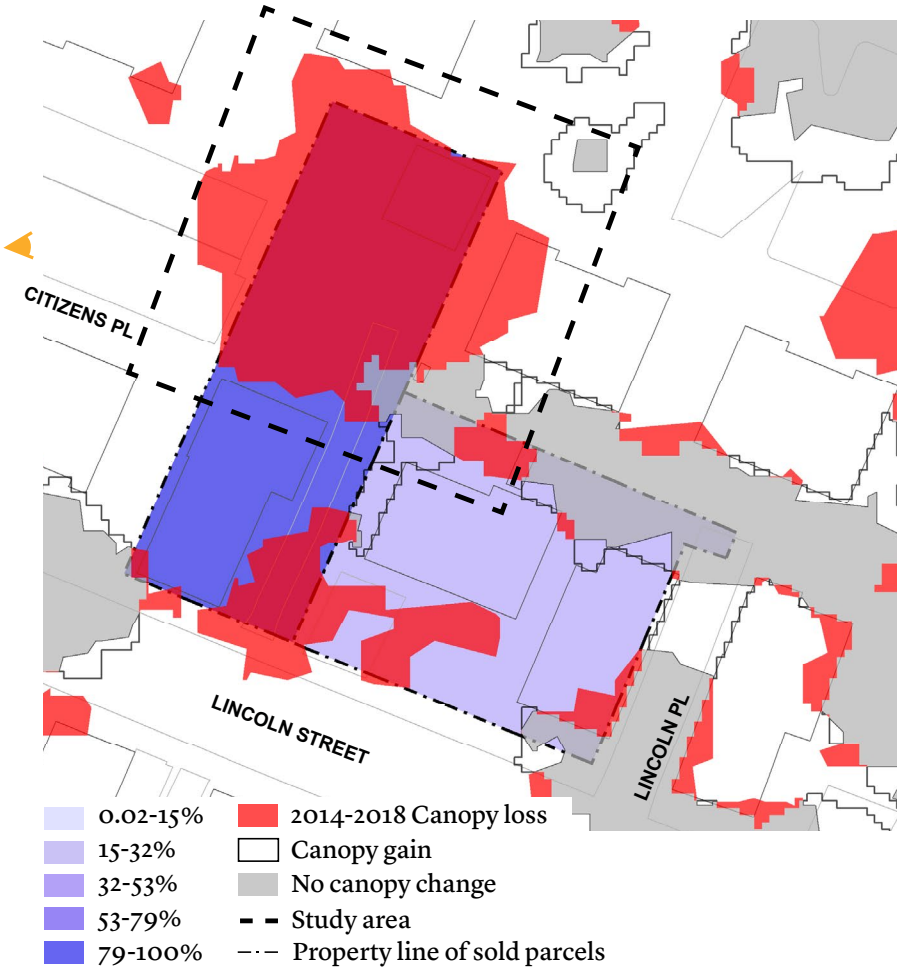
2017



Project type: Residential

NEW CONSTRUCTION

Tree removal on Lincoln Street is associated with a new residential building.



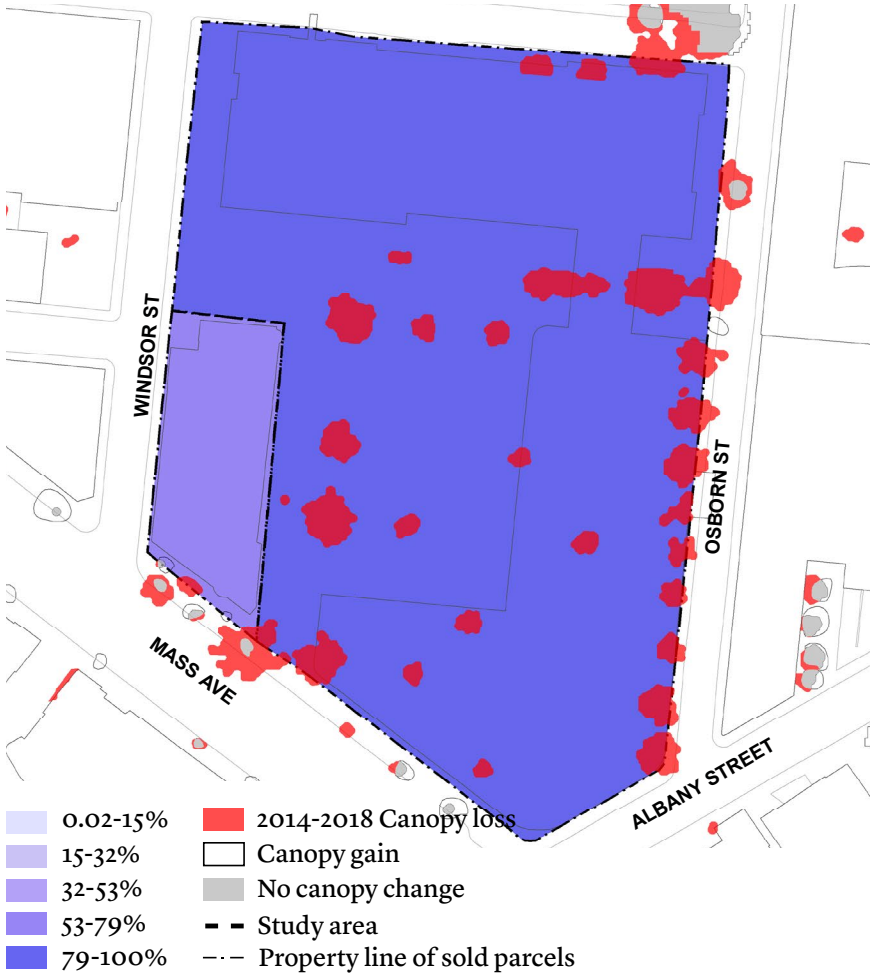
2011

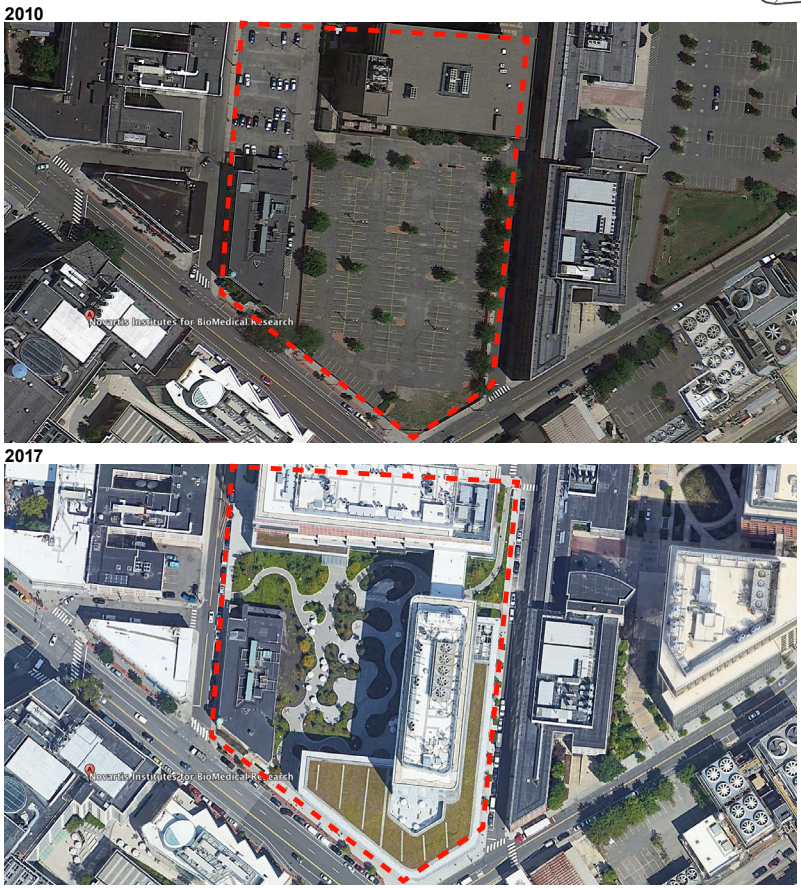
2018

Project type: Residential

NEW CONSTRUCTION

Novartis replaced the parking lot and trees, however the project provides an open space with new trees and a green roof

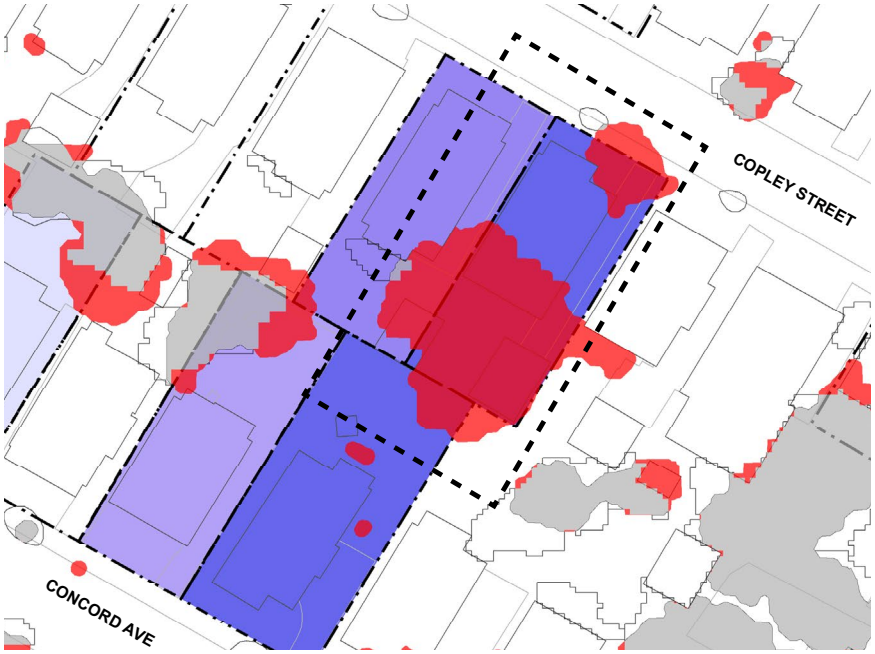




Project type: Commercial

RENOVATION

Trees removal associated with a backyard renovation on Copley Street after ownership change.



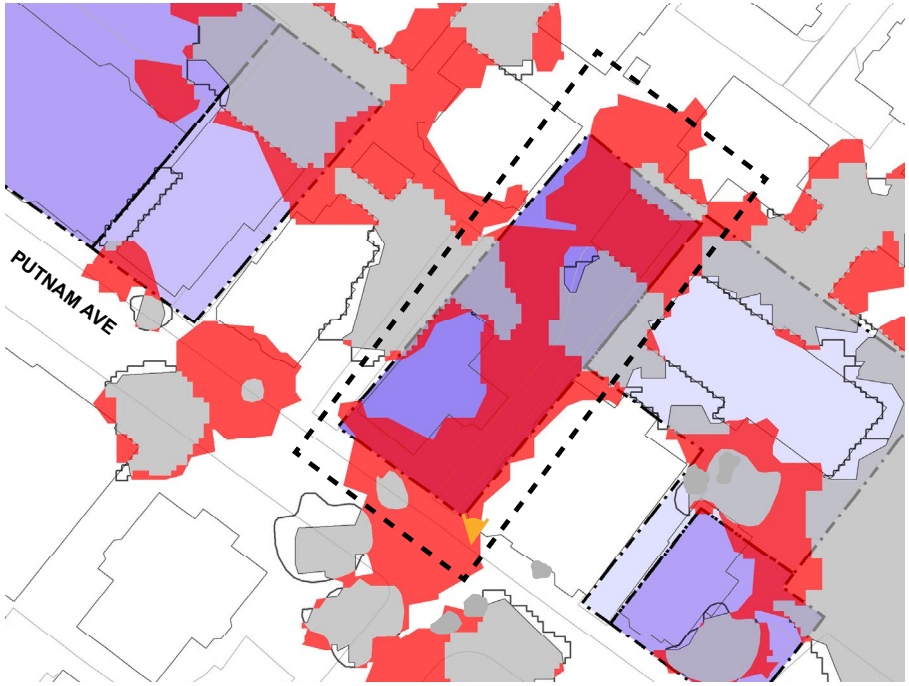
0.02-15%
15-32%
32-53%
53-79%
79-100%

2014-2018 Canopy loss
Canopy gain
No canopy change
Study area
Property line of sold parcels

Project type: Residential

UNCATEGORIZED

Two large trees on Putnam Ave were removed after ownership change



0.02-15%
15-32%
32-53%
53-79%
79-100%

2014-2018 Canopy loss
Canopy gain
No canopy change
Study area
Property line of sold parcels

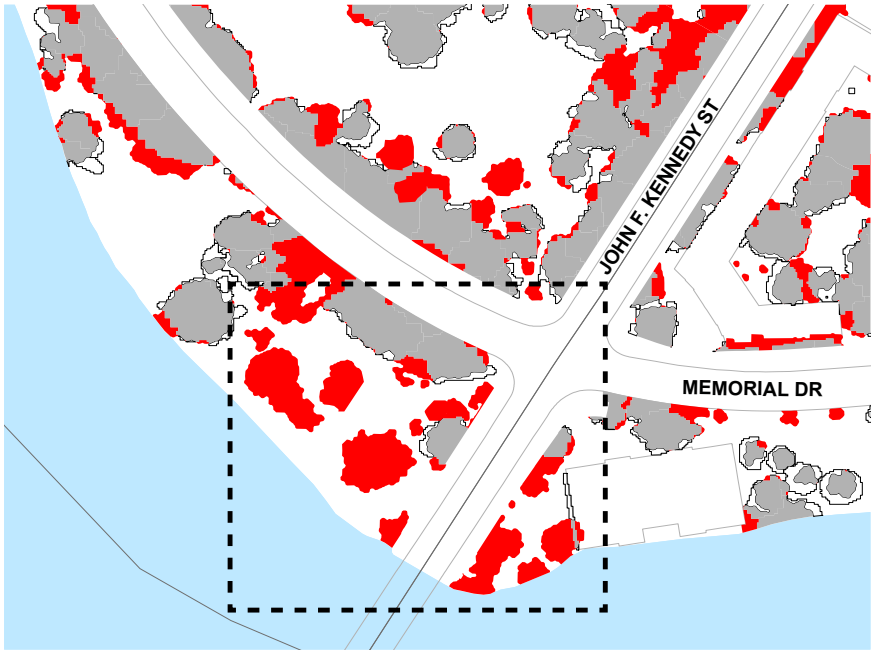
2011

2015

Project type: Residential

NEW CONSTRUCTION

During the restoration of Anderson Memorial Bridge, most of the trees along the river were removed.



2014-2018 Canopy loss
Canopy gain
No canopy change
Study area

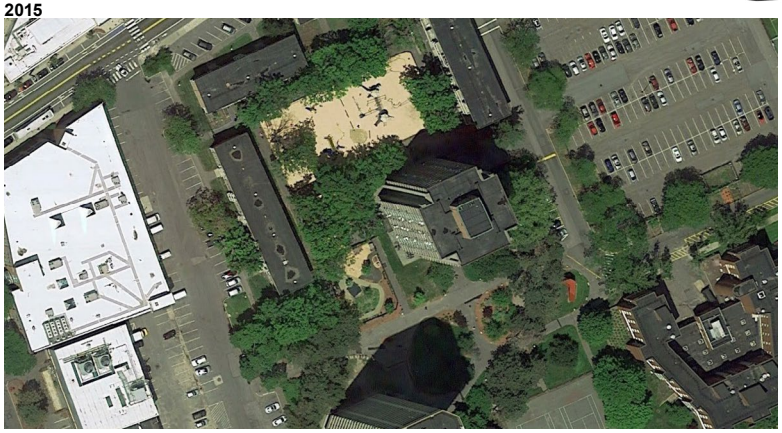
Project type: State (DCR + Mass DOT)

RENOVATION

Tree removal is asociated with the MIT Westgate complex renovation.

2009-2018 Canopy loss
Canopy gain
No canopy change

2015

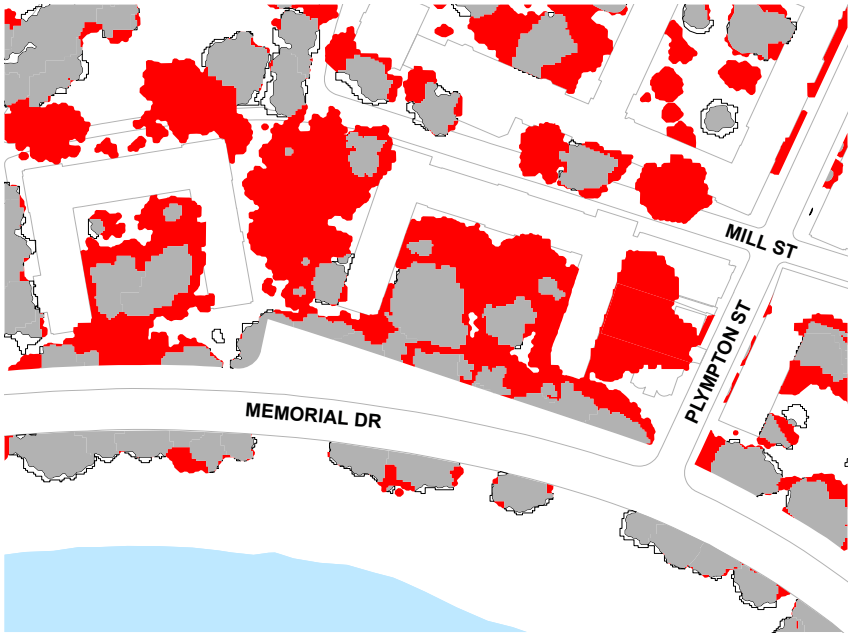


2018

Project type: Institutional

RENOVATION

Tree removal is associated with the Harvard Winthrop House renovation.



2014-2018 Canopy loss
Canopy gain
No canopy change

2010

2018

Project type: Institutional

MORTALITY

Trees at the Porter Square parking lot were replaced by new small trees.

2013

2016

Project type: Commercial

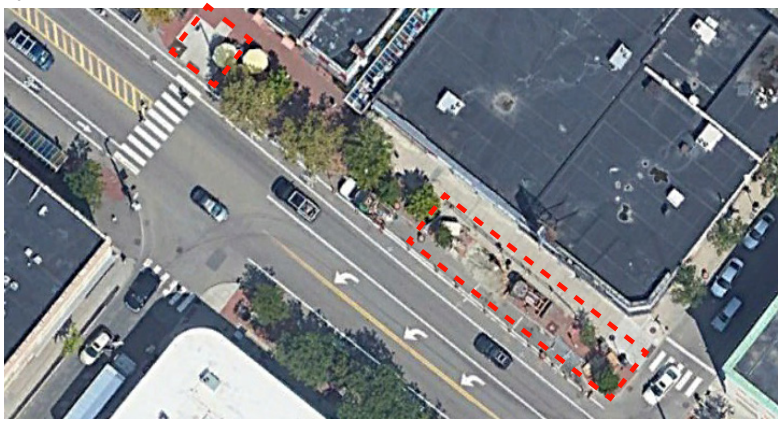
UNCATEGORIZED

Trees on Mass Ave were removed due to infrastructure renovation and lost to mortality

3

2013

2017

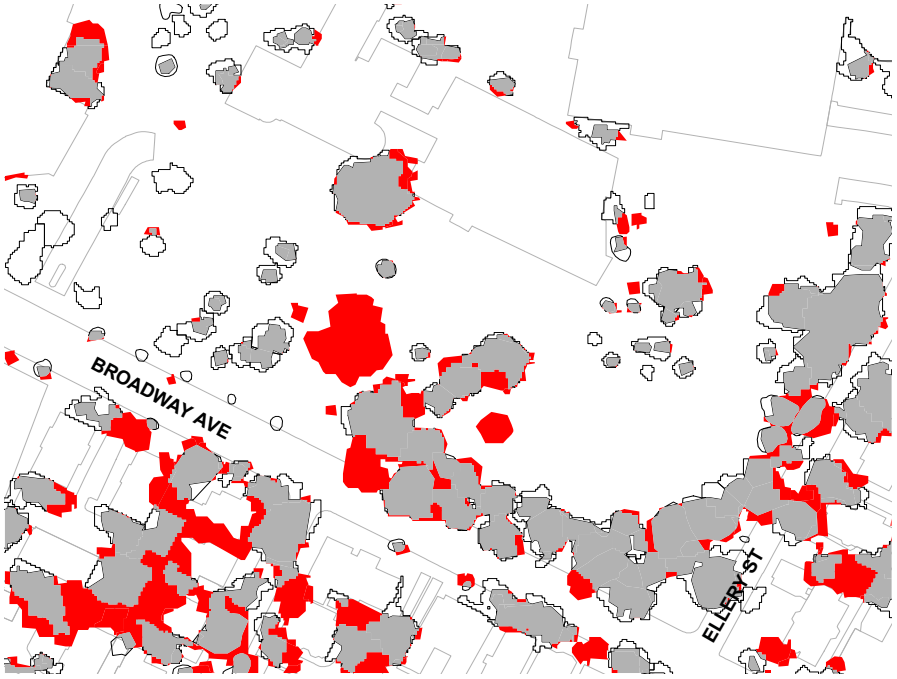


Project type: Public ROW

UNCATEGORIZED

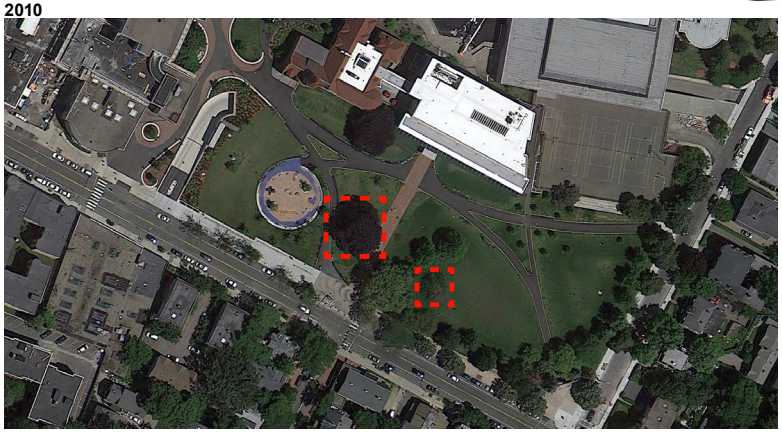
3

Two trees at the Cambridge Public Library died due to construction activity and transplanting

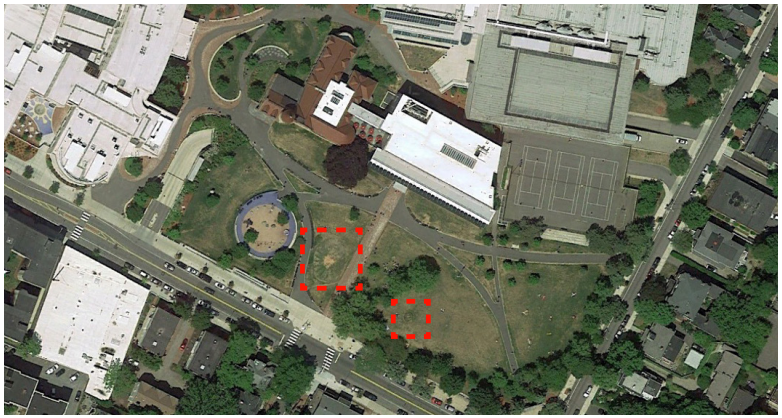


2014-2018 Canopy loss
Canopy gain
No canopy change

2010



2015

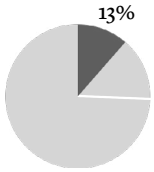


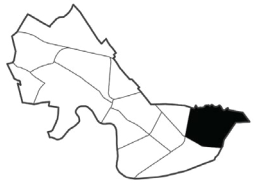
Project type: Public

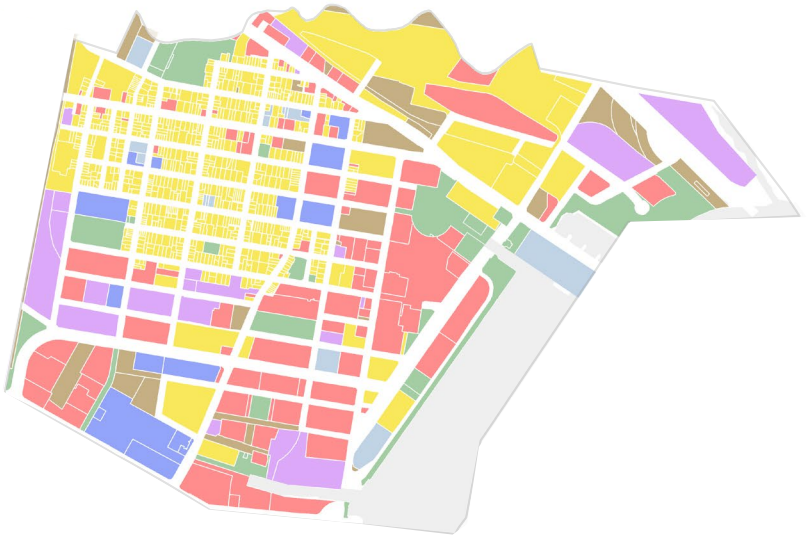
APPENDIX J: CANOPY COVER STUDIES BY NEIGHBORHOOD

LAND USE

Generalized relationship to canopy cover - East Cambridge
13% canopy cover







LAND USE & CANOPY

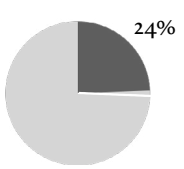
- COMMERCIAL
- OPEN SPACE
- INDUSTRIAL
- INSTITUTIONAL
- PUBLIC
- RESIDENTIAL
- TRANSPORTATION
- R.O.W.

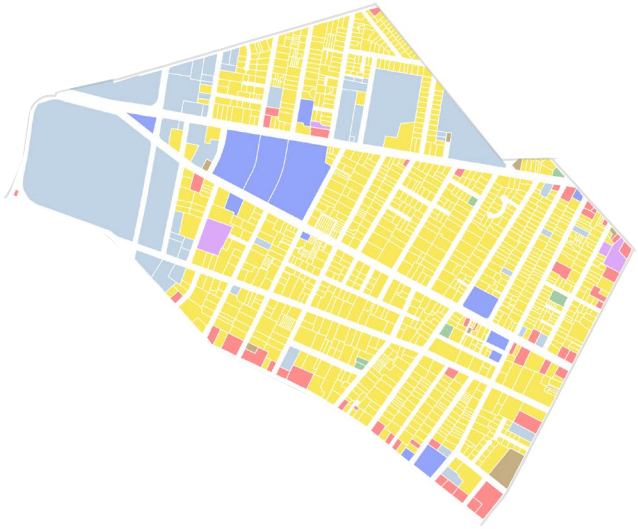
PLANTABLE AREA

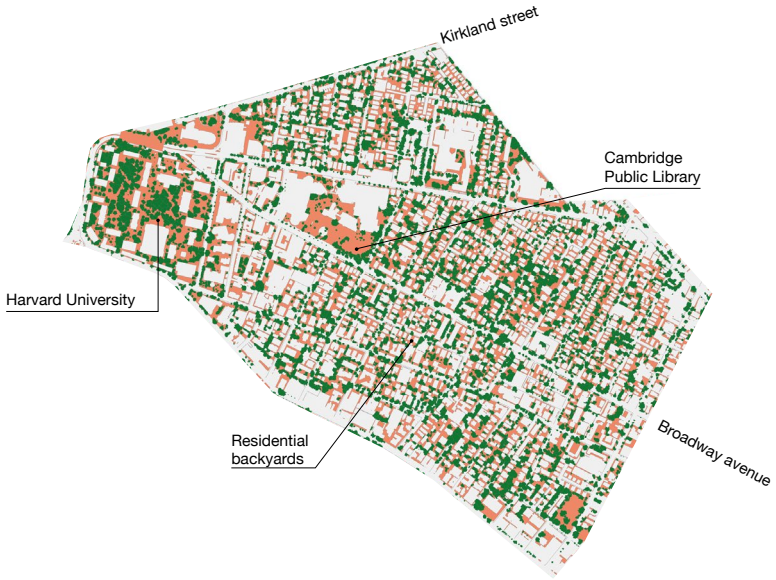
- PLANTABLE
- CANOPY COVER
- NON-PLANTABLE

LAND USE

Generalized relationship to canopy cover - Mid Cambridge
29% canopy cover







LAND USE & CANOPY

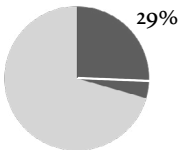
- COMMERCIAL
- OPEN SPACE
- INDUSTRIAL
- INSTITUTIONAL
- PUBLIC
- RESIDENTIAL
- TRANSPORTATION
- R.O.W.

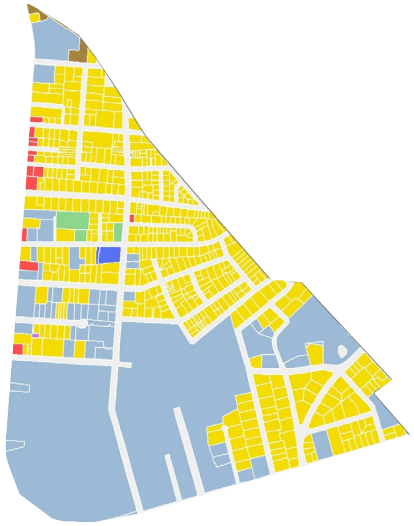
PLANTABLE AREA

- PLANTABLE
- CANOPY COVER
- NON-PLANTABLE

LAND USE

Generalized relationship to canopy cover - Agassiz
29% canopy cover





LAND USE & CANOPY

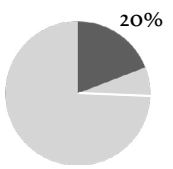
- COMMERCIAL
- OPEN SPACE
- INDUSTRIAL
- INSTITUTIONAL
- PUBLIC
- RESIDENTIAL
- TRANSPORTATION
- R.O.W.

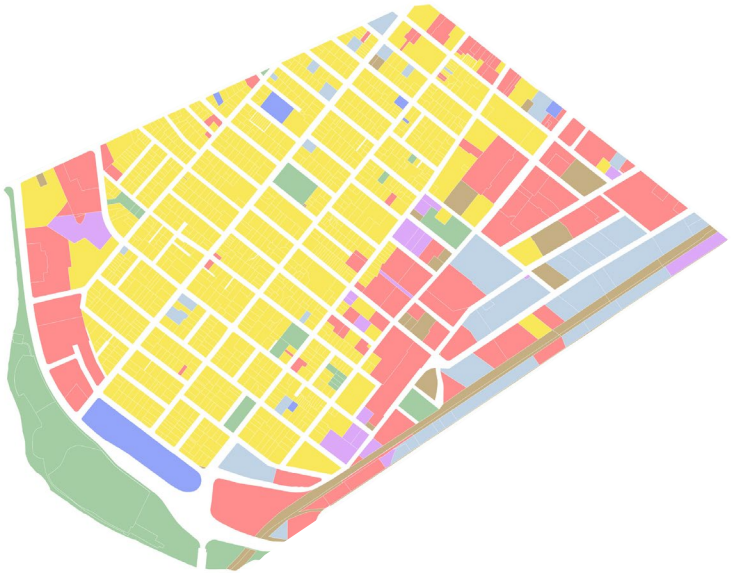
PLANTABLE AREA

- PLANTABLE
- CANOPY COVER
- NON-PLANTABLE

LAND USE

Generalized relationship to canopy cover - Cambridgeport
20% canopy cover





LAND USE & CANOPY

- COMMERCIAL
- OPEN SPACE
- INDUSTRIAL
- INSTITUTIONAL
- PUBLIC
- RESIDENTIAL
- TRANSPORTATION
- R.O.W.

PLANTABLE AREA

- PLANTABLE
- CANOPY COVER
- NON-PLANTABLE

APPENDIX K: CANOPY CHANGE MODEL METHODOLOGY, PARAMETERS AND ASSUMPTIONS, MODEL RESULTS

ISSUE DATE
March 14, 2019

TO
Catherine Woodbury
Owen O'Riordan
COMPANY
City of Cambridge

FROM
Reed Hilderbrand

PROJECT NAME/NUMBER
Cambridge UFMP

RE
Climate Modeling

The team has conducted a draft run of what the composition of Cambridge's urban forest in 2030 would be, given a baseline mortality rate, projected pest & disease load, and projected temperature increase. Extreme events of drought and flooding have also been modeled.

Based on further review of the model outcome, the team is recommending a change from modeling the removal of individual trees to removal of canopy area. We are also proposing to present a lower and upper bound to the modeling results and to model 2030-2050 and 2050-2070. This removal rate would be calibrated it to Cambridge's 2009 to 2018 canopy loss rate. Below we detail these changes and the rationale for doing so.

Expected Results

The model will provide two main outcomes:
1. Percentage of the canopy remaining for the years 2030, 2050 and 2070 under two scenarios: a) historic rates of loss/replanting and b) if climate change were to accelerate those rates of loss. From here, we will be able to update our curb loss/gain canopy graphs to account for climate change. This will help us to understand what replanting efforts are needed.
2. Evaluation of how vulnerable the current forest is to climate change. This will help inform our recommended planting list.

The output will be a spreadsheet showing the percentage of each species remaining. A map for 2030, 2050, and 2070 will be generated but this will depict one of almost endless possibilities for the urban forest.

Baseline Climate Model Changes

The baseline climate model asks the question: What will the urban forest look like, starting from current conditions and without additional replanting, in 2030 and 2070 given the baseline mortality rate, projected pest & disease load, and projected temperature increase?

In this section, we summarize the three major modifications to the climate model:

1) Climate change analysis model to be based on canopy area loss rate rather than individual tree count.
    i) Rationale: This approach is suggested for the following reasons:
        (1) Due to the limitations of delineating canopy from LIDAR, the AES 2018 canopy layer underestimates the number of individuals. The method could not account for close spacing of trees in tree clusters or capture understory trees beneath the forest canopy. Thus, removing individual trees at the literature-based rate of 4.5% may be overestimating removal of canopy. Please note that the AES 2018 canopy area is not an underestimation.
        (2) Individual tree mortality rate cannot be directly related to actual canopy loss rate.
        (3) The benefit of switching the methodology is that we can calibrate future loss rate to actual canopy loss rate. Additionally, the City can continue to use this methodology with future remote sensing data.
    ii) Methodology: A canopy loss model can be calibrated to the actual 2009-2018 canopy loss rate for the entire city. Individual polygons of tree species are then assigned a canopy loss rate based on species tree mortality rates as defined by Bartlett.
    iii) Challenge of Using A Canopy Loss Model
        (1) Individual species canopy losses used in the model can total more than the actual canopy loss rate for the city as measured in the 2009-2018 period. An overestimate of annual canopy loss can occur because:
            (a) The proportion of the forest canopy for each species is unequal in the total forest canopy; Norway maple and green ash have a disproportionate share of the canopy compared to other species and a high mortality rate, potentially resulting in an overestimate of overall forest canopy loss; and
            (b) The size of individual tree canopies varies by species—Callery pear has a much smaller canopy than a red oak, and removing an individual pear reduces the canopy area by a smaller amount than removing an oak.
        (2) Overcoming this problem requires that the canopy loss rate be weighed by the proportion of low, moderate and high loss species in the canopy. (It was beyond the scope of the project to model canopy loss based on the different canopy sizes of species.)

2) The historic loss rate will be based on 2009 to 2018 canopy loss numbers
    a) Due to a potential overestimate of canopy in the 2014 data (see Spot Check Accuracy of Change Analysis 2014-2018 below), canopy loss in the 2009-2014 period may be too low, and canopy loss in the 2014-2018 period may be too high. Using the entire 2009-2018 period reduces the effect of the 2014 data on the canopy loss rate. Also, capturing a longer period of time helps to capture the variability during different economic periods.

Reed Hilderbrand LLC
Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

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Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

b) Please see Section titled "Spot Check Accuracy of Change Analysis 2014-2018" for a description of the process used to determine that the 2014 canopy was overestimated.

3) Presenting Tree Loss with an Lower Bound and Upper Bound
   a) We are introducing the idea of a lower and upper bound for the baseline climate modeling, similar to what we did for the flooding and drought scenarios. This helps us to understand the range that climate impacts may have on the forest. The lower bound scenario is a best case scenario of assuming no additional mortality from climate change and we would carry through the historic loss rate of 2009 to 2018. We understand that whatever upper bound scenario we choose will be arbitrary but that this would tie it to the question of: what if climate change doubles the historic rate of loss? To test the upper bound, we would then double the rate of loss for species (the rate varies by species based on climate susceptibility).

Baseline Climate Model Methodology

Modeling loss based on canopy area rather than by individual trees requires a different methodology though the underlying concepts of the model are the same.

What is the same

Canopy loss rate was assigned by species due to pest and disease loading (low, medium and high) and hardiness zones. Please refer to the 10/25/2018 Climate Modeling memo for assumptions on how pest/diseases and increased temperature affects species mortality rates.

Canopy Area Model Methodology

The historic canopy loss rate from 2009 to 2018 is calculated to be 1.55% (Table 1).

Table 1. Cambridge Canopy Loss Rates, 2009-2018

Time Period	Canopy Area at Start of Period (ac.)	Canopy Polygon Area Lost in Period (ac.)	Canopy Polygon Area Gained in Period (ac.)	Canopy Area of No Polygon Change in Period (ac.)	Canopy Loss Minus Canopy Gain in Period (ac.)	Loss Minus Gain as Percent of Starting Canopy in Period (%)	Annual Average Loss Minus Gain in Period (ac.)	Annual Negative Compounded Loss Minus Gain Rate in Period (%)
2009-2014	1,219.7	216.6	163.7	1,003.1	52.9	4.34	10.6	0.95
2014-2018	1,166.8	335.6	212.0	844.1	123.6	10.59	30.9	2.70
2009-2018	1,219.7	397.2	233.4	822.5	163.8	13.43	18.2	1.55

Assigning Mortality Rate by Species. There is a challenge of assigning loss rate by species so that the overall loss rate is equal to the historic rate; some species have a high pest

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Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

MEMORANDUM

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loading loss rate while others have a low pest loading loss rate, and some species are common in the urban forest while others are rare. For this reason, a canopy loss percent is assigned to each species equivalent to, but on a different scale than the mortality rates for pest-disease loading. Although there is a relationship between the mortality rates of species and the canopy loss rates (both rates assumed to be due to pest-disease loading), this relationship in a GIS model is complex and beyond this study to determine. Thus, we use a relative scale of canopy loss for species which is scaled to mortality scale for species.

We used the proportion of species with low, moderate and high mortality rates to calculate a weighted canopy loss rate for species with low, moderate and high mortality rates. Species with low mortality rates comprised 5.7% of the forest canopy, moderate rates comprised 21.3%, and high rates comprised 73.0%. The canopy loss model weighs the canopy loss rate for species at each mortality level by the proportion of the canopy made up by that group of species with the same mortality rate. For example, Norway maple and green ash were in the high mortality group, which comprised 73.0% of the canopy. The canopy loss rate for those species was weighted in the model so that 73.0% of the forest canopy was reduced at the high loss rate.

We weighted the species canopy loss rates by the proportion of the canopy made up of species in low, moderate, or high mortality groups. There are innumerable combinations of species canopy loss rates with species proportions in the canopy which can produce the target annual rate of 1.55%. We decided to maintain the mortality rates from the previous model of 2.5%, 4.5%, 6.5% for low, moderate and high loss species. Accounting for the canopy proportion of each group, AES assigned canopy loss rates of 0.3%, 1.0% and 1.7% to the same groups. In combination with the weighting for the proportion of each species in the canopy, these rates produced an annual canopy loss rate of 1.55%, close to the observed annual canopy loss rate in the 2009-2018 period.

Canopy Removal Model. We wrote a script to randomly select polygons for removal in each year, beginning in 2018, and adding the annual losses until the species annual canopy loss rate was reached. The canopy loss rate was written as a slot to facilitate the program's operations. The slot is half the interval between loss rate categories, or 0.35 percentage points above and below the species annual loss rate; this eliminated overlap among slots. For 2030, no old trees were removed because the average tree age exceeded the model end date. The 252 out-of-hardiness zone trees (red pine, tamarack) also were not removed in the model because their loss was insignificant; however, these species were removed from the resulting 2030 species table.

The script randomly creates many combinations of canopy polygons selected for removal in the GIS model, and to identify the best combination of polygons where the sum of the

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130 Bishop Allen Drive
Cambridge, MA 02139

canopy area is closest to the area to be removed each year for each species. This avoided the need to run Monte Carlo simulations to produce a similar outcome.

Upper bound canopy loss. It is reasonable to assume that climate change effects in the 2009-2018 period will not represent climate change effects in the 2018-2050 period.

a) The upper bound model uses a canopy loss rate that is higher than the rate in the 2009-2014 period; i.e., it uses the starting canopy area minus the canopy polygon area lost in the period (columns 2 and 3 in Table 1). This rate assumes no gain in canopy area due to tree planting, growth of tree canopies, or other factors that could increase tree canopy area in the 2018-2030 period. That annual canopy loss rate, accounting for negative compounding, is 4.3%. The scale used for low, moderate and high mortality rate species mirrors the scale for the lower bound model: 3.6%, 4.3%, and 5.0%.
b) Running the model for the upper bound for the 2018-2030 period will proceed as described above.

2050/2070 Climate Model Run. The ending canopy area for the 2018-2030 period will be used as the starting point for modeling change in the 2030-2050 and the 2050-2070 period. An upper and lower bound will be established using the same method as above. Removals due to species migrating outside their plant hardiness zones will also be incorporated in both model runs.

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130 Bishop Allen Drive
Cambridge, MA 02139

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Spot Check Accuracy of Change Analysis 2014-2018

To help determine which canopy loss years to use (2009 to 2018 or 2014 to 2018), AES needed to understand the cause of the higher loss rate in the 2014-2018 period compared to the 2009-2014 period. Thus, AES examined 2018 Google Earth image to loss areas and have included notes for three spot check sites below:

1) NW corner of city, north of Acorn Park Drive: major features are three buildings, one parking lot, one pond.
   a) Canopy loss area at edge of 2018 canopy layer around pond is bare ground or turf.
   b) Canopy loss area where Acorn Park Drive meets west city boundary is turf and road.
   c) Cluster of loss areas within central forested area is shrub-scrub wetland.
   d) Row of conifers at north edge of parking lot was eliminated by AES classification because it was not visible due to satellite angle.
   e) SUMMARY: Three large areas of loss from 2014-2018 are due to overestimation of forest canopy in the 2014 layer. A small area of conifer loss was misclassified.
2) SW corner of City, in Strawberry Hill; major features are many buildings and roads, with some forest patches.
   a) Large loss area east of Grove St. (city boundary) and north of Belmont St. is buildings which were present in 1995.
   b) Large loss area west side of narrow forest strip (angling NNE from city boundary to Fresh Pond) just north of southern city boundary is turf.
   c) Large loss area east of Cushing St. and Thingvalla Ave. is a driveway.
   d) Several small loss areas in large forest block east of Cushing St. and south of Locust St. is about 50:50 due to AES not detecting the forest canopy and half is due to tree removal or trimming.
   e) SUMMARY: The large loss areas identified were due to overestimation of forest canopy in 2014. Some small loss areas could in part be due to AES classification process not detecting them.
3) Center of city, densely settled city block surrounded by Huron Ave. Reservoir St., Fayerweather St.
   a) Biggest small-loss area is no longer a tree.
   b) Small tree loss area SE of Fayerweather St. and Huron Ave. is a location where a

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large tree was removed and small tree(s) planted.

c) Small tree loss area halfway between Huron St. and where Reservoir St. bends to the west is canopy not detected in AES 2018 classification.
d) Cluster of small tree loss areas east of Fayerweather halfway between Huron St. and Reservoir St. is due to canopy removal (trimming, tree removal), with less than a quarter due to AES 2018 classification not detecting canopy.
e) SUMMARY: While AES's classification did not detect every area of tree canopy, in this area with scattered small loss areas, the majority of tree loss is due to actual tree loss.

AES noted that the City's 2009 and 2014 canopy layers included forest outside the city boundary. We have removed the canopy outside the city boundary from further consideration for both layers.

Overall conclusion from this limited sample of spot checking (3):

a) 2014 tree canopy was overestimated
b) Some loss, much less than half, was due to AES's classification not detecting all of 2018 canopy cover.
c) The actual loss that occurred likely exceeds the loss due to AES not detecting canopy; hence, loss demonstrated in the model is actual loss, not an artifact of the canopy modeling process.
d) SUMMARY: The higher rate of canopy loss in the 2014-2018 period is largely due to actual tree losses plus an overestimation of 2014 canopy. A small amount of loss is due to AES's classification not detecting canopy present in 2018. This is a hypothesis based on a limited sample, provided enough insight into reasons for the higher loss rate to justify using the 2009-2018 period, rather than the 2014-2018 period.

Reed Hilderbrand LLC
Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

Climate Change and Canopy Change Analysis – City of Cambridge
Brandon Moore, Kim Chapman, Applied Ecological Services
February 22, 2019

1. Use Canopy Loss Rate Versus Tree Loss Rate
    a. Approach
        i. A canopy loss model was calibrated to the actual 2009-2018 canopy loss rate for the entire city. Individual polygons of tree species were assigned a canopy loss rate based on species tree mortality rates as defined by Bartlett. This produced annual canopy losses consistent with measured canopy loss rates for the 2009-2018 period.
    b. Rationale
        i. Instead of employing a climate change analysis method using individual tree mortality rates reported in the scientific literature, AES used the actual measured past canopy loss rate. This approach was used because a) individual tree mortality rate cannot be directly related to actual canopy loss rate, and b) AES's tree total using individual tree loss rates was less than the actual total due to undercounting of trees. The AES modeled tree number (47,000) could not be calibrated with Bartlett's field inventory number (78,000±10,000) because AES's analysis was not able to identify all individual trees in tree clusters or detect 10,000-15,000 small trees beneath the forest canopy; in addition, Bartlett's expansion from a 5-percent survey of the city may have overestimated the number of trees due to an unbalanced distribution of sample plots relative to the extent of land cover/use in the city which those plots were intended to represent.
    c. Pros and Cons of Using Canopy Loss Model
        i. Pros
            1. Can calibrate future canopy loss to past canopy loss rates
            2. Can update with remote sensing data and directly compare years
            3. May communicate better people's perceptions of the urban forest: e.g., "23 percent of the city is shaded by trees" versus "There are 47,000 trees".
        ii. Cons
            1. Tree mortality data are tied to individual trees, not tree canopy
            2. In order to recommend an annual number of trees to be planted, a number must be estimated from the amount of canopy lost each year. (EarthWatch's Cambridge State of the Forest report suggested 700 street trees must be planted each year to make up for losses; currently about 300 trees are planted each year.
    d. The Challenge of Using A Canopy Loss Model
        i. Individual species canopy losses used in the model can total more than the actual canopy loss rate for the city as measured in the 2009-2018 period. An overestimate of annual canopy loss can occur because:
            1. The proportion of the forest canopy for each species is unequal in the total forest canopy; Norway maple and green ash have a disproportionate share of the canopy compared to other species and a high mortality rate, potentially resulting in an overestimate of overall forest canopy loss; and
            2. The size of individual tree canopies varies by species—Callery pear has a much smaller canopy than a red oak, and removing an individual pear reduces the canopy area by a smaller amount than removing an oak.
        ii. Overcoming this problem requires that the canopy loss rate be weighed by the proportion of low, moderate and high loss species in the canopy. (It was beyond the scope of the project to model canopy loss based on the different canopy sizes of species.)
        iii. A similar issue arises when increasing the canopy removal rate of trees next to pavement; these trees, representing street trees, are

expected to have a higher mortality rate than trees away from pavement. The proportion of street trees among all trees also must be weighted to prevent overestimates of canopy loss.

2. Canopy Change Analysis Approach 2018-2030 Period
    a. Canopy loss rate was assigned relative to the species' mortality rates due to pest and disease loading as reported in the scientific literature; in addition, species were removed that were outside their hardiness zone in the period.
    b. Method
        i. Create a column in Bartlett's mortality table with total area (sq. meters) of canopy cover by species in 2018.
        ii. Calculate from 2009-2018 actual canopy loss the average compounded annual canopy loss for the forest as a whole. The past does not represent the future, however, and the effects of future climate change are unknown and may accelerate. For this reason, the annual canopy loss rate as calibrated to the actual 2009-2018 loss rate will be considered a lower bound of canopy loss.
        iii. AES will use an annual canopy loss rate for the forest as a whole of 1.55%, calculated from the actual canopy loss rate in the 2009-2018 period (Table 1). This is a negatively compounded rate; it uses the previous year-end canopy area to calculate the next year-end canopy rate.
        iv. Due to a potential overestimate of canopy in the 2014 data (see Spot Check Accuracy of Change Analysis 2014-2018 below), canopy loss in the 2009-2014 period may be too low, and canopy loss in the 2014-2018 period may be too high. Using the entire 2009-2018 period reduces the effect of the 2014 data on the canopy loss rate.
        v. An adjustment for proportion of street trees also was made.

Table 1. Cambridge Canopy Loss Rates, 2009-2018

Time Period	Canopy Area at Start of Period (ac.)	Canopy Polygon Area Lost in Period (ac.)	Canopy Polygon Area Gained in Period (ac.)	Canopy Area of No Polygon Change in Period (ac.)	Canopy Loss Minus Canopy Gain in Period (ac.)	Loss Minus Gain as Percent of Starting Canopy in Period (%)	Annual Average Loss Minus Gain in Period (ac.)	Annual Negative Compounded Loss Minus Gain Rate in Period (%)
2009-2014	1,219.7	216.6	163.7	1,003.1	52.9	4.34	10.6	0.95
2014-2018	1,166.8	335.6	212.0	844.1	123.6	10.59	30.9	2.70
2009-2018	1,219.7	397.2	233.4	822.5	163.8	13.43	18.2	1.55

        iii. AES quantified the canopy loss for each species by distributing the 1.55% annual canopy among the species. Some species had a high loss rate while others had a low loss rate, and some species were common while others were rare. For this reason, a canopy loss percent was assigned to each species equivalent to, but on a different scale than the mortality rates for pest-disease loading in Bartlett's mortality rate table. Although there is a relationship between the mortality rates of species and the canopy loss rates (both rates assumed to be due to pest-disease loading), this relationship in a GIS model is complex and beyond this study to determine. For this reason, AES used a relative scale of canopy loss for species which was scaled to Bartlett's tree mortality scale for species.
        iv. AES used the proportion of species with low, moderate and high mortality rates (from Bartlett's data) to calculate a weighted canopy loss rate for species with low, moderate and high mortality rates. Species with low mortality rates comprised 5.7% of the forest canopy, moderate 21.3%, and high 73.0%. The canopy loss model weights the canopy loss rate for species at each mortality level by the proportion of the canopy made up by that group of species with the same mortality rate. For example, Norway maple and green ash were in the high mortality group, which comprised 73.0% of the canopy. The canopy loss rate for those species was weighted in the model so that 73.0% of the forest canopy was reduced at the high loss rate.

v. AES weighted the species canopy loss rates by the proportion of the canopy made up of species in low, moderate, or high mortality groups. There are innumerable combinations of species canopy loss rates with species proportions in the canopy which can produce the target annual rate of 1.55%. AES decided to maintain the evenly-spaced Bartlett species mortality scale of 2.5%, 4.5%, 6.5% for low, moderate and high loss species. Accounting for the canopy proportion of each group, AES assigned canopy loss rates of 0.3%, 1.0% and 1.7% to the same groups. In combination with the weighting for the proportion of each species in the canopy, these rates produced an annual canopy loss rate of 1.55%, close to the observed annual canopy loss rate in the 2009-2018 period.

vi. An adjustment for the proportion of street trees in the forest canopy was also needed to prevent an overestimate of the amount of annual canopy loss. The annual area of tree canopy loss is determined as the mathematical product of the mortality rate and the final canopy area of the previous year. The annual area loss is then substituted into the following expression:
, where x is the mortality loss percentage for both street and non-street trees and x+1 is the increased mortality rate for street trees. Using the annual loss area in the above expression prevents an overestimate of loss in the overall canopy area when the increase in street tree mortality is factored in. For example, if the canopy loss rate for a species is 1.7%, the street tree loss rate would be 2.4% thereby removing more tree canopy than the 1.7% rate.

vii. AES wrote script to randomly select polygons for removal in each year, beginning in 2018, and adding the annual losses until the species annual canopy loss rate was reached. The canopy loss rate was written as a slot to facilitate the program's operations. The slot is half the interval between loss rate categories, or 0.35 percentage points above and below the species annual loss rate; this eliminated overlap among slots. For the 2030 model, no old trees were removed because the average tree age exceeded the model end date. The 252 out-of-hardiness zone trees (red pine, tamarack) also were not removed in the model because their loss was insignificant; however, these species were removed from the resulting 2030 species table.

viii. The model was run for each year through 2030. This was the lower bound model run. The model was validated by calculating the annual canopy loss percent compared to the baseline annual canopy loss rate for 2009-2018.

ix. AES wrote script to randomly create many combinations of canopy polygons selected for removal in the GIS model, and to identify the best combination of polygons where the sum of the canopy area is closest to the area to be removed each year for each species. This avoided the need to run Monte Carlo simulations to produce a similar outcome.

x. For an upper bound canopy loss, it is reasonable to assume that climate change effects in the 2009-2018 period will not represent climate change effects in the 2018-2050 period. For instance, summer daytime temperatures will be higher, resulting in greater heat outputs in the vicinity of impervious cover of roads and pavement, with adverse effects on nearby trees. For this reason, an upper bound model was needed.

xi. The upper bound model uses a canopy loss rate that is higher than the rate in the 2009-2014 period; i.e., it uses the starting canopy area minus the canopy polygon area lost in the period (columns 2 and 3 in Table 1). This rate assumes no gain in canopy area due to tree planting, growth of tree canopies, or other factors that could increase tree canopy area in the 2018-2030 period. That annual canopy loss rate, accounting for negative compounding, is 4.3%. The scale used for low, moderate and high mortality rate species mirrors the scale for the lower bound model: 3.6%, 4.3%, and 5.0%.

xii. Running the model for the upper bound for the 2018-2030 period will proceed as described above.

3. Canopy Change Analysis Approach 2030-2050 Period
    a. The ending canopy area for the 2018-2030 period will be used as the starting point for modeling change in the 2030-2050 period. An upper and lower bound will be established using the same method as above.
    b. Removals due to species migrating outside their plant hardiness zones will also be incorporated in the 2030-2050 model run.

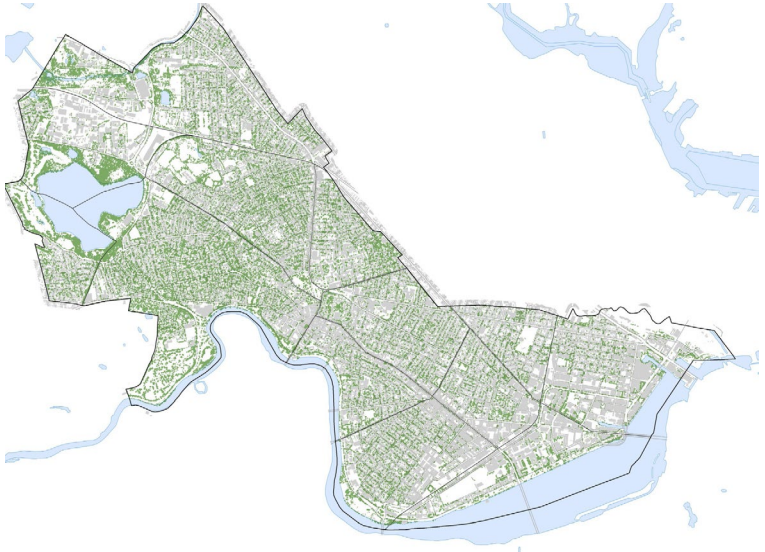
Spot Check Accuracy of Change Analysis 2014-2018

1. To select an annual canopy loss rate, AES needed to understand the cause of the higher loss rate in the 2014-2018 period compared to the 2009-2014 period. AES examined 2018 Google Earth image to loss areas in the 2018 data and determined the reason for the loss.
2. The city's 2014 layer included forest outside the city boundary (as provided by the city). AES removed the 2014 canopy outside the city boundary from further consideration (and also from the 2009 canopy data).
3. NW corner of city, north of Acorn Park Drive: major features are three buildings, one parking lot, one pond.
    a. Canopy loss area at edge of 2018 canopy layer around pond is bare ground or turf.
    b. Canopy loss area where Acorn Park Drive meets west city boundary is turf and road.
    c. Cluster of loss areas within central forested area is shrub-scrub wetland.
    d. Row of conifers at north edge of parking lot was eliminated by AES classification because it was not visible due to satellite angle.
    e. SUMMARY: Three large areas of loss from 2014-2018 are due to overestimation of forest canopy in the 2014 layer. A small area of conifer loss was misclassified.
4. SW corner of City, in Strawberry Hill; major features are many buildings and roads, with some forest patches.
    a. Large loss area east of Grove St. (city boundary) and north of Belmont St. is buildings which were present in 1995.
    b. Large loss area west side of narrow forest strip (angling NNE from city boundary to Fresh Pond) just north of southern city boundary is turf.
    c. Large loss area east of Cushing St. and Thingvalla Ave. is a driveway.
    d. Several small loss areas in large forest block east of Cushing St. and south of Locust St. is about 50:50 due to AES not detecting the forest canopy and half is due to tree removal or trimming.
    e. SUMMARY: The large loss areas identified were due to overestimation of forest canopy in 2014. Some small loss areas could in part be due to AES classification process not detecting them.
5. Center of city, densely settled city block surrounded by Huron Ave. Reservoir St., Fayerweather St.
    a. Biggest small-loss area is no longer a tree.
    b. Small tree loss area SE of Fayerweather St. and Huron Ave. is a location where a large tree was removed and small tree(s) planted.
    c. Small tree loss area halfway between Huron St. and where Reservoir St. bends to the west is canopy not detected in AES 2018 classification.
    d. Cluster of small tree loss areas east of Fayerweather halfway between Huron St. and Reservoir St. is due to canopy removal (trimming, tree removal), with less than a quarter due to AES 2018 classification not detecting canopy.
    e. SUMMARY: While AES's classification did not detect every area of tree canopy, in this area with scattered small loss areas, the majority of tree loss is due to actual tree loss.
6. Overall conclusion from this limited sample
    a. 2014 tree canopy was overestimated
    b. Some loss, much less than half, was due to AES's classification not detecting all 2018 canopy cover.
    c. The actual loss that occurred likely exceeds the loss due to AES not detecting canopy; hence, loss demonstrated in the model is actual loss, not an artifact of the canopy modeling process.
    d. SUMMARY: The higher rate of canopy loss in the 2014-2018 period is largely due to actual tree losses plus an overestimation of 2014 canopy. A small amount of loss is due to AES's classification not detecting canopy present in 2018. This is a hypothesis based on a limited sample, provided enough insight into reasons for the higher loss rate to justify using the 2009-2018 period, rather than the 2014-2018 period.

Cambridge Urban Forest Master Plan

AES Work Summary, 11/5/2018

Tree Canopy Mapping & Classification



Model Mapping Accuracy

- Compared Bartlett's field ID of 5% of Cambridge's street trees to AES's modeled tree ID
- *Acer x freemanii* had low accuracy rate— blended traits of red & silver maple
- Accuracy for rare species was lower due to small sample size

Species	Accuracy
All species	97.10%
Acer platanoides	97.20%
Quercus palustris	97.70%
Gleditsia triacanthos	98.40%
Acer rubrum	95.20%
Quercus rubra	98.60%
Tilia cordata	96.40%
Pyrus calleryana	98.10%
Platanus acerifolia	95.30%
Fraxinus pennsylvanica	97.90%
Ulmus americana	98.50%

Baseline Model 2030 & 2070

- Mortality Rate
  - 4.5% annual average (Cambridge Earthwatch, Roman & Scantena)
  - 6.5% for high pest/disease load & 2.5% for low
- Topics
  - Annual mortality rate 2014-2018 appears to be 6%
  - Norway maple is 12.6% of all city trees; has >20% mortality (Earthwatch)
  - Any species with short life span will die by 2070

Baseline Model 2030 & 2070

- Temperature Increase
  - Cambridge shift from 6b to 7a hardiness zone by 2070
  - Remove species outside hardiness zone by 2070
- Topics
  - Tree outside hardiness zone today are removed in 2030

Extreme Events 2030

- Rejected events with poor data, poor predictability, small effect
- 100-year flood in areas of 2ft depth with duration of more than 1 day will affect flood intolerant species, especially individuals in poor condition
- Moderate drought will affect drought intolerant species, especially individuals in poor condition
- Condition derived from reflectivity in LiDAR

Model Steps Baseline 2030

- Step 1: Remove trees that are outside the temperature/hardiness zone
- Black Ash, Bigtooth Aspen, Pin Cherry, Balsam Fir, Red Pine, and Tamarack.

- Step 2: Remove trees with lifespan shorter than 12 years (this does not apply to any trees in 2030 but would apply in 2070)
- This does not include the current age of trees already located in the city
- 12 years is derived from 2030-2018

- Step 3: Tree species are assumed to have mortality rate of 4.5%. Based on pests/ disease loading, adjust mortality rate above or below 4.5% (+/- 2%).

- Step 4: For trees that are in close proximity to pavement, these trees will have an added 2% mortality rate. We distinguish between street trees and non-street trees by assuming trees within 15’ from the impervious layer (subtracting buildings) are street trees.

Model Steps Extreme Events

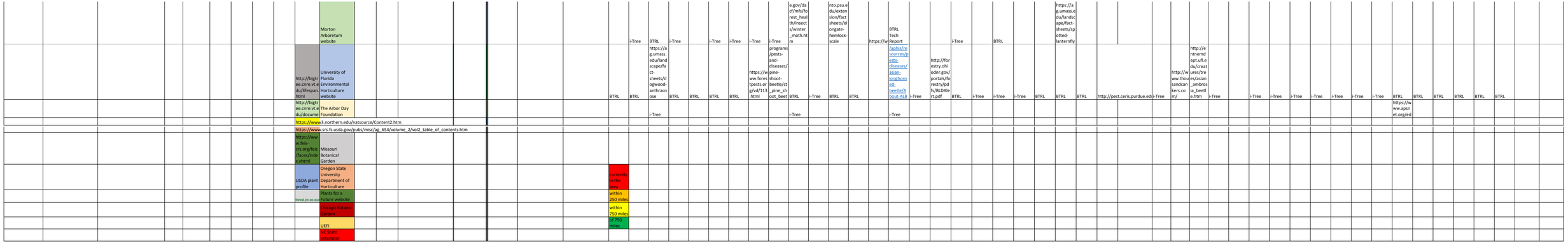
- Additive to Baseline Mortality in 2030
  - Flooding: Trees are removed if they meet all three of the following criteria: will experience 2’ of standing water, are a flood intolerant species, and are in poor condition.
  - Moderate Drought: All drought intolerant trees in poor condition are removed.

CAMBRIDGE TREE SPECIES CLIMATE PESTS AND DISEASES RISKS SPREADSHEET

| | | | | | | | | | | | | | | Present in Middlesex County | | | | | | | | | | | | | | | | | | | | Within 250 Miles of Middlesex County in 2014 -OR- Could be present by 2030 | | | | | | | | | | | | | | | | Within 750 Miles From Mid | Farther Than 750 Miles From Middlesex County in 2014 -OR-Currently overseas | | | | | | | | | | | | | | | | | | |

| | | |

| Genus | Species | Comm_Name | Total Count in 5% Sample | % of Sample Population | % Dead Condition in Sample | % Fair Condition in Sample | % Good Condition in Sample | % Poor Condition in Sample | Average Lifespan | Hardiness Zones (Cambridge in Zone 6b) | Outside Hardiness Zone 6b in 2018? | Outside Hardiness Zone 7a (assume in 2070)? | Average Annual Extreme Minimum Temp (USDA) | Flood Tolerance Summary | Drought Final | Summary Pest/Disease Annual Mortality Level by 2030 (change up or down from 4.5% based on pest/disease load, based on red and orange columns) | Adjusted Pest/Disease Annual Mortality Level by 2030 (2.5, 4.5, 7.5 adjusted upward for species that will be gone by 2030) | Present in Middlesex County: Beech Bark Disease | Chestnut Blight | Anthracnose | Dutch Elm Disease | Emerald Ash Borer | Gypsy Moth | Hemlock Wooly Adelgid | Large Aspen Tortrix | Pine Shoot Beetle | Winter Moth | White Pine Blister Rust | Elongate Hemlock Scale | Needlecast | Butternut Canker | Within 250 Miles of Middlesex County in 2014 -OR- Could be present by 2030: Asian Longhorned Beetle | Balsam Wooly Adelgid | Beech Leaf Disease | Oak Wilt | Spruce Beetle | Southern Pine Beetle | Sirex Wood Wasp | Pear Thrilla Rust | Spotted Lanternfly | Bacterial Leaf Scorch | Velvet longhorned beetle | EFFECT OF THESE SPECIES WITHIN THE STUDY TIME PERIOD (2019-2070) UNKNOWN DUE TO UNCERTAINTIES OF SPREAD MECHANISMS | Within 750 Miles From Mid: Aspen Leafminer | Thousand Canker Disease | Ambrosia Beetle (exotic) | Farther Than 750 Miles From Middlesex County in 2014 -OR-Currently overseas: Douglas-fir Black Stain Root Disease | Laurel Wilt Disease | Douglas-fir Beetle | Fir Engraver | Mountain Pine Beetle | Northern Spruce Engraver | Polyphagous Shot Hole Borer | Sudden Oak Death | Western Spruce Budworm | Pine Wilt Nematode | Japanese Oak Wilt | Ash Dieback | Spruce Bark Beetle | Beech Bleeding Canker | Large Pine Weevil | Heat Stress Tolerance (use 2-3 papers, & plant hardiness zone's southern limit? - tolerant, intermedia te | American Horticultur e Society Plant Heat-Zone Rating |
|---|---|---


Morton Arboretum website
http://bigtree.cnre.vt.edu/lifespan.html
University of Florida Environmental Horticulture website
http://bigtree.cnre.vt.edu/docume
The Arbor Day Foundation
https://www3.northern.edu/natsource/Content2.htm
https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_2/vol2_table_of_contents.htm
https://www.feis-crs.org/feis/faces/index.xhtml
Missouri Botanical Garden
USDA plant profile
Oregon State University Department of Horticulture
forest.jrc.ec.eu
Plants for a Future website
Chicago Botanic Garden
UEFI
NC State extension
currently in the area
within 250 miles
within 750 miles
>750 miles
i-Tree
BTRL
https://ag.umass.edu/landscape/fact-sheets/dogwood-anthracnose
https://www.fores.tpests.org/vd/113_.html
i-Tree programs/pests-and-diseases/pine-shoot-beetle/ctpine_shoot_beet
e.gov/dacf/mfs/forest_health/insects/winter_moth.htm
nto.psu.edu/extension/factsheets/elongate-hemlock-scale
https://www
BTRL Tech Report
/aphis/resources/pests-diseases/asian-longhorned-beetle/About-ALB
http://forestry.ohiodnr.gov/portals/forestry/pdfs/BLDAlert.pdf
https://ag.umass.edu/landscape/fact-sheets/spotted-lanternfly
http://www.thousandcankers.com/
http://entnemdept.ufl.edu/creatures/trees/asian_ambrosia_beetle.htm
http://pest.ceris.purdue.edu
https://www.apsnet.org/ed

CAMBRIDGE UFMP MODEL PARAMETERS

Cambridge Urban Forest - Conservative Climate Impact Model
Parameters for Establishing Baseline Mortality Levels and Mortality from an Extreme Event (from Janowiak et al. 2018)
Team Reviewed 8/9/2018; Team Revised 9/6/2018, 9/14/2018 & 10/4/2018

Baseline Mortality Model - Calibrate to Current Mortality Rates and Add Increased Pest/Disease Loading & Temperature Increas; Separate Pavement Trees from Residential/Park Trees; add Longevity Factor						
Parameter	**Use in Model?**	**Change in Parameter**	**Metric Background**	**Potential Effect**	**Application in Model**	**Data Source**
Pests & Diseases	Yes	Increasing severity of existing pests & diseases; potential for new pests & diseases	Severity estimated for pest/disease load from present time to 2030	Loss of species - hemlock (woolly adelgid), white pine (blister rust), ash (emerald ash borer), etc.	Assume an average baseline annual mortality rate across the urban forest of 4.5% (which includes pest/disease effects). Decrease or increase the mortality level (to 2.5 or 6.5) for tree species based on pest/disease load from the present time to 2030.	i-Tree. 2018; Bartlett Tree Research Laboratories. Research Laboratory Technical Report. 2018; https://ag.umass.edu/landscape/fact-sheets/dogwood-anthracnose. UMASS Extension. Dogwood Anthracnose. Accessed 09/01/2018; https://www.forestpests.org/vd/113.html. Forest Pest Insects in North America: a Photographic Guide. Large Aspen Tortrix. Accessed 09/01/2018; https://www.apsnet.org/edcenter/intropp/lessons/Nematodes/Pages/PineWilt.aspx. The American Pathological Society. Pine Wilt Disease. Accessed 09/01/2018; http://entnemdept.ufl.edu/creatures/trees/asian_ambrosia_beetle.htm. UF|IFAS. Featured Creatures. Granulate Ambrosia Beetle. Accessed 09/01/2018; http://www.thousandcankers.com/. Thousandcankers.com. Thousand Cankers Disease. Accessed 09/01/2018; http://pest.ceris.purdue.edu/pest.php?code=INALQPA. Purdue University. Pest Tracker. Velvet longhorned beetle. Accessed 09/01/2018; https://ag.umass.edu/landscape/fact-sheets/spotted-lanternfly. UMASS Extension. Spotted Lanternfly. Accessed
Temperature	Yes	Increasing temperature	Northward shift in plant hardiness zones results in species with a northern distribution moving out of normal temperature ranges for that species; species hardiness zone preference is compared to future hardiness zone locations in 2018 and 2070	Steady, gradual die-off of trees at south edge of range (e.g., aspen, birch, spruce, fir); steady increase in species at center or north edge of range (e.g., red maple red oak, black cherry, Am. basswood)	Use USDA Plant Hardiness Zone to identify species that currently are, or will be by 2070, outside the hardiness zones for which they are rated. Remove currently out-of-zone species from the forest by 2030, and future out-of-zone species by 2070	https://hort.ifas.ufl.edu/database/trees/trees_scientific.shtml. University of Florida. Environmental Horticulture. 680 Tree Fact Sheets. Accessed 09/05/2018; http://www.mortonarb.org/trees-plants/search-trees/search-all-trees-and-plants. The Morton Arboretum. Search Trees and Plants. Accessed 09/05/2018; https://www.arborday.org/trees/whattree/easterntrees.cfm. Arbor Day Foundation. Eastern & Central U.S. Trees. Accessed 09/05/2018; http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx. Missouri Botanical Garden. Plant Finder. Accessed 09/05/2018; https://oregonstate.edu/dept/ldplants/.

Parameter	Use in Model?	Change in Parameter	Metric Background	Potential Effect	Application in Model	Data Source
Temperature	Yes	Increasing temperature	Northward shift in plant hardiness zones results in species with a northern distribution moving out of normal temperature ranges for that species; species hardiness zone preference is compared to future hardiness zone locations in 2018 and 2070	Steady, gradual die-off of trees at south edge of range (e.g., aspen, birch, spruce, fir); steady increase in species at center or north edge of range (e.g., red maple red oak, black cherry, Am. basswood)	Use USDA Plant Hardiness Zone to identify species that currently are, or will be by 2070, outside the hardiness zones for which they are rated. Remove currently out-of-zone species from the forest by 2030, and future out-of-zone species by 2070	Trees and Plants. Accessed 09/05/2018; https://www.arborday.org/trees/whattree/easterntrees.cfm. Arbor Day Foundation. Eastern & Central U.S. Trees. Accessed 09/05/2018; http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx. Missouri Botanical Garden. Plant Finder. Accessed 09/05/2018; https://oregonstate.edu/dept/ldplants/. Oregon State University. Department of Horticulture. Landscape Plants. Accessed 09/05/2018; https://pfaf.org/user/Default.aspx. Plants For A Future. Accessed 09/05/2018.
Pavement Proximity	Yes	Not applicable	In proximity to pavement (street, parking lot, drive, etc.) air temperatures in summer are significantly higher than at locations away from pavement (e.g., 90 F vs. 125 F). Salt levels also build up in soil near pavement due to winter snow removal. Trees near pavement, therefore, are expected to have high mortality rates than trees away from pavement.	Not applicable	Use Cambridge impervious cover layer and remove buildings, leaving streets, parking lots, drives, etc. Buffer resulting pavement layer by 15 feet. Assign all trees whose centroid is within the resulting pavement + buffer an annual mortality rate 2 percentage points higher than the mortality rate due to pest/disease loading (see above).	EarthWatch study 2011 reported higher mortality rates of street trees versus non-street trees, but regression model was weakly predictive (low r2). Need other citiations documenting shorter life of trees near streets compared to residential and park areas.
Longevity	Yes	Not applicable	An existing tree has expended part of its lifespan and may die by 2070; shorter-lived trees have the greatest potential to die by 2070	Not applicable	Use available sources to identify the average longevity of tree species. Assume average age of urban tree is 20 years and that some species will grow only 50 more years to 2070. Remove all trees at 2070 with average longevity less than 70 years (80 years?)	https://plants.usda.gov/java/. United States Department of Agriculture. Natural Resources Conseration Service. Plants Database. Accessed 09/15/2018; http://bigtree.cnre.vt.edu/lifespan.html. Virginia BIG Trees. Lifespans of Common Trees in Virginia. Accessed 09/15/2018; Loehle. Tree life history strategies: the role of defenses. Canadian Journal of Forest Research. 1987; https://www3.northern.edu/natsource/Content2.htm. Northern State University. The Natural Source. Accessed 09/15/2018; https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_2/vol2_table_of_contents.htm. United States Department of Agriculture Forest Service. Volume 2: Hardwoods. Accessed 09/15/2018; https://www.feis-crs.org/feis/faces/index.xhtml. United Stated Department of Agriculture. Fire Effects Information System (FEIS). Accessed 09/15/2018; file:///C:/Users/Nmartin/Downloads/Fagus_sylvatica.pdf. T.H. Durrant, D. de Rigo,G. Caudullo. Fagus Sylvatica in Eupore: distribution, habitat, usage and threats. European Atlas of Forest Tree

Extreme Event Model - Model Event Effect and Develop Emergency Planting Plan for Each Event						
Parameter	**Use in Model**	**Change in Parameter**	**Metric Background**	**Potential Effect**	**Recommendation for Model**	**Data Source**
Flooding From Precipitation	Yes	Greater frequency of large precipitation events resulting in flooding of low-lying areas	Severity of large storms will increase due to larger precipitation volumes; worst case scenario for which modeling is available is a 100-year, 24-hour storm	Death of individual trees of flood intolerant species that are in poor or fair condition	Using CCVA modeling, identify locations affected by a 100-year, 24-hour storm in 2030 (with slightly higher precipitation volume at that time) and which have flood duration greater than 48 hours; identify each species as flood tolerant, intolerant, or intermediately tolerant; remove all poor condition trees of flood intolerant species at locations with greater than 2 foot flood depth in a 2030 flooding event (assume one 100-yr, 24-hr storm in 2018-2044 period)	Flood extent, depth and duration obtained from the latest flood maps using the City's ICM 2D model (June 2018 version); Iowa State University. University Extension. Understanding the Effects of Flooding on Trees. June 1994; University of Tennessee Agriculture Extension Service. SP656 Shade and Flood Tolerance of Trees. 2005; United States Department of Agriculture. Field Guide for Managing Tree-of-heaven in teh Southwest. September 2014; http://woodyplants.cals.cornell.edu/home. Cornell University. Woody Plants Database. Accessed 09/10/2018; Cregg.Landscape Management. Right Tree: Right Place Flooding and poor drainage. July/August 2014; https://plants.usda.gov/java/. United States Department of Agriculture. Natural Resources Conseration Service. Plants Database. Accessed 09/10/2018.
Drought	Yes	Increased frequency and duration of drought events	Increase in frequency of 1-3 month droughts due to higher temperatures with little precipitation increase; higher frequency of 1-3 month drought most likely to occur in summer and fall; possibility exists for a moderate drought (3-6 months) in next 50 years	Death of drought intolerant species; lower growth rates for surviving trees during drought years; increased susceptibility in surviving trees to death from additive factors (e.g., pest/disease)	Identify each species as drought tolerant, intolerant, or intermediately tolerant; remove all poor and fair condition trees of drought intolerant species in a 2030 moderate drought event (3-6 month duration)	https://hort.ifas.ufl.edu/database/trees/trees_scientific.shtml. University of Florida. Environmental Horticulture. 680 Tree Fact Sheets. Accessed 09/05/2018; https://plants.usda.gov/java/. United States Department of Agriculture. Natural Resources Conseration Service. Plants Database. Accessed 09/10/2018.:Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. Degaetano, T.J. Troy and D. Wolfe. 2006. Past and future changes in climate and hydrological indicators in the U.S. Northeast. Climate Dynamics 28:381–407.

DATA INPUTS FOR CAMBRIDGE TREE CANOPY LOSS MODEL

Data Inputs for Cambridge Tree Canopy Loss Model - FINAL
March 25, 2019

1. **Model – Internal Run Sequence**
   - Lower and Upper Bounds
     - 2018-2030 baseline loss; 2030-2050 baseline loss; 2050-2070 baseline loss
     - 2018-2030 baseline loss with loss due to flood extreme event in 2030; 2030-2050 baseline loss; 2050-2070 baseline loss
     - 2018-2030 baseline loss; 2030-2050 baseline loss with loss due to drought extreme event in 2050; 2050-2070 baseline loss

2. **Model Runs – Time Period, Inputs, Outputs**

2018-2030 – Lower Bound
- For baseline canopy loss rate, model removes trees using canopy loss rate, with minor adjustments; additional run for flood extreme event
- Tree canopy loss rates are 0.3%, 1.0%, and 1.7% per year
- Inputs:
  - 2018 Tree Canopy Layer
    - Polygon area
    - Annual tree canopy loss rate
    - Hardiness Zone – in Excel tables, remove species currently out of zone
    - For flood extreme event modeling, use projected 2030 flood extent and remove flood intolerant species
  - Summary Statistics Excel file for each tree species with total area
- Outputs
  - Shapefile of Tree Canopy with individual polygons (City-wide tree canopy)
    - Spatially explicit
  - Shapefile of Tree Canopy with dissolved polygons for individual tree species
    - Spatially explicit
  - Summary Statistics Excel file for tree species, with total area for each
    - Not spatially explicit

2018-2030 – Upper Bound
- Inputs and outputs the same as lower bound model run, but doubles tree canopy loss rate
- Tree canopy loss rates are 0.6%, 2.0%, and 3.4% per year

2030 – 2050 – Lower Bound

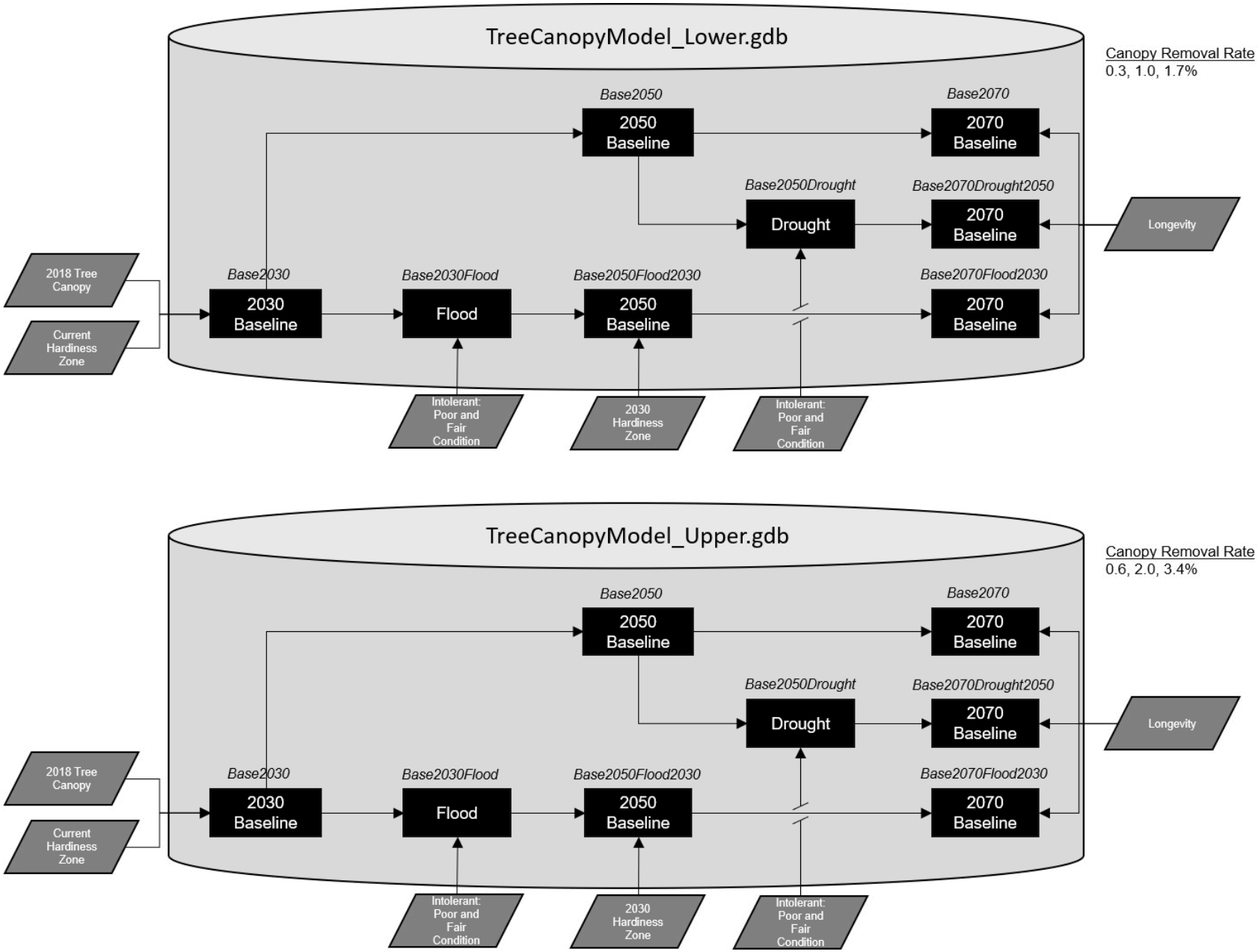
- For baseline canopy loss rate, model removes trees using canopy loss rate and hardiness zone; additional run for drought extreme event
- Tree canopy loss rates are 0.3%, 1.0%, and 1.7% per year
- Inputs:
  - 2030 Tree Canopy Layer
    - Polygon area
    - Tree canopy loss rate
    - Hardiness Zone – remove all trees that fall out of future Hardiness Zone
    - For drought extreme event, remove drought intolerant trees
  - Summary Statistics Excel file for each tree species with total area
- Outputs
  - Shapefile of Tree Canopy with individual polygons (City-wide tree canopy)
    - Spatially explicit
  - Shapefile of Tree Canopy with dissolved polygons for individual tree species
    - Spatially explicit
  - Summary Statistics Excel file for tree species, with total area for each
    - Not spatially explicit

2030-2050 – Upper Bound
- Inputs and outputs the same as lower bound model run, but doubles tree canopy loss rate
- Tree canopy loss rates are 0.6%, 2.0%, and 3.4% per year

2050 – 2070 – Lower Bound
- Removes trees based on canopy loss rate and longevity
- Canopy loss rates are 0.3%, 1.0%, and 1.7% per year
- Inputs:
  - 2050 Tree Canopy Layer
    - Polygon area
    - Canopy loss rate
    - Lifespan – remove species with lifespan shorter than 2018-2070 period
  - Summary Statistics Excel file for each tree species with total area
- Outputs
  - Shapefile of Tree Canopy with individual polygons (City-wide tree canopy)
    - Spatially explicit
  - Shapefile of Tree Canopy with dissolved polygons for individual tree species
    - Spatially explicit
  - Summary Statistics Excel file for tree species, with total area for each
    - Not spatially explicit

2050-2070 – Upper Bound
- Inputs and outputs the same as lower bound model run, but doubles tree canopy loss rate
- Tree canopy loss rates are 0.6%, 2.0%, and 3.4% per year

TREE CANOPY MODEL - OUTPUT FLOW CHART- NAMING CONVENTIONS



BASE 2030 FLOODTABLE LOWER 2

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	2030 City Canopy Acres -baseline	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	difference
Prunus Ã— yedoensis	Yoshino Cherry	1.0	7	0.08	0.01	0.00	0.00	0.07	0.00	0.08	-0.07
Stewartia sp	Stewartia	0.3	4	0.03	0.00	2.00	0.03	0.03	0.00	0.01	0.00
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	127.00	2.12	2.19	0.25	0.60	-0.07
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	118.00	1.50	1.52	0.18	0.39	-0.02
Acer campestre	Hedge Maple	1.7	299	4.63	0.45	273.00	3.69	3.73	0.44	0.94	-0.03
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.12	421.00	9.33	9.41	1.11	2.35	-0.08
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.27	1302.00	18.95	19.00	2.26	4.66	-0.06
Tilia americana	Basswood	1.7	550	13.79	1.33	497.00	11.07	11.11	1.32	2.72	-0.03
Acer platanoides	Norway Maple	1.7	7810	192.08	18.47	7047.00	154.25	154.65	18.42	37.83	-0.40
Prunus sp	Cherry	1.0	277	3.75	0.36	264.00	3.28	3.29	0.39	0.47	-0.01
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.70	608.00	6.95	6.96	0.83	0.35	-0.01
Quercus alba	White Oak	1.7	130	3.33	0.32	115.00	2.68	2.68	0.32	0.65	-0.01
Acer palmatum	Japanese Maple	1.7	141	1.83	0.18	130.00	1.47	1.47	0.18	0.36	0.00
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	471.00	4.98	4.99	0.60	0.25	-0.01
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.89	2000.00	57.62	57.66	6.88	14.00	-0.04
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.49	260.00	4.87	4.87	0.58	0.24	0.00
Abies concolor	White Fir	1.0	15	0.27	0.03	13.00	0.25	0.25	0.03	0.03	0.00
Abies sp	Fir	1.0	7	0.04	0.00	5.00	0.03	0.03	0.00	0.01	0.00
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	4.00	0.05	0.05	0.01	0.01	0.00
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	35.00	0.50	0.50	0.06	0.11	0.00
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	29.00	0.17	0.17	0.02	0.04	0.00
Acer negundo	Boxelder	1.7	7	0.29	0.03	5.00	0.25	0.25	0.03	0.04	0.00
Acer nigrum	Black Maple	1.7	3	0.08	0.01	1.00	0.04	0.04	0.00	0.05	0.00
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.57	181.00	4.74	4.74	0.57	1.14	0.00
Acer rubrum	Red Maple	1.7	4461	71.75	6.90	4100.00	57.77	57.77	6.90	13.98	0.00
Acer saccharinum	Silver Maple	1.7	344	7.86	0.76	309.00	6.33	6.33	0.76	1.53	0.00
Acer saccharum	Sugar Maple	1.7	968	27.20	2.62	878.00	21.90	21.90	2.62	5.30	0.00
Acer sp	Maple	1.7	15	0.17	0.02	12.00	0.13	0.13	0.02	0.04	0.00
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	20.00	0.22	0.22	0.03	0.05	0.00
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	35.00	0.40	0.40	0.05	0.09	0.00
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.21	125.00	1.73	1.73	0.21	0.42	0.00
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	69.00	1.96	1.96	0.23	0.27	0.00
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	13.00	0.38	0.38	0.05	0.05	0.00
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	29.00	0.25	0.25	0.03	0.01	0.00
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	216.00	3.59	3.59	0.43	0.17	0.00
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	7.00	0.03	0.03	0.00	0.00	0.00
Betula nigra	River Birch	1.7	180	2.83	0.27	166.00	2.28	2.28	0.27	0.55	0.00
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	39.00	0.41	0.41	0.05	0.10	0.00
Betula pendula	European White Birch	1.7	39	0.70	0.07	35.00	0.56	0.56	0.07	0.13	0.00
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	36.00	0.73	0.73	0.09	0.17	0.00
Betula sp	Birch	1.7	22	0.61	0.06	18.00	0.49	0.49	0.06	0.12	0.00
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	63.00	0.65	0.65	0.08	0.16	0.00
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	40.00	0.72	0.72	0.09	0.03	0.00
Carya sp	Hickory	1.0	3	0.04	0.00	2.00	0.04	0.04	0.00	0.01	0.00
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	46.00	1.29	1.29	0.15	0.06	0.00
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	137.00	2.12	2.12	0.25	0.51	0.00
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	57.00	0.96	0.96	0.11	0.23	0.00
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.32	169.00	2.65	2.65	0.32	0.64	0.00
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	56.00	1.39	1.39	0.17	0.19	0.00
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	179.00	2.61	2.61	0.31	0.63	0.00
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	1.00	0.03	0.03	0.00	0.02	0.00
Cornus sp	Dogwood	1.7	4	0.03	0.00	2.00	0.02	0.02	0.00	0.01	0.00
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	3.00	0.02	0.02	0.00	0.00	0.00
Cotinus sp	Smoketree	1.7	20	0.40	0.04	15.00	0.33	0.33	0.04	0.07	0.00
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	52.00	0.73	0.73	0.09	0.17	0.00
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	8.00	0.30	0.30	0.04	0.01	0.00
Eucommia ulmoides	Hardy Rubber Tree	0.3	9	0.01	0.00	8.00	0.01	0.01	0.00	0.00	0.00
Fagus grandifolia	American Beech	1.7	10	0.16	0.02	7.00	0.14	0.14	0.02	0.02	0.00
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	109.00	3.04	3.04	0.36	0.73	0.00
Fraxinus americana	White Ash	1.7	345	11.10	1.07	311.00	4.47	4.47	0.53	6.63	0.00
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.74	1040.00	12.47	12.47	1.49	15.97	0.00
Fraxinus sp	Ash	1.7	90	2.29	0.22	80.00	0.92	0.92	0.11	1.36	0.00
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.58	7124.00	151.21	151.21	18.05	21.25	0.00
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	165.00	2.90	2.90	0.35	0.14	0.00
Hamamelis sp	Witchhazel	0.3	5	0.03	0.00	3.00	0.01	0.01	0.00	0.02	0.00
Ilex opaca	American Holly	0.3	10	0.38	0.04	8.00	0.34	0.34	0.04	0.04	0.00

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	2030 City Canopy Acres -baseline	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	difference
Ilex sp	Holly	0.3	7	0.05	0.00	5.00	0.04	0.04	0.00	0.01	0.00
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	15.00	0.50	0.50	0.06	0.13	0.00
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	75.00	1.04	1.04	0.12	0.05	0.00
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	123.00	1.37	1.37	0.16	0.33	0.00
Larix sp	Larch	1.7	4	0.13	0.01	2.00	0.04	0.04	0.01	0.09	0.00
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.56	362.00	4.68	4.68	0.56	1.13	0.00
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.62	272.00	5.70	5.70	0.68	0.80	0.00
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	76.00	1.27	1.27	0.15	0.06	0.00
Magnolia sp	Magnolia	0.3	196	3.04	0.29	190.00	2.90	2.90	0.35	0.14	0.00
Magnolia stellata	Star Magnolia	0.3	3	0.02	0.00	2.00	0.01	0.01	0.00	0.00	0.00
Magnolia x soulangiana	Saucer Magnolia	0.3	3	0.01	0.00	2.00	0.01	0.01	0.00	0.00	0.00
Malus sp	Flowering Crabapple	1.7	458	6.10	0.59	423.00	4.91	4.91	0.59	1.19	0.00
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	48.00	1.32	1.32	0.16	0.05	0.00
Morus alba	White Mulberry	1.0	33	1.28	0.12	30.00	1.12	1.12	0.13	0.16	0.00
Morus rubra	Red Mulberry	1.0	4	0.13	0.01	2.00	0.05	0.05	0.01	0.08	0.00
Morus sp	Mulberry	1.0	38	1.13	0.11	35.00	1.00	1.00	0.12	0.13	0.00
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	16.00	0.29	0.29	0.04	0.07	0.00
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	3.00	0.04	0.04	0.00	0.02	0.00
Oxydendrum arboreum	Sourwood	1.7	6	0.02	0.00	3.00	0.02	0.02	0.00	0.00	0.00
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	32.00	0.75	0.75	0.09	0.03	0.00
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	89.00	1.63	1.63	0.19	0.08	0.00
Picea abies	Norway Spruce	1.7	40	1.04	0.10	35.00	0.85	0.85	0.10	0.20	0.00
Picea glauca	White Spruce	1.7	6	0.06	0.01	4.00	0.05	0.05	0.01	0.02	0.00
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	48.00	0.74	0.74	0.09	0.17	0.00
Picea sp	Spruce	1.7	5	0.02	0.00	4.00	0.02	0.02	0.00	0.00	0.00
Pinus sp	Pine	1.7	101	5.35	0.51	88.00	4.31	4.31	0.52	1.03	0.00
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	7.00	0.15	0.15	0.02	0.03	0.00
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.48	1828.00	29.14	29.14	3.48	7.05	0.00
Platanus occidentalis	Sycamore	1.7	964	32.40	3.12	872.00	26.09	26.09	3.11	6.31	0.00
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.08	18.00	0.64	0.64	0.08	0.15	0.00
Populus sp	Poplar	1.7	31	0.40	0.04	24.00	0.33	0.33	0.04	0.08	0.00
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	15.00	0.41	0.41	0.05	0.09	0.00
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.25	189.00	2.24	2.24	0.27	0.31	0.00
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	10.00	0.49	0.49	0.06	0.10	0.00
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	132.00	2.09	2.09	0.25	0.29	0.00
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	40.00	0.90	0.90	0.11	0.13	0.00
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	12.00	0.54	0.54	0.06	0.10	0.00
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	62.00	0.85	0.85	0.10	0.12	0.00
Pyrus sp	Pear	1.7	13	0.10	0.01	11.00	0.08	0.08	0.01	0.02	0.00
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.77	321.00	6.49	6.49	0.77	1.57	0.00
Quercus imbricaria	Shingle Oak	1.7	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	1.00	0.09	0.09	0.01	0.09	0.00
Quercus palustris	Pin Oak	1.7	3676	107.61	10.35	3326.00	86.64	86.64	10.34	20.97	0.00
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	7.00	0.31	0.31	0.04	0.07	0.00
Quercus robur	English Oak	1.0	11	0.17	0.02	9.00	0.15	0.15	0.02	0.01	0.00
Quercus sp	Oak	1.7	38	0.54	0.05	34.00	0.45	0.45	0.05	0.09	0.00
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.47	155.00	3.95	3.95	0.47	0.96	0.00
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.07	15.00	0.66	0.66	0.08	0.03	0.00
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	41.00	1.59	1.59	0.19	0.10	0.00
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	114.00	4.01	4.01	0.48	0.19	0.00
Salix babylonica	Weeping Willow	1.7	56	1.42	0.14	48.00	1.15	1.15	0.14	0.27	0.00
Salix sp	Willow	1.7	51	1.31	0.13	43.00	1.05	1.05	0.13	0.25	0.00
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	2.00	0.06	0.06	0.01	0.02	0.00
Taxus sp	Yew	1.0	11	0.07	0.01	9.00	0.07	0.07	0.01	0.01	0.00
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	12.00	0.19	0.19	0.02	0.01	0.00
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	3.00	0.11	0.11	0.01	0.03	0.00
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.31	1744.00	27.73	27.73	3.31	6.71	0.00
Tilia europaea	European Linden	1.7	39	1.26	0.12	33.00	1.02	1.02	0.12	0.24	0.00
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	81.00	1.49	1.49	0.18	0.36	0.00
Abies balsamea	Balsam Fir	1.0	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acer freemanii	Freeman Maple	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carpinus betulus	European Hornbeam	0.3	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Castanea dentata	American Chestnut	1.7	2	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Cedrus libani	Cedar of Lebanon	0.3	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Chamaecyparis sp	Falsecypress	0.3	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Enkianthus campanulatus	Enkianthus	0.3	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	2030 City Canopy Acres -baseline	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	difference
Fraxinus nigra	Black Ash	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Halesia carolina	Carolina Siverbell	0.3	2	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Larix laricina	Tamarack	1.7	2	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Malus pumila	Apple	1.7	1	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Pinus banksiana	Jack Pine	1.7	1	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Pinus parviflora	Japanese White Pine	1.7	2	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Pinus resinosa	Red Pine	1.7	255	4.21	0.40	0.00	0.00	0.00	0.00	4.21	0.00
Prunus pennsylvanica	Pin Cherry	1.7	3	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Pseudotsuga menziesii	Douglas Fir	1.0	2	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Quercus coccinea	Scarlet Oak	1.7	1	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Salix alba	White Willow	1.7	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Sorbus alnifolia	Korean Mountain Ash	1.7	2	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	35.00	0.84	***0.00***	0.10	0.20	0.84
Tsuga caroliniana	Carolina Hemlock	1.7	2	0.01	0.00	1.00	0.00	0.84	0.00	0.00	-0.84
Ulmus americana	American Elm	1.7	389	9.95	0.96	355.00	8.01	0.00	0.96	1.94	8.00
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	172.00	3.45	8.01	0.41	0.83	-4.56
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	31.00	0.75	3.45	0.09	0.18	-2.70
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	20.00	0.43	0.75	0.05	0.09	-0.32
Ulmus sp	Elm	1.7	793	13.52	1.30	735.00	10.89	0.43	1.30	2.64	10.46
Viburnum sp	Viburnum	0.3	4	0.03	0.00	2.00	0.03	10.89	0.00	0.01	-10.86
Zelkova serrata	Zelkova	0.3	761	16.35	1.57	750.00	15.61	0.03	1.86	0.75	15.58
								15.61			

BASE 2030 FLOODTABLE LOWER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030
		% Surviving Baseline	% Surviving under flooding - upper	% Surviving under flooding - lower					
Gleditsia triacanthos	Common Thornless Honeylocust	70.4%	78%	88%					
Acer platanoides	Norway Maple	56.1%	65%	80%					
Quercus palustris	Pin Oak	56.1%	65%	81%					
Acer rubrum	Red Maple	56.1%	65%	81%					
Quercus rubra	Northern Red Oak	56.1%	65%	80%					
Platanus acerifolia	London Planetree	56.1%	65%	81%					
Tilia cordata	Littleleaf Linden	56.1%	65%	81%					
Platanus occidentalis	Sycamore	56.1%	65%	81%					
Acer saccharum	Sugar Maple	56.1%	65%	81%					
Pyrus calleryana	Callery Pear		65%	80%					
Zelkova serrata	Zelkova	88.3%	92%	95%					

BASE 2030 FLOODTABLE LOWER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% surviving
Total		*NA*	*NA*	*0.00*	*NA*	*NA*	*871.00*	*NA*	*0.00*	
Acer platanoides	Norway Maple	1.7	7810	192.08	18.19	7047.00	154.25	8.95	37.83	80%
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.33	7124.00	151.21	8.77	21.25	88%
Quercus palustris	Pin Oak	1.7	3676	107.61	10.19	3326.00	86.64	5.02	20.97	81%
Acer rubrum	Red Maple	1.7	4461	71.75	6.79	4100.00	57.77	3.35	13.98	81%
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.78	2000.00	57.62	3.34	14.00	80%
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.43	1828.00	29.14	1.69	7.05	81%
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.26	1744.00	27.73	1.61	6.71	81%
Platanus occidentalis	Sycamore	1.7	964	32.40	3.07	872.00	26.09	1.51	6.31	81%
Acer saccharum	Sugar Maple	1.7	968	27.20	2.58	878.00	21.90	1.27	5.30	81%
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.23	1302.00	18.95	1.10	4.66	80%
Zelkova serrata	Zelkova	0.3	761	16.35	1.55	750.00	15.61	0.91	0.75	95%
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.69	1040.00	12.47	0.72	15.97	44%
Tilia americana	Basswood	1.7	550	13.79	1.31	497.00	11.07	0.64	2.72	80%
Ulmus sp	Elm	1.7	793	13.52	1.28	735.00	10.89	0.63	2.64	81%
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.11	421.00	9.33	0.54	2.35	80%
Ulmus americana	American Elm	1.7	389	9.95	0.94	355.00	8.01	0.46	1.94	81%
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.69	608.00	6.95	0.40	0.35	95%
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.76	321.00	6.49	0.38	1.57	81%
Acer saccharinum	Silver Maple	1.7	344	7.86	0.74	309.00	6.33	0.37	1.53	81%
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.61	272.00	5.70	0.33	0.80	88%
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	471.00	4.98	0.29	0.25	95%
Malus sp	Flowering Crabapple	1.7	458	6.10	0.58	423.00	4.91	0.28	1.19	81%
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.48	260.00	4.87	0.28	0.24	95%
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	181.00	4.74	0.27	1.14	81%
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.55	362.00	4.68	0.27	1.13	81%
Fraxinus americana	White Ash	1.7	345	11.10	1.05	311.00	4.47	0.26	6.63	40%
Pinus sp	Pine	1.7	101	5.35	0.51	88.00	4.31	0.25	1.03	81%
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	114.00	4.01	0.23	0.19	95%
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.46	155.00	3.95	0.23	0.96	81%
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	273.00	3.69	0.21	0.94	80%
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	216.00	3.59	0.21	0.17	95%
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	172.00	3.45	0.20	0.83	81%
Prunus sp	Cherry	1.0	277	3.75	0.36	264.00	3.28	0.19	0.47	87%
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	109.00	3.04	0.18	0.73	81%
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	165.00	2.90	0.17	0.14	95%
Magnolia sp	Magnolia	0.3	196	3.04	0.29	190.00	2.90	0.17	0.14	95%
Quercus alba	White Oak	1.7	130	3.33	0.32	115.00	2.68	0.16	0.65	80%
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.31	169.00	2.65	0.15	0.64	81%
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	179.00	2.61	0.15	0.63	81%
Betula nigra	River Birch	1.7	180	2.83	0.27	166.00	2.28	0.13	0.55	81%
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.24	189.00	2.24	0.13	0.31	88%
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	127.00	2.12	0.12	0.60	78%
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	137.00	2.12	0.12	0.51	81%
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	132.00	2.09	0.12	0.29	88%
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	69.00	1.96	0.11	0.27	88%
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.20	125.00	1.73	0.10	0.42	81%
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	89.00	1.63	0.09	0.08	96%
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	41.00	1.59	0.09	0.10	94%
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	118.00	1.50	0.09	0.39	79%
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	81.00	1.49	0.09	0.36	81%
Acer palmatum	Japanese Maple	1.7	141	1.83	0.17	130.00	1.47	0.09	0.36	80%
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	56.00	1.39	0.08	0.19	88%
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	123.00	1.37	0.08	0.33	81%
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	48.00	1.32	0.08	0.05	96%
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	46.00	1.29	0.07	0.06	95%
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	76.00	1.27	0.07	0.06	95%
Salix babylonica	Weeping Willow	1.7	56	1.42	0.13	48.00	1.15	0.07	0.27	81%
Morus alba	White Mulberry	1.0	33	1.28	0.12	30.00	1.12	0.07	0.16	88%
Salix sp	Willow	1.7	51	1.31	0.12	43.00	1.05	0.06	0.25	81%
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	75.00	1.04	0.06	0.05	96%
Tilia europaea	European Linden	1.7	39	1.26	0.12	33.00	1.02	0.06	0.24	81%

Morus sp	Mulberry	1.0	38	1.13	0.11	35.00	1.00	0.06	0.13	88%
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	57.00	0.96	0.06	0.23	81%
Fraxinus sp	Ash	1.7	90	2.29	0.22	80.00	0.92	0.05	1.36	40%
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	40.00	0.90	0.05	0.13	88%
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	62.00	0.85	0.05	0.12	88%
Picea abies	Norway Spruce	1.7	40	1.04	0.10	35.00	0.85	0.05	0.20	81%
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	35.00	0.84	0.05	0.20	81%
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	31.00	0.75	0.04	0.18	81%
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	32.00	0.75	0.04	0.03	96%
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	48.00	0.74	0.04	0.17	81%
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	52.00	0.73	0.04	0.17	81%
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	36.00	0.73	0.04	0.17	81%
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	40.00	0.72	0.04	0.03	96%
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.06	15.00	0.66	0.04	0.03	96%
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	63.00	0.65	0.04	0.16	81%
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.07	18.00	0.64	0.04	0.15	81%
Betula pendula	European White Birch	1.7	39	0.70	0.07	35.00	0.56	0.03	0.13	81%
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	12.00	0.54	0.03	0.10	84%
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	15.00	0.50	0.03	0.13	79%
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	35.00	0.50	0.03	0.11	81%
Betula sp	Birch	1.7	22	0.61	0.06	18.00	0.49	0.03	0.12	80%
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	10.00	0.49	0.03	0.10	84%
Quercus sp	Oak	1.7	38	0.54	0.05	34.00	0.45	0.03	0.09	83%
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	20.00	0.43	0.02	0.09	82%
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	39.00	0.41	0.02	0.10	81%
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	15.00	0.41	0.02	0.09	81%
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	35.00	0.40	0.02	0.09	81%
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	13.00	0.38	0.02	0.05	89%
Ilex opaca	American Holly	0.3	10	0.38	0.04	8.00	0.34	0.02	0.04	88%
Cotinus sp	Smoketree	1.7	20	0.40	0.04	15.00	0.33	0.02	0.07	83%
Populus sp	Poplar	1.7	31	0.40	0.04	24.00	0.33	0.02	0.08	81%
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	7.00	0.31	0.02	0.07	81%
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	8.00	0.30	0.02	0.01	98%
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	16.00	0.29	0.02	0.07	82%
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	29.00	0.25	0.01	0.01	96%
Abies concolor	White Fir	1.0	15	0.27	0.03	13.00	0.25	0.01	0.03	91%
Acer negundo	Boxelder	1.7	7	0.29	0.03	5.00	0.25	0.01	0.04	85%
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	20.00	0.22	0.01	0.05	81%
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	12.00	0.19	0.01	0.01	96%
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	29.00	0.17	0.01	0.04	81%
Quercus robur	English Oak	1.0	11	0.17	0.02	9.00	0.15	0.01	0.01	92%
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	7.00	0.15	0.01	0.03	83%
Fagus grandifolia	American Beech	1.7	10	0.16	0.01	7.00	0.14	0.01	0.02	89%
Acer sp	Maple	1.7	15	0.17	0.02	12.00	0.13	0.01	0.04	76%
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	3.00	0.11	0.01	0.03	81%
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	1.00	0.09	0.01	0.09	50%
Pyrus sp	Pear	1.7	13	0.10	0.01	11.00	0.08	0.00	0.02	83%
Taxus sp	Yew	1.0	11	0.07	0.01	9.00	0.07	0.00	0.01	93%
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	2.00	0.06	0.00	0.02	75%
Morus rubra	Red Mulberry	1.0	4	0.13	0.01	2.00	0.05	0.00	0.08	41%
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	4.00	0.05	0.00	0.01	90%
Picea glauca	White Spruce	1.7	6	0.06	0.01	4.00	0.05	0.00	0.02	75%
Larix sp	Larch	1.7	4	0.13	0.01	2.00	0.04	0.00	0.09	34%
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	3.00	0.04	0.00	0.02	72%
Ilex sp	Holly	0.3	7	0.05	0.00	5.00	0.04	0.00	0.01	82%
Carya sp	Hickory	1.0	3	0.04	0.00	2.00	0.04	0.00	0.01	85%
Acer nigrum	Black Maple	1.7	3	0.08	0.01	1.00	0.04	0.00	0.05	43%
Abies sp	Fir	1.0	7	0.04	0.00	5.00	0.03	0.00	0.01	79%
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	7.00	0.03	0.00	0.00	88%
Viburnum sp	Viburnum	0.3	4	0.03	0.00	2.00	0.03	0.00	0.01	82%
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	1.00	0.03	0.00	0.02	63%
Stewartia sp	Stewartia	0.3	4	0.03	0.00	2.00	0.03	0.00	0.01	82%
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	3.00	0.02	0.00	0.00	85%
Cornus sp	Dogwood	1.7	4	0.03	0.00	2.00	0.02	0.00	0.01	68%

BASE 2030 FLOODTABLE UPPER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% Canopy Remaining
Total		*NA*	*NA*	*0.00*	*NA*	*NA*	*730.14*	*NA*	*0.00*	
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.33	6699.00	133.85	9.26	38.61	78%
Acer platanoides	Norway Maple	1.7	7810	192.08	18.19	6246.00	125.10	8.66	66.98	65%
Quercus palustris	Pin Oak	1.7	3676	107.61	10.19	2945.00	70.26	4.86	37.35	65%
Acer rubrum	Red Maple	1.7	4461	71.75	6.79	3681.00	46.85	3.24	24.90	65%
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.78	1771.00	46.72	3.23	24.90	65%
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.43	1639.00	23.63	1.64	12.56	65%
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.26	1561.00	22.48	1.56	11.95	65%
Platanus occidentalis	Sycamore	1.7	964	32.40	3.07	767.00	21.15	1.46	11.24	65%
Acer saccharum	Sugar Maple	1.7	968	27.20	2.58	780.00	17.76	1.23	9.44	65%
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.23	1166.00	15.37	1.06	8.23	65%
Zelkova serrata	Zelkova	0.3	761	16.35	1.55	740.00	15.05	1.04	1.30	92%
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.69	978.00	11.04	0.76	17.40	39%
Tilia americana	Basswood	1.7	550	13.79	1.31	440.00	8.97	0.62	4.82	65%
Ulmus sp	Elm	1.7	793	13.52	1.28	667.00	8.83	0.61	4.69	65%
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.11	370.00	7.55	0.52	4.13	65%
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.69	605.00	6.70	0.46	0.59	92%
Ulmus americana	American Elm	1.7	389	9.95	0.94	316.00	6.50	0.45	3.45	65%
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.76	291.00	5.26	0.36	2.80	65%
Acer saccharinum	Silver Maple	1.7	344	7.86	0.74	273.00	5.13	0.36	2.73	65%
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.61	257.00	5.04	0.35	1.45	78%
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	468.00	4.81	0.33	0.42	92%
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.48	256.00	4.70	0.33	0.41	92%
Malus sp	Flowering Crabapple	1.7	458	6.10	0.58	385.00	3.98	0.28	2.12	65%
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	114.00	3.87	0.27	0.33	92%
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	158.00	3.84	0.27	2.04	65%
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.55	326.00	3.79	0.26	2.02	65%
Fraxinus americana	White Ash	1.7	345	11.10	1.05	276.00	3.62	0.25	7.47	33%
Pinus sp	Pine	1.7	101	5.35	0.51	79.00	3.51	0.24	1.84	66%
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	216.00	3.47	0.24	0.30	92%
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.46	139.00	3.20	0.22	1.70	65%
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	248.00	2.99	0.21	1.64	65%
Prunus sp	Cherry	1.0	277	3.75	0.36	251.00	2.91	0.20	0.85	77%
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	165.00	2.80	0.19	0.24	92%
Magnolia sp	Magnolia	0.3	196	3.04	0.29	189.00	2.80	0.19	0.24	92%
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	153.00	2.80	0.19	1.49	65%
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	96.00	2.47	0.17	1.31	65%
Quercus alba	White Oak	1.7	130	3.33	0.32	101.00	2.17	0.15	1.16	65%
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.31	157.00	2.15	0.15	1.14	65%
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	161.00	2.12	0.15	1.12	65%
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.24	178.00	1.98	0.14	0.57	78%
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	131.00	1.85	0.13	0.53	78%
Betula nigra	River Birch	1.7	180	2.83	0.27	150.00	1.85	0.13	0.98	65%
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	118.00	1.78	0.12	0.94	65%
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	64.00	1.73	0.12	0.50	78%
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	121.00	1.72	0.12	0.91	65%
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	87.00	1.57	0.11	0.14	92%
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	41.00	1.54	0.11	0.16	91%
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.20	112.00	1.40	0.10	0.75	65%
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	48.00	1.27	0.09	0.10	92%
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	46.00	1.24	0.09	0.10	92%
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	54.00	1.23	0.09	0.35	78%
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	77.00	1.22	0.08	0.11	92%
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	105.00	1.21	0.08	0.68	64%
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	73.00	1.21	0.08	0.64	66%
Acer palmatum	Japanese Maple	1.7	141	1.83	0.17	120.00	1.19	0.08	0.64	65%
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	110.00	1.11	0.08	0.59	65%
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	76.00	1.01	0.07	0.09	92%
Morus alba	White Mulberry	1.0	33	1.28	0.12	27.00	1.00	0.07	0.28	78%
Salix babylonica	Weeping Willow	1.7	56	1.42	0.13	44.00	0.93	0.06	0.49	65%

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% Canopy Remaining
Morus sp	Mulberry	1.0	38	1.13	0.11	33.00	0.89	0.06	0.24	79%
Salix sp	Willow	1.7	51	1.31	0.12	38.00	0.87	0.06	0.44	66%
Tilia europaea	European Linden	1.7	39	1.26	0.12	28.00	0.84	0.06	0.42	66%
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	40.00	0.80	0.06	0.23	78%
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	52.00	0.78	0.05	0.41	65%
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	61.00	0.76	0.05	0.21	78%
Fraxinus sp	Ash	1.7	90	2.29	0.22	73.00	0.75	0.05	1.54	33%
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	32.00	0.71	0.05	0.06	92%
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	41.00	0.69	0.05	0.06	92%
Picea abies	Norway Spruce	1.7	40	1.04	0.10	31.00	0.69	0.05	0.36	66%
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	31.00	0.68	0.05	0.36	66%
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.06	14.00	0.64	0.04	0.05	93%
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	28.00	0.61	0.04	0.32	66%
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	45.00	0.60	0.04	0.31	65%
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	46.00	0.60	0.04	0.31	66%
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	33.00	0.59	0.04	0.31	65%
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.07	17.00	0.54	0.04	0.25	69%
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	57.00	0.53	0.04	0.28	65%
Betula pendula	European White Birch	1.7	39	0.70	0.07	30.00	0.46	0.03	0.24	65%
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	12.00	0.44	0.03	0.20	69%
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	14.00	0.42	0.03	0.22	66%
Betula sp	Birch	1.7	22	0.61	0.06	16.00	0.41	0.03	0.20	68%
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	34.00	0.41	0.03	0.21	66%
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	9.00	0.39	0.03	0.19	68%
Quercus sp	Oak	1.7	38	0.54	0.05	29.00	0.36	0.02	0.19	66%
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	18.00	0.34	0.02	0.17	66%
Ilex opaca	American Holly	0.3	10	0.38	0.04	8.00	0.34	0.02	0.04	88%
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	14.00	0.34	0.02	0.16	67%
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	34.00	0.33	0.02	0.17	66%
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	11.00	0.33	0.02	0.10	78%
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	31.00	0.32	0.02	0.17	66%
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	8.00	0.30	0.02	0.01	96%
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	4.00	0.27	0.02	0.11	70%
Cotinus sp	Smoketree	1.7	20	0.40	0.04	14.00	0.26	0.02	0.13	67%
Populus sp	Poplar	1.7	31	0.40	0.04	21.00	0.26	0.02	0.14	66%
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	29.00	0.24	0.02	0.02	92%
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	11.00	0.24	0.02	0.12	67%
Acer negundo	Boxelder	1.7	7	0.29	0.03	5.00	0.22	0.02	0.07	76%
Abies concolor	White Fir	1.0	15	0.27	0.03	12.00	0.22	0.02	0.05	81%
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	18.00	0.19	0.01	0.09	68%
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	12.00	0.19	0.01	0.01	95%
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	27.00	0.14	0.01	0.07	65%
Quercus robur	English Oak	1.0	11	0.17	0.02	8.00	0.13	0.01	0.03	81%
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	7.00	0.12	0.01	0.06	68%
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	3.00	0.11	0.01	0.03	81%
Acer sp	Maple	1.7	15	0.17	0.02	9.00	0.11	0.01	0.06	65%
Fagus grandifolia	American Beech	1.7	10	0.16	0.01	7.00	0.11	0.01	0.05	68%
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	1.00	0.09	0.01	0.09	50%
Pyrus sp	Pear	1.7	13	0.10	0.01	9.00	0.07	0.01	0.03	71%
Taxus sp	Yew	1.0	11	0.07	0.01	8.00	0.06	0.00	0.01	84%
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	2.00	0.06	0.00	0.02	75%
Morus rubra	Red Mulberry	1.0	4	0.13	0.01	2.00	0.05	0.00	0.08	41%
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	4.00	0.05	0.00	0.01	83%
Picea glauca	White Spruce	1.7	6	0.06	0.01	4.00	0.04	0.00	0.02	70%
Larix sp	Larch	1.7	4	0.13	0.01	2.00	0.04	0.00	0.09	34%
Ilex sp	Holly	0.3	7	0.05	0.00	5.00	0.04	0.00	0.01	82%
Carya sp	Hickory	1.0	3	0.04	0.00	2.00	0.04	0.00	0.01	85%
Acer nigrum	Black Maple	1.7	3	0.08	0.01	1.00	0.04	0.00	0.05	43%
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	3.00	0.04	0.00	0.02	63%
Abies sp	Fir	1.0	7	0.04	0.00	5.00	0.03	0.00	0.01	75%
Viburnum sp	Viburnum	0.3	4	0.03	0.00	2.00	0.03	0.00	0.01	82%
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	1.00	0.03	0.00	0.02	63%

BASE 2030 TABLE LOWER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% survival	% survival flood scenario	difference
Acer platanoic	Norway Maple	1.7	7810	192.079871	18.18534048	7070	154.6499939	18.10920733	37.42987709	81%	0.803073676	0.69%
Gleditsia triac	Common Thornless	1	7504	172.4628742	16.32808306	7124	151.2089326	17.70626587	21.25394162	88%	0.876762221	0.00%
Quercus palus	Pin Oak	1.7	3676	107.6065583	10.18775101	3326	86.63773843	10.1451072	20.96881988	81%	0.805134369	0.00%
Acer rubrum	Red Maple	1.7	4461	71.74848791	6.792854841	4100	57.76712447	6.764415614	13.98136344	81%	0.805133685	0.00%
Quercus rubra	Northern Red Oak	1.7	2219	71.62014985	6.780704315	2003	57.66399649	6.752339532	13.95615336	81%	0.804549594	0.06%
Platanus aceri	London Planetree	1.7	1986	36.19004745	3.42632641	1828	29.13785937	3.411985497	7.052188073	81%	0.8051346	0.00%
Tilia cordata	Littleleaf Linden	1.7	1907	34.4355029	3.260213273	1744	27.72558494	3.246610964	6.709917962	81%	0.805145347	0.00%
Platanus occic	Sycamore	1.7	964	32.398342	3.067343169	872	26.085586	3.054570344	6.312755997	81%	0.805151881	0.00%
Acer saccharu	Sugar Maple	1.7	968	27.20253438	2.575425249	878	21.90214388	2.564697574	5.300390503	81%	0.805150857	0.00%
Pyrus callerya	Callery Pear	1.7	1429	23.6038454	2.234716022	1313	19.0044718	2.225385926	4.599373597	81%	0.802658626	0.25%
Zelkova serrat	Zelkova	0.3	761	16.35420563	1.548349632	750	15.60550841	1.827374059	0.74869722	95%	0.954219897	0.00%

BASE 2030 TABLE UPPER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% survival	% survival flood scenario	difference
Gleditsia triacanthos	Common Thornless Honey	2	7504	172.4628742	16.32808306	6699	133.8504121	9.255351065	38.61246214	78%	78%	0.00%
Acer platanoides	Norway Maple	3.4	7810	192.079871	18.18534048	6266	125.414899	8.672060857	66.66497199	65%	65%	0.16%
Quercus palustris	Pin Oak	3.4	3676	107.6065583	10.18775101	2945	70.25976918	4.858250485	37.34678912	65%	65%	0.00%
Acer rubrum	Red Maple	3.4	4461	71.74848791	6.792854841	3681	46.84712106	3.239336697	24.90136685	65%	65%	0.00%
Quercus rubra	Northern Red Oak	3.4	2219	71.62014985	6.780704315	1774	46.76331275	3.233541606	24.85683709	65%	65%	0.06%
Platanus acerifolia	London Planetree	3.4	1986	36.19004745	3.42632641	1639	23.62968224	1.633921041	12.56036521	65%	65%	0.00%
Tilia cordata	Littleleaf Linden	3.4	1907	34.4355029	3.260213273	1561	22.48403713	1.554703148	11.95146577	65%	65%	0.00%
Platanus occidentalis	Sycamore	3.4	964	32.398342	3.067343169	767	21.1543572	1.462759803	11.2439848	65%	65%	0.00%
Acer saccharum	Sugar Maple	3.4	968	27.20253438	2.575425249	780	17.76142548	1.228148839	9.441108899	65%	65%	0.00%
Pyrus calleryana	Callery Pear	3.4	1429	23.6038454	2.234716022	1175	15.41189763	1.065686096	8.191947769	65%	65%	0.17%
Zelkova serrata	Zelkova	0.6	761	16.35420563	1.548349632	740	15.05060091	1.040703521	1.303604719	92%	92%	0.00%

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% survival
Metasequoia glyptostr	Dawn Redwood	0.6	51	1.38	0.11	48.00	1.27	0.15	0.10	92%
Catalpa speciosa	Northern Catalpa	0.6	50	1.35	0.11	46.00	1.24	0.15	0.10	92%
Robinia pseudoacacia	Black Locust	0.6	119	4.20	0.33	114.00	3.87	0.45	0.33	92%
Gymnocladus dioicus	Kentucky Coffeetree	0.6	171	3.04	0.24	165.00	2.80	0.33	0.24	92%
Maackia amurensis	Amur Maackia	0.6	81	1.33	0.10	77.00	1.22	0.14	0.11	92%
Amelanchier sp	Serviceberry	0.6	222	3.76	0.30	216.00	3.47	0.41	0.30	92%
Phellodendron amure	Amur Corktree	0.6	93	1.70	0.13	87.00	1.57	0.18	0.14	92%
Magnolia sp	Magnolia	0.6	196	3.04	0.24	189.00	2.80	0.33	0.24	92%
Styphnolobium japoni	Japanese Snowbell	0.6	268	5.11	0.40	257.00	4.70	0.55	0.41	92%
Ginkgo biloba	Ginkgo	0.6	618	7.30	0.58	606.00	6.71	0.79	0.58	92%
Syringa reticulata	Japanese Lilac Tree	0.6	480	5.23	0.41	469.00	4.81	0.56	0.42	92%

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2030 Polygon Count	2030 City Canopy Acres	% of City Canopy in 2030	Canopy Acres Lost 2018 to 2030	% survival
Fraxinus americana	White Ash	3.4	345	11.10	0.88	276.00	3.62	0.43	7.47	33%
Fraxinus pennsylvanic	Green Ash	2.0	1100	28.44	2.25	978.00	11.04	1.30	17.40	39%
Juniperus virginiana	Eastern Redcedar	0.6	80	1.09	0.09	76.00	1.01	0.12	0.09	50%
Koelreuteria paniculat	Panicled Goldenraintree	3.4	136	1.70	0.13	110.00	1.11	0.13	0.59	55%
Acer palmatum	Japanese Maple	3.4	141	1.83	0.14	121.00	1.20	0.14	0.63	60%
Tilia tomentosa	Silver Linden	3.4	90	1.85	0.15	73.00	1.21	0.14	0.64	61%
Acer platanoides	Norway Maple	3.4	7810	192.08	15.16	6266.00	125.41	14.72	66.66	65%
Tilia cordata	Littleleaf Linden	3.4	1907	34.44	2.72	1561.00	22.48	2.64	11.95	65%
Quercus palustris	Pin Oak	3.4	3676	107.61	8.50	2945.00	70.26	8.25	37.35	65%
Acer saccharum	Sugar Maple	3.4	968	27.20	2.15	780.00	17.76	2.09	9.44	65%
Platanus acerifolia	London Planetree	3.4	1986	36.19	2.86	1639.00	23.63	2.77	12.56	65%

BASE 2050 DROUGHT TABLE LOWER

Genus/Species Name	Common Name
Abies balsamea	Balsam Fir
Acer freemanii	Freeman Maple
Acer nigrum	Black Maple
Betula papyrifera	Paper Birch
Betula pendula	European White Birch
Betula populifolia	Gray Birch
Carpinus betulus	European Hornbeam
Castanea dentata	American Chestnut
Cedrus libani	Cedar of Lebanon
Chamaecyparis sp	Falsecypress
Cornus mas	Corneliancherry Dogwood
Cornus sp	Dogwood
Enkianthus campanulatus	Enkianthus
Fraxinus nigra	Black Ash
Halesia carolina	Carolina Siverbell
Larix laricina	Tamarack
Malus pumila	Apple
Picea glauca	White Spruce
Pinus banksiana	Jack Pine
Pinus parviflora	Japanese White Pine
Pinus resinosa	Red Pine
Populus tremuloides	Quaking Aspen
Prunus Ã— yedoensis	Yoshino Cherry
Prunus pennsylvanica	Pin Cherry
Prunus virginiana	Common Chokecherry
Pseudotsuga menziesii	Douglas Fir
Quercus coccinea	Scarlet Oak
Quercus imbricaria	Shingle Oak
Quercus lyrata	Overcup Oak
Salix alba	White Willow
Sophora japonica	Japanese Pagodatree
Sorbus alnifolia	Korean Mountain Ash
Tsuga caroliniana	Carolina Hemlock
Tsuga canadensis	Canadian Hemlock
Acer rubrum	Red Maple
Pinus strobus	Eastern White Pine
Carpinus caroliniana	American Hornbeam
Fraxinus americana	White Ash
Tilia americana	Basswood
Amelanchier arborea	Downy Serviceberry
Carpinus sp	Hornbeam
Magnolia sp	Magnolia
Amelanchier sp	Serviceberry
Acer saccharum	Sugar Maple
Ailanthus altissima	Tree of Heaven
Quercus velutina	Eastern Black Oak
Thuja occidentalis	Eastern Arborvitae
Cornus florida	Flowering Dogwood
Quercus rubra	Northern Red Oak
Quercus alba	White Oak
Pinus sp	Pine
Abies concolor	White Fir
Acer buergerianum	Trident Maple
Acer campestre	Hedge Maple
Acer ginnala	Amur Maple
Acer griseum	Paperbark Maple
Acer negundo	Boxelder
Acer palmatum	Japanese Maple
Acer platanoides	Norway Maple
Acer pseudoplatanus	Sycamore Maple
Acer saccharinum	Silver Maple
Acer sp	Maple
Acer tataricum	Tatarian Maple
Acer x freemanii	Freeman Maple
Aesculus hippocastanum	Horsechestnut
Alnus glutinosa	Common Alder
Amelanchier x grandiflora	Apple Serviceberry
Betula nigra	River Birch
Carya sp	Hickory
Catalpa speciosa	Northern Catalpa

Celtis occidentalis	Hackberry
Cercidiphyllum japonicum	Katsuratree
Cercis canadensis	Eastern Redbud
Cladrastis kentukea	Yellowwood
Cornus kousa	Kousa Dogwood
Cotinus obovatus	American Smoketree
Cotinus sp	Smoketree
Crataegus sp	Hawthorn
Elaegnus angustifolia	Russian Olive
Eucommia ulmoides	Hardy Rubber Tree
Fagus grandifolia	American Beech
Fagus sylvatica	European Beech
Fraxinus pennsylvanica	Green Ash
Ginkgo biloba	Ginkgo
Gleditsia triacanthos	Common Thornless Honeylocust
Gymnocladus dioicus	Kentucky Coffeetree
Hamamelis sp	Witchhazel
Ilex opaca	American Holly
Ilex sp	Holly
Juglans nigra	Black Walnut
Juniperus virginiana	Eastern Redcedar
Koelreuteria paniculata	Panicled Goldenraintree
Larix sp	Larch
Liquidambar styraciflua	Sweetgum
Liriodendron tulipifera	Tuliptree
Maackia amurensis	Amur Maackia
Magnolia stellata	Star Magnolia
Magnolia x soulangiana	Saucer Magnolia
Malus sp	Flowering Crabapple
Metasequoia glyptostroboides	Dawn Redwood
Morus alba	White Mulberry
Morus rubra	Red Mulberry
Morus sp	Mulberry
Nyssa sylvatica	Black Tupelo
Ostrya virginiana	American Hophornbeam
Oxydendrum arboreum	Sourwood

Parrotia persica	Persian Parrotia
Phellodendron amurense	Amur Corktree
Picea abies	Norway Spruce
Picea pungens	Colorado Spruce
Picea sp	Spruce
Pinus nigra	Austrian Pine
Pinus sylvestris	Scotch Pine
Platanus acerifolia	London Planetree
Platanus occidentalis	Sycamore
Populus deltoides	Eastern Poplar
Populus sp	Poplar
Prunus sargentii	Sargent Cherry
Prunus serotina	Black Cherry
Prunus serrulata	Flowering Cherry
Prunus sp	Cherry
Prunus subhirtella	Weeping Cherry
Prunus x incamp	Okame Cherry
Pyrus calleryana	Callery Pear
Pyrus sp	Pear
Quercus bicolor	Swamp White Oak
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus robur	English Oak
Quercus sp	Oak
Rhamnus cathartica	European Buckthorn
Rhamnus frangula	Glossy Buckthorn
Robinia pseudoacacia	Black Locust
Salix babylonica	Weeping Willow
Salix sp	Willow
Stewartia sp	Stewartia
Styphnolobium japonicum	Japanese Snowbell
Syringa reticulata	Japanese Lilac Tree
Taxus sp	Yew
Thuja plicata	Western Redcedar
Tilia cordata	Littleleaf Linden
Tilia europaea	European Linden

Tilia tomentosa	Silver Linden	0.0%
Ulmus americana	American Elm	0.0%
Ulmus parvifolia	Chinese Elm	0.0%
Ulmus pumila	Siberian Elm	0.0%
Ulmus rubra	Slippery Elm	0.0%
Ulmus sp	Elm	0.0%
Viburnum sp	Viburnum	0.0%
Zelkova serrata	Zelkova	0.0%

BASE 2050 DROUGHT TABLE UPPER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2050 Polygon Count	2050 City Canopy Acres	% of City Canopy in 2050	Canopy Acres Lost 2018 to 2050	% surviving
Abies balsamea	Balsam Fir	1.0	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Acer freemanii	Freeman Maple	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Acer nigrum	Black Maple	1.7	3	0.08	0.01	0.00	0.00	0.00	0.08	0
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	0.00	0.00	0.00	0.51	0
Betula pendula	European White Birch	1.7	39	0.70	0.07	0.00	0.00	0.00	0.70	0
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	0.00	0.00	0.00	0.90	0
Carpinus betulus	European Hornbeam	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Castanea dentata	American Chestnut	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Cedrus libani	Cedar of Lebanon	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Chamaecyparis sp	Falsecypress	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Cornus sp	Dogwood	1.7	4	0.03	0.00	0.00	0.00	0.00	0.03	0
Enkianthus campanulatus	Enkianthus	0.3	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Fraxinus nigra	Black Ash	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Halesia carolina	Carolina Siverbell	0.3	2	0.02	0.00	0.00	0.00	0.00	0.02	0
Larix laricina	Tamarack	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03	0
Malus pumila	Apple	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02	0
Picea glauca	White Spruce	1.7	6	0.06	0.01	0.00	0.00	0.00	0.06	0
Pinus banksiana	Jack Pine	1.7	1	0.03	0.00	0.00	0.00	0.00	0.03	0
Pinus parviflora	Japanese White Pine	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Pinus resinosa	Red Pine	1.7	255	4.21	0.40	0.00	0.00	0.00	4.21	0
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	0.00	0.00	0.00	0.50	0
Prunus Ã— yedoensis	Yoshino Cherry	1.0	7	0.08	0.01	0.00	0.00	0.00	0.08	0
Prunus pennsylvanica	Pin Cherry	1.7	3	0.04	0.00	0.00	0.00	0.00	0.04	0
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	0.00	0.00	0.00	0.64	0
Pseudotsuga menziesii	Douglas Fir	1.0	2	0.02	0.00	0.00	0.00	0.00	0.02	0
Quercus coccinea	Scarlet Oak	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02	0
Quercus imbricaria	Shingle Oak	1.7	2	0.00	0.00	0.00	0.00	0.00	0.00	0
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	0.00	0.00	0.00	0.19	0
Salix alba	White Willow	1.7	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	0.00	0.00	0.00	0.08	0
Sorbus alnifolia	Korean Mountain Ash	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03	0
Tsuga caroliniana	Carolina Hemlock	1.7	2	0.01	0.00	0.00	0.00	0.00	0.01	0
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	1.00	0.04	0.01	0.99	0.043337066
Fraxinus sp	Ash	1.7	90	2.29	0.22	29.00	0.23	0.06	2.05	0.10219507
Fraxinus americana	White Ash	1.7	345	11.10	1.05	114.00	1.30	0.34	9.80	0.117249166
Larix sp	Larch	1.7	4	0.13	0.01	1.00	0.03	0.01	0.10	0.200568052
Acer rubrum	Red Maple	1.7	4461	71.75	6.79	1438.00	16.43	4.27	55.32	0.228949882
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.11	161.00	2.69	0.70	8.99	0.230391421
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	19.00	0.19	0.05	0.62	0.232976123
Tilia americana	Basswood	1.7	550	13.79	1.31	176.00	3.28	0.85	10.51	0.237978431
Morus rubra	Red Mulberry	1.0	4	0.13	0.01	1.00	0.03	0.01	0.10	0.246638558
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.69	758.00	7.23	1.88	21.21	0.254365351
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.46	70.00	1.38	0.36	3.52	0.282041698
Acer saccharum	Sugar Maple	1.7	968	27.20	2.58	393.00	7.71	2.00	19.49	0.28346202
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	8.00	0.18	0.05	0.45	0.290241967
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	68.00	0.79	0.21	1.93	0.290687864
Acer sp	Maple	1.7	15	0.17	0.02	4.00	0.05	0.01	0.12	0.290878163
Abies sp	Fir	1.0	7	0.04	0.00	2.00	0.01	0.00	0.03	0.299981553
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.78	966.00	21.59	5.61	50.03	0.301503261
Quercus alba	White Oak	1.7	130	3.33	0.32	60.00	1.01	0.26	2.32	0.302554544
Hamamelis sp	Witchhazel	0.3	5	0.03	0.00	2.00	0.01	0.00	0.02	0.31638475
Acer platanoides	Norway Maple	1.7	7810	192.08	18.18	3868.00	61.63	16.01	130.45	0.320858795
Quercus palustris	Pin Oak	1.7	3676	107.61	10.19	1835.00	34.53	8.97	73.08	0.320860259
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.43	1061.00	11.61	3.02	24.58	0.32086141
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.23	738.00	7.57	1.97	16.03	0.320867843
Platanus occidentalis	Sycamore	1.7	964	32.40	3.07	468.00	10.40	2.70	22.00	0.320868577
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.26	1001.00	11.05	2.87	23.39	0.320872837
Malus sp	Flowering Crabapple	1.7	458	6.10	0.58	252.00	1.96	0.51	4.14	0.320888611
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.76	196.00	2.59	0.67	5.47	0.32090769
Ulmus sp	Elm	1.7	793	13.52	1.28	439.00	4.34	1.13	9.18	0.32091336
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.55	211.00	1.86	0.48	3.94	0.320928649
Betula nigra	River Birch	1.7	180	2.83	0.27	96.00	0.91	0.24	1.92	0.320934836
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	165.00	1.49	0.39	3.14	0.320955038

Acer saccharinum	Silver Maple	1.7	344	7.86	0.74	166.00	2.52	0.66	5.34	0.320976786
Ulmus americana	American Elm	1.7	389	9.95	0.94	201.00	3.19	0.83	6.75	0.32099894
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	76.00	0.85	0.22	1.79	0.321062225
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.31	104.00	1.06	0.27	2.24	0.321135861
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	93.00	1.38	0.36	2.91	0.321167501
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	97.00	1.89	0.49	3.99	0.32119574
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	69.00	0.55	0.14	1.15	0.321264123
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	33.00	0.38	0.10	0.81	0.321363673
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	99.00	1.04	0.27	2.20	0.321395741
Acer palmatum	Japanese Maple	1.7	141	1.83	0.17	86.00	0.59	0.15	1.24	0.321427714
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	58.00	1.21	0.32	2.56	0.321525113
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	66.00	0.61	0.16	1.28	0.321862612
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.20	74.00	0.69	0.18	1.46	0.321929593
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	26.00	0.29	0.08	0.62	0.321967289
Pinus sp	Pine	1.7	101	5.35	0.51	43.00	1.72	0.45	3.63	0.32205049
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	45.00	0.60	0.15	1.25	0.322442907
Salix babylonica	Weeping Willow	1.7	56	1.42	0.13	27.00	0.46	0.12	0.97	0.322536838
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	2.00	0.12	0.03	0.26	0.323350545
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	28.00	0.29	0.08	0.61	0.324783927
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	18.00	0.16	0.04	0.33	0.325294361
Picea abies	Norway Spruce	1.7	40	1.04	0.10	19.00	0.34	0.09	0.70	0.32703956
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	16.00	0.07	0.02	0.14	0.32926567
Betula sp	Birch	1.7	22	0.61	0.06	7.00	0.20	0.05	0.41	0.331401467
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	5.00	0.19	0.05	0.39	0.333634493
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	23.00	0.21	0.05	0.41	0.334215232
Populus sp	Poplar	1.7	31	0.40	0.04	10.00	0.13	0.04	0.27	0.335040613
Tilia europaea	European Linden	1.7	39	1.26	0.12	16.00	0.43	0.11	0.83	0.338961917
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	18.00	0.32	0.08	0.61	0.340474483
Quercus sp	Oak	1.7	38	0.54	0.05	19.00	0.19	0.05	0.36	0.345671174
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.07	11.00	0.28	0.07	0.52	0.34792727
Salix sp	Willow	1.7	51	1.31	0.12	21.00	0.46	0.12	0.85	0.350354632
Cotinus sp	Smoketree	1.7	20	0.40	0.04	8.00	0.14	0.04	0.26	0.351723515
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	11.00	0.10	0.03	0.18	0.35932421
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	11.00	0.19	0.05	0.33	0.363445288
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	2.00	0.02	0.01	0.04	0.369174971
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	1.00	0.05	0.01	0.08	0.390242924
Magnolia x soulangiana	Saucer Magnolia	0.3	3	0.01	0.00	1.00	0.00	0.00	0.01	0.407732358
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	6.00	0.15	0.04	0.21	0.412388717
Oxydendrum arboreum	Sourwood	1.7	6	0.02	0.00	2.00	0.01	0.00	0.01	0.424501263
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	44.00	1.01	0.26	1.22	0.451765058
Pyrus sp	Pear	1.7	13	0.10	0.01	5.00	0.05	0.01	0.05	0.464149825
Fagus grandifolia	American Beech	1.7	10	0.16	0.01	4.00	0.08	0.02	0.08	0.480063173
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	5.00	0.09	0.02	0.09	0.484379696
Picea sp	Spruce	1.7	5	0.02	0.00	3.00	0.01	0.00	0.01	0.494120313
Ilex sp	Holly	0.3	7	0.05	0.00	3.00	0.02	0.01	0.02	0.50570362
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.33	5212.00	87.73	22.79	84.73	0.508704117
Prunus sp	Cherry	1.0	277	3.75	0.36	204.00	1.91	0.50	1.84	0.50877782
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.61	202.00	3.31	0.86	3.19	0.508852107
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.24	141.00	1.30	0.34	1.25	0.50893131
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	111.00	1.22	0.32	1.17	0.5090539
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	48.00	0.50	0.13	0.47	0.513220829
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	42.00	0.81	0.21	0.77	0.513827975
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	31.00	0.53	0.14	0.50	0.513988925
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	8.00	0.22	0.06	0.21	0.514692005
Morus sp	Mulberry	1.0	38	1.13	0.11	25.00	0.59	0.15	0.54	0.522363779
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	5.00	0.02	0.00	0.01	0.527974767
Morus alba	White Mulberry	1.0	33	1.28	0.12	21.00	0.68	0.18	0.60	0.528385307
Carya sp	Hickory	1.0	3	0.04	0.00	1.00	0.02	0.01	0.02	0.531360264
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	2.00	0.01	0.00	0.01	0.547479388
Abies concolor	White Fir	1.0	15	0.27	0.03	8.00	0.15	0.04	0.12	0.555952452
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	3.00	0.03	0.01	0.03	0.565941424
Magnolia stellata	Star Magnolia	0.3	3	0.02	0.00	1.00	0.01	0.00	0.01	0.606010495
Acer negundo	Boxelder	1.7	7	0.29	0.03	3.00	0.18	0.05	0.11	0.608196976
Viburnum sp	Viburnum	0.3	4	0.03	0.00	1.00	0.02	0.01	0.01	0.612234841
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	20.00	0.16	0.04	0.10	0.631538452
Taxus sp	Yew	1.0	11	0.07	0.01	6.00	0.05	0.01	0.02	0.66108295

Carpinus sp	Hornbeam	0.3	45	0.75	0.07	25.00	0.50	0.13	0.25	0.665650738
Magnolia sp	Magnolia	0.3	196	3.04	0.29	120.00	2.03	0.53	1.01	0.66783076
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	155.00	2.67	0.69	1.09	0.710058329
Quercus robur	English Oak	1.0	11	0.17	0.02	5.00	0.12	0.03	0.05	0.710749992
Ilex opaca	American Holly	0.3	10	0.38	0.04	6.00	0.28	0.07	0.11	0.720208008
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	37.00	1.27	0.33	0.42	0.751494299
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	6.00	0.24	0.06	0.07	0.767118968
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	7.00	0.15	0.04	0.04	0.777560453
Zelkova serrata	Zelkova	0.3	761	16.35	1.55	693.00	13.10	3.40	3.25	0.801318112
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.69	581.00	5.85	1.52	1.45	0.801318254
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.48	240.00	4.09	1.06	1.01	0.801389472
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	449.00	4.19	1.09	1.04	0.801484445
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	71.00	1.06	0.28	0.26	0.801726438
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	155.00	2.44	0.63	0.60	0.801934933
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	80.00	1.37	0.35	0.34	0.802671765
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	68.00	0.88	0.23	0.22	0.802728331
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	106.00	3.38	0.88	0.82	0.804236782
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	44.00	1.11	0.29	0.27	0.805314849
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	42.00	1.09	0.28	0.26	0.805677446
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	28.00	0.63	0.16	0.15	0.808187192
Stewartia sp	Stewartia	0.3	4	0.03	0.00	2.00	0.03	0.01	0.01	0.822777432
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.06	12.00	0.57	0.15	0.11	0.8369308
Eucommia ulmoides	Hardy Rubber Tree	0.3	9	0.01	0.00	7.00	0.01	0.00	0.00	0.867923952
Total		***NA***	***NA***	***0.01***	***NA***	***NA***	***393.72***	***NA***	***0.00***	30354.10652

BASE 2050 TABLE LOWER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2050 Polygon Count	2050 City Canopy Acres	% of City Canopy in 2050	Canopy Acres Lost 2018 to 2050	% surviving
Abies balsamea	Balsam Fir	1.0	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Abies concolor	White Fir	1.0	15	0.27	0.03	11.00	0.21	0.02	0.06	0.778239919
Abies sp	Fir	1.0	7	0.04	0.00	4.00	0.03	0.00	0.01	0.656339125
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	3.00	0.05	0.00	0.01	0.845539136
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	231.00	2.60	0.21	2.03	0.561071557
Acer freemanii	Freeman Maple	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	27.00	0.35	0.03	0.26	0.568758722
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	24.00	0.12	0.01	0.09	0.573431879
Acer negundo	Boxelder	1.7	7	0.29	0.03	3.00	0.18	0.01	0.11	0.608196976
Acer nigrum	Black Maple	1.7	3	0.08	0.01	0.00	0.00	0.00	0.08	0
Acer palmatum	Japanese Maple	1.7	141	1.83	0.18	111.00	1.03	0.08	0.80	0.561351962
Acer platanoides	Norway Maple	1.7	7810	192.08	18.44	5698.00	107.76	8.62	84.32	0.561025264
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	143.00	3.30	0.26	2.58	0.561729351
Acer rubrum	Red Maple	1.7	4461	71.75	6.89	3379.00	40.25	3.22	31.50	0.561025584
Acer saccharinum	Silver Maple	1.7	344	7.86	0.75	245.00	4.41	0.35	3.45	0.561132238
Acer saccharum	Sugar Maple	1.7	968	27.20	2.61	710.00	15.26	1.22	11.94	0.561046936
Acer sp	Maple	1.7	15	0.17	0.02	9.00	0.08	0.01	0.09	0.455642208
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	16.00	0.16	0.01	0.11	0.591597845
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	27.00	0.28	0.02	0.21	0.563491218
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.21	102.00	1.21	0.10	0.94	0.561955052
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	58.00	1.57	0.13	0.65	0.706820903
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	11.00	0.31	0.02	0.12	0.715082475
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	26.00	0.23	0.02	0.03	0.901487157
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	208.00	3.32	0.27	0.44	0.882620667
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	5.00	0.02	0.00	0.01	0.727138538
Betula nigra	River Birch	1.7	180	2.83	0.27	138.00	1.59	0.13	1.24	0.561760819
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	0.00	0.00	0.00	0.51	0
Betula pendula	European White Birch	1.7	39	0.70	0.07	0.00	0.00	0.00	0.70	0
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	0.00	0.00	0.00	0.90	0
Betula sp	Birch	1.7	22	0.61	0.06	14.00	0.32	0.03	0.29	0.531112993
Carpinus betulus	European Hornbeam	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	50.00	0.45	0.04	0.35	0.561849809
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	35.00	0.67	0.05	0.09	0.885382607
Carya sp	Hickory	1.0	3	0.04	0.00	1.00	0.02	0.00	0.02	0.531360264
Castanea dentata	American Chestnut	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	43.00	1.20	0.10	0.14	0.892628499
Cedrus libani	Cedar of Lebanon	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	110.00	1.48	0.12	1.16	0.561669998
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	45.00	0.67	0.05	0.52	0.561770992
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.32	146.00	1.85	0.15	1.44	0.561440174
Chamaecyparis sp	Falsecypress	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	49.00	1.12	0.09	0.46	0.706920467
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	108.00	1.53	0.12	1.19	0.561466268
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	146.00	1.82	0.15	1.42	0.561126656
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Cornus sp	Dogwood	1.7	4	0.03	0.00	0.00	0.00	0.00	0.03	0
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	2.00	0.01	0.00	0.01	0.615300078
Cotinus sp	Smoketree	1.7	20	0.40	0.04	12.00	0.24	0.02	0.16	0.59487652
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	41.00	0.51	0.04	0.39	0.564267797
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	6.00	0.24	0.02	0.07	0.767118968
Enkianthus campanulatus	Enkianthus	0.3	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Eucommia ulmoides	Hardy Rubber Tree	0.3	9	0.01	0.00	7.00	0.01	0.00	0.00	0.886373344
Fagus grandifolia	American Beech	1.7	10	0.16	0.02	5.00	0.10	0.01	0.05	0.649181313
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	87.00	2.12	0.17	1.65	0.561910106
Fraxinus americana	White Ash	1.7	345	11.10	1.07	250.00	3.11	0.25	7.98	0.280561054
Fraxinus nigra	Black Ash	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.73	925.00	10.01	0.80	18.43	0.35210067
Fraxinus sp	Ash	1.7	90	2.29	0.22	66.00	0.65	0.05	1.64	0.282687153
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.70	598.00	6.44	0.51	0.86	0.882540941
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.55	6350.00	121.45	9.71	51.02	0.704183774
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	159.00	2.69	0.21	0.35	0.883390161
Halesia carolina	Carolina Siverbell	0.3	2	0.02	0.00	0.00	0.00	0.00	0.02	0
Hamamelis sp	Witchhazel	0.3	5	0.03	0.00	2.00	0.01	0.00	0.02	0.31638475
Ilex opaca	American Holly	0.3	10	0.38	0.04	6.00	0.28	0.02	0.11	0.720208008
Ilex sp	Holly	0.3	7	0.05	0.00	3.00	0.02	0.00	0.02	0.50570362
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	12.00	0.32	0.03	0.31	0.503687298
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	69.00	0.96	0.08	0.13	0.883575044
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	101.00	0.95	0.08	0.74	0.562457631
Larix laricina	Tamarack	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03	0
Larix sp	Larch	1.7	4	0.13	0.01	1.00	0.03	0.00	0.10	0.200568052
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.56	302.00	3.26	0.26	2.55	0.561116733
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.62	245.00	4.58	0.37	1.92	0.70445785
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	70.00	1.17	0.09	0.15	0.883945431
Magnolia sp	Magnolia	0.3	196	3.04	0.29	183.00	2.68	0.21	0.36	0.882711758
Magnolia stellata	Star Magnolia	0.3	3	0.02	0.00	1.00	0.01	0.00	0.01	0.606010495
Magnolia x soulangiana	Saucer Magnolia	0.3	3	0.01	0.00	1.00	0.00	0.00	0.01	0.407732358
Malus pumila	Apple	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02	0
Malus sp	Flowering Crabapple	1.7	458	6.10	0.59	356.00	3.42	0.27	2.68	0.56110412
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	43.00	1.22	0.10	0.15	0.889793368
Morus alba	White Mulberry	1.0	33	1.28	0.12	26.00	0.91	0.07	0.37	0.709133385

Morus rubra	Red Mulberry	1.0	4	0.13	0.01	1.00	0.03	0.00	0.10	0.246638558
Morus sp	Mulberry	1.0	38	1.13	0.11	31.00	0.81	0.07	0.32	0.719720818
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	9.00	0.21	0.02	0.15	0.581314452
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	2.00	0.03	0.00	0.03	0.535721567
Oxydendrum arboreum	Sourwood	1.7	6	0.02	0.00	2.00	0.01	0.00	0.00	0.78787512
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	29.00	0.69	0.06	0.08	0.898173242
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	84.00	1.50	0.12	0.20	0.883939537
Picea abies	Norway Spruce	1.7	40	1.04	0.10	26.00	0.59	0.05	0.45	0.567446932
Picea glauca	White Spruce	1.7	6	0.06	0.01	0.00	0.00	0.00	0.06	0
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	36.00	0.52	0.04	0.39	0.567038322
Picea sp	Spruce	1.7	5	0.02	0.00	3.00	0.01	0.00	0.01	0.625153995
Pinus banksiana	Jack Pine	1.7	1	0.03	0.00	0.00	0.00	0.00	0.03	0
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	96.00	1.06	0.09	0.83	0.562042044
Pinus parviflora	Japanese White Pine	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Pinus resinosa	Red Pine	1.7	255	4.21	0.40	0.00	0.00	0.00	4.21	0
Pinus sp	Pine	1.7	101	5.35	0.51	69.00	3.00	0.24	2.35	0.561005929
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.12	339.00	6.56	0.52	5.13	0.561179342
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	5.00	0.12	0.01	0.06	0.655764102
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.47	1508.00	20.30	1.62	15.89	0.56102634
Platanus occidentalis	Sycamore	1.7	964	32.40	3.11	696.00	18.18	1.45	14.22	0.56104304
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.08	13.00	0.43	0.03	0.36	0.545249355
Populus sp	Poplar	1.7	31	0.40	0.04	18.00	0.23	0.02	0.17	0.566874865
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	0.00	0.00	0.00	0.50	0
Prunus Ã— yedoensis	Yoshino Cherry	1.0	7	0.08	0.01	0.00	0.00	0.00	0.08	0
Prunus pennsylvanica	Pin Cherry	1.7	3	0.04	0.00	0.00	0.00	0.00	0.04	0
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.25	171.00	1.80	0.14	0.75	0.704464126
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	6.00	0.33	0.03	0.25	0.574970972
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	117.00	1.68	0.13	0.71	0.704547552
Prunus sp	Cherry	1.0	277	3.75	0.36	242.00	2.65	0.21	1.11	0.704483672
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	34.00	0.72	0.06	0.30	0.705952126
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	0.00	0.00	0.00	0.64	0
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	56.00	0.69	0.05	0.28	0.707304158
Pseudotsuga menziesii	Douglas Fir	1.0	2	0.02	0.00	0.00	0.00	0.00	0.02	0
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.27	1076.00	13.24	1.06	10.36	0.561032862
Pyrus sp	Pear	1.7	13	0.10	0.01	8.00	0.06	0.00	0.04	0.60445024
Quercus alba	White Oak	1.7	130	3.33	0.32	92.00	1.87	0.15	1.46	0.561688211
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.77	269.00	4.52	0.36	3.54	0.561072899
Quercus coccinea	Scarlet Oak	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02	0
Quercus imbricaria	Shingle Oak	1.7	2	0.00	0.00	0.00	0.00	0.00	0.00	0
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	0.00	0.00	0.00	0.19	0
Quercus palustris	Pin Oak	1.7	3676	107.61	10.33	2679.00	60.37	4.83	47.24	0.56102659
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	3.00	0.24	0.02	0.14	0.641229636
Quercus robur	English Oak	1.0	11	0.17	0.02	7.00	0.13	0.01	0.03	0.805369054
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.87	1611.00	40.18	3.21	31.44	0.56103086
Quercus sp	Oak	1.7	38	0.54	0.05	26.00	0.31	0.03	0.23	0.579457153
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.47	126.00	2.75	0.22	2.15	0.561234581
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.07	13.00	0.61	0.05	0.07	0.89328331
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	37.00	1.40	0.11	0.29	0.828339805
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	109.00	3.71	0.30	0.49	0.882927819
Salix alba	White Willow	1.7	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Salix babylonica	Weeping Willow	1.7	56	1.42	0.14	38.00	0.80	0.06	0.62	0.563515875
Salix sp	Willow	1.7	51	1.31	0.13	34.00	0.76	0.06	0.55	0.579697617
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	0.00	0.00	0.00	0.08	0
Sorbus alnifolia	Korean Mountain Ash	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03	0
Stewartia sp	Stewartia	0.3	4	0.03	0.00	2.00	0.03	0.00	0.01	0.822777432
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.49	250.00	4.51	0.36	0.60	0.882636924
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	462.00	4.61	0.37	0.61	0.882495719
Taxus sp	Yew	1.0	11	0.07	0.01	6.00	0.06	0.00	0.02	0.773673474
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	10.00	0.18	0.01	0.02	0.905060696
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	1.00	0.05	0.00	0.08	0.390242924
Tilia americana	Basswood	1.7	550	13.79	1.32	400.00	7.74	0.62	6.05	0.561074899
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.31	1431.00	19.32	1.54	15.12	0.561034987
Tilia europaea	European Linden	1.7	39	1.26	0.12	26.00	0.73	0.06	0.53	0.576143291
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	66.00	1.04	0.08	0.81	0.564070953
Total		***NA***	***NA***	***1.85***	***NA***	***NA***	***639.53***	***NA***	***0.81***	345.8119409
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	29.00	0.59	0.05	0.44	0.571760917
Tsuga caroliniana	Carolina Hemlock	1.7	2	0.01	0.00	0.00	0.00	0.00	0.01	0
Ulmus americana	American Elm	1.7	389	9.95	0.95	290.00	5.58	0.45	4.37	0.561103333
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	139.00	2.40	0.19	1.88	0.561203343
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	26.00	0.54	0.04	0.39	0.583269349
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	16.00	0.32	0.03	0.20	0.622925066
Ulmus sp	Elm	1.7	793	13.52	1.30	619.00	7.59	0.61	5.94	0.561071612
Viburnum sp	Viburnum	0.3	4	0.03	0.00	1.00	0.02	0.00	0.01	0.612234841
Zelkova serrata	Zelkova	0.3	761	16.35	1.57	728.00	14.43	1.15	1.92	0.882507406
				1058.11						

BASE 2050 TABLE LOWER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2050 Polygon Count	2050 City Canopy Acres	% of City Canopy in 2050	Canopy Acres Lost 2018 to 2050	% surviving
Abies balsamea	Balsam Fir	1.0	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Abies concolor	White Fir	1.0	15	0.27	0.03	11.00	0.21	0.02	0.06	0.778239919
Abies sp	Fir	1.0	7	0.04	0.00	4.00	0.03	0.00	0.01	0.656339125
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	3.00	0.05	0.00	0.01	0.845539136
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	231.00	2.60	0.21	2.03	0.561071557
Acer freemanii	Freeman Maple	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	27.00	0.35	0.03	0.26	0.568758722
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	24.00	0.12	0.01	0.09	0.573431879
Acer negundo	Boxelder	1.7	7	0.29	0.03	3.00	0.18	0.01	0.11	0.608196976
Acer nigrum	Black Maple	1.7	3	0.08	0.01	0.00	0.00	0.00	0.08	0
Acer palmatum	Japanese Maple	1.7	141	1.83	0.18	111.00	1.03	0.08	0.80	0.561351962
Acer platanoides	Norway Maple	1.7	7810	192.08	18.44	5698.00	107.76	8.62	84.32	0.561025264
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	143.00	3.30	0.26	2.58	0.561729351
Acer rubrum	Red Maple	1.7	4461	71.75	6.89	3379.00	40.25	3.22	31.50	0.561025584
Acer saccharinum	Silver Maple	1.7	344	7.86	0.75	245.00	4.41	0.35	3.45	0.561132238
Acer saccharum	Sugar Maple	1.7	968	27.20	2.61	710.00	15.26	1.22	11.94	0.561046936
Acer sp	Maple	1.7	15	0.17	0.02	9.00	0.08	0.01	0.09	0.455642208
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	16.00	0.16	0.01	0.11	0.591597845
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	27.00	0.28	0.02	0.21	0.563491218
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.21	102.00	1.21	0.10	0.94	0.561955052
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	58.00	1.57	0.13	0.65	0.706820903
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	11.00	0.31	0.02	0.12	0.715082475
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	26.00	0.23	0.02	0.03	0.901487157
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	208.00	3.32	0.27	0.44	0.882620667
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	5.00	0.02	0.00	0.01	0.727138538
Betula nigra	River Birch	1.7	180	2.83	0.27	138.00	1.59	0.13	1.24	0.561760819
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	0.00	0.00	0.00	0.51	0
Betula pendula	European White Birch	1.7	39	0.70	0.07	0.00	0.00	0.00	0.70	0
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	0.00	0.00	0.00	0.90	0
Betula sp	Birch	1.7	22	0.61	0.06	14.00	0.32	0.03	0.29	0.531112993
Carpinus betulus	European Hornbeam	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	50.00	0.45	0.04	0.35	0.561849809
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	35.00	0.67	0.05	0.09	0.885382607
Carya sp	Hickory	1.0	3	0.04	0.00	1.00	0.02	0.00	0.02	0.531360264
Castanea dentata	American Chestnut	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	43.00	1.20	0.10	0.14	0.892628499
Cedrus libani	Cedar of Lebanon	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	110.00	1.48	0.12	1.16	0.561669998
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	45.00	0.67	0.05	0.52	0.561770992
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.32	146.00	1.85	0.15	1.44	0.561440174
Chamaecyparis sp	Falsecypress	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	49.00	1.12	0.09	0.46	0.706920467
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	108.00	1.53	0.12	1.19	0.561466268
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	146.00	1.82	0.15	1.42	0.561126656
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Cornus sp	Dogwood	1.7	4	0.03	0.00	0.00	0.00	0.00	0.03	0
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	2.00	0.01	0.00	0.01	0.615300078
Cotinus sp	Smoketree	1.7	20	0.40	0.04	12.00	0.24	0.02	0.16	0.59487652
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	41.00	0.51	0.04	0.39	0.564267797
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	6.00	0.24	0.02	0.07	0.767118968
Enkianthus campanulatus	Enkianthus	0.3	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Eucommia ulmoides	Hardy Rubber Tree	0.3	9	0.01	0.00	7.00	0.01	0.00	0.00	0.886373344
Fagus grandifolia	American Beech	1.7	10	0.16	0.02	5.00	0.10	0.01	0.05	0.649181313
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	87.00	2.12	0.17	1.65	0.561910106
Fraxinus americana	White Ash	1.7	345	11.10	1.07	250.00	3.11	0.25	7.98	0.280561054
Fraxinus nigra	Black Ash	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.73	925.00	10.01	0.80	18.43	0.35210067
Fraxinus sp	Ash	1.7	90	2.29	0.22	66.00	0.65	0.05	1.64	0.282687153
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.70	598.00	6.44	0.51	0.86	0.882540941
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.55	6350.00	121.45	9.71	51.02	0.704183774
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	159.00	2.69	0.21	0.35	0.883390161
Halesia carolina	Carolina Siverbell	0.3	2	0.02	0.00	0.00	0.00	0.00	0.02	0
Hamamelis sp	Witchhazel	0.3	5	0.03	0.00	2.00	0.01	0.00	0.02	0.31638475
Ilex opaca	American Holly	0.3	10	0.38	0.04	6.00	0.28	0.02	0.11	0.720208008
Ilex sp	Holly	0.3	7	0.05	0.00	3.00	0.02	0.00	0.02	0.50570362
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	12.00	0.32	0.03	0.31	0.503687298
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	69.00	0.96	0.08	0.13	0.883575044
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	101.00	0.95	0.08	0.74	0.562457631
Larix laricina	Tamarack	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03	0
Larix sp	Larch	1.7	4	0.13	0.01	1.00	0.03	0.00	0.10	0.200568052
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.56	302.00	3.26	0.26	2.55	0.561116733
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.62	245.00	4.58	0.37	1.92	0.70445785
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	70.00	1.17	0.09	0.15	0.883945431
Magnolia sp	Magnolia	0.3	196	3.04	0.29	183.00	2.68	0.21	0.36	0.882711758
Magnolia stellata	Star Magnolia	0.3	3	0.02	0.00	1.00	0.01	0.00	0.01	0.606010495
Magnolia x soulangiana	Saucer Magnolia	0.3	3	0.01	0.00	1.00	0.00	0.00	0.01	0.407732358
Malus pumila	Apple	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02	0
Malus sp	Flowering Crabapple	1.7	458	6.10	0.59	356.00	3.42	0.27	2.68	0.56110412
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	43.00	1.22	0.10	0.15	0.889793368
Morus alba	White Mulberry	1.0	33	1.28	0.12	26.00	0.91	0.07	0.37	0.709133385

Morus rubra	Red Mulberry	1.0	4	0.13	0.01	1.00	0.03	0.00	0.10	0.246638558
Morus sp	Mulberry	1.0	38	1.13	0.11	31.00	0.81	0.07	0.32	0.719720818
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	9.00	0.21	0.02	0.15	0.581314452
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	2.00	0.03	0.00	0.03	0.535721567
Oxydendrum arboreum	Sourwood	1.7	6	0.02	0.00	2.00	0.01	0.00	0.00	0.78787512
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	29.00	0.69	0.06	0.08	0.898173242
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	84.00	1.50	0.12	0.20	0.883939537
Picea abies	Norway Spruce	1.7	40	1.04	0.10	26.00	0.59	0.05	0.45	0.567446932
Picea glauca	White Spruce	1.7	6	0.06	0.01	0.00	0.00	0.00	0.06	0
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	36.00	0.52	0.04	0.39	0.567038322
Picea sp	Spruce	1.7	5	0.02	0.00	3.00	0.01	0.00	0.01	0.625153995
Pinus banksiana	Jack Pine	1.7	1	0.03	0.00	0.00	0.00	0.00	0.03	0
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	96.00	1.06	0.09	0.83	0.562042044
Pinus parviflora	Japanese White Pine	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	0
Pinus resinosa	Red Pine	1.7	255	4.21	0.40	0.00	0.00	0.00	4.21	0
Pinus sp	Pine	1.7	101	5.35	0.51	69.00	3.00	0.24	2.35	0.561005929
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.12	339.00	6.56	0.52	5.13	0.561179342
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	5.00	0.12	0.01	0.06	0.655764102
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.47	1508.00	20.30	1.62	15.89	0.56102634
Platanus occidentalis	Sycamore	1.7	964	32.40	3.11	696.00	18.18	1.45	14.22	0.56104304
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.08	13.00	0.43	0.03	0.36	0.545249355
Populus sp	Poplar	1.7	31	0.40	0.04	18.00	0.23	0.02	0.17	0.566874865
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	0.00	0.00	0.00	0.50	0
Prunus Ã— yedoensis	Yoshino Cherry	1.0	7	0.08	0.01	0.00	0.00	0.00	0.08	0
Prunus pennsylvanica	Pin Cherry	1.7	3	0.04	0.00	0.00	0.00	0.00	0.04	0
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.25	171.00	1.80	0.14	0.75	0.704464126
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	6.00	0.33	0.03	0.25	0.574970972
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	117.00	1.68	0.13	0.71	0.704547552
Prunus sp	Cherry	1.0	277	3.75	0.36	242.00	2.65	0.21	1.11	0.704483672
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	34.00	0.72	0.06	0.30	0.705952126
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	0.00	0.00	0.00	0.64	0
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	56.00	0.69	0.05	0.28	0.707304158
Pseudotsuga menziesii	Douglas Fir	1.0	2	0.02	0.00	0.00	0.00	0.00	0.02	0
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.27	1076.00	13.24	1.06	10.36	0.561032862
Pyrus sp	Pear	1.7	13	0.10	0.01	8.00	0.06	0.00	0.04	0.60445024
Quercus alba	White Oak	1.7	130	3.33	0.32	92.00	1.87	0.15	1.46	0.561688211
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.77	269.00	4.52	0.36	3.54	0.561072899
Quercus coccinea	Scarlet Oak	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02	0
Quercus imbricaria	Shingle Oak	1.7	2	0.00	0.00	0.00	0.00	0.00	0.00	0
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	0.00	0.00	0.00	0.19	0
Quercus palustris	Pin Oak	1.7	3676	107.61	10.33	2679.00	60.37	4.83	47.24	0.56102659
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	3.00	0.24	0.02	0.14	0.641229636
Quercus robur	English Oak	1.0	11	0.17	0.02	7.00	0.13	0.01	0.03	0.805369054
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.87	1611.00	40.18	3.21	31.44	0.56103086
Quercus sp	Oak	1.7	38	0.54	0.05	26.00	0.31	0.03	0.23	0.579457153
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.47	126.00	2.75	0.22	2.15	0.561234581
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.07	13.00	0.61	0.05	0.07	0.89328331
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	37.00	1.40	0.11	0.29	0.828339805
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	109.00	3.71	0.30	0.49	0.882927819
Salix alba	White Willow	1.7	1	0.01	0.00	0.00	0.00	0.00	0.01	0
Salix babylonica	Weeping Willow	1.7	56	1.42	0.14	38.00	0.80	0.06	0.62	0.563515875
Salix sp	Willow	1.7	51	1.31	0.13	34.00	0.76	0.06	0.55	0.579697617
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	0.00	0.00	0.00	0.08	0
Sorbus alnifolia	Korean Mountain Ash	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03	0
Stewartia sp	Stewartia	0.3	4	0.03	0.00	2.00	0.03	0.00	0.01	0.822777432
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.49	250.00	4.51	0.36	0.60	0.882636924
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	462.00	4.61	0.37	0.61	0.882495719
Taxus sp	Yew	1.0	11	0.07	0.01	6.00	0.06	0.00	0.02	0.773673474
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	10.00	0.18	0.01	0.02	0.905060696
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	1.00	0.05	0.00	0.08	0.390242924
Tilia americana	Basswood	1.7	550	13.79	1.32	400.00	7.74	0.62	6.05	0.561074899
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.31	1431.00	19.32	1.54	15.12	0.561034987
Tilia europaea	European Linden	1.7	39	1.26	0.12	26.00	0.73	0.06	0.53	0.576143291
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	66.00	1.04	0.08	0.81	0.564070953
Total		***NA***	***NA***	***1.85***	***NA***	***NA***	***639.53***	***NA***	***0.81***	345.8119409
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	29.00	0.59	0.05	0.44	0.571760917
Tsuga caroliniana	Carolina Hemlock	1.7	2	0.01	0.00	0.00	0.00	0.00	0.01	0
Ulmus americana	American Elm	1.7	389	9.95	0.95	290.00	5.58	0.45	4.37	0.561103333
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	139.00	2.40	0.19	1.88	0.561203343
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	26.00	0.54	0.04	0.39	0.583269349
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	16.00	0.32	0.03	0.20	0.622925066
Ulmus sp	Elm	1.7	793	13.52	1.30	619.00	7.59	0.61	5.94	0.561071612
Viburnum sp	Viburnum	0.3	4	0.03	0.00	1.00	0.02	0.00	0.01	0.612234841
Zelkova serrata	Zelkova	0.3	761	16.35	1.57	728.00	14.43	1.15	1.92	0.882507406
				1058.11						

BASE 2070 TABLE LOWER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2070 Polygon Count	2070 City Canopy Acres	% of City Canopy in 2070	Canopy Acres Lost 2018 to 2070	
Abies balsamea	Balsam Fir	1.0	1	0.00	0.00	0.00	0.00	0.00	0.00	
Abies concolor	White Fir	1.0	15	0.27	0.03	9.00	0.18	0.04	0.09	
Abies sp	Fir	1.0	7	0.04	0.00	3.00	0.02	0.00	0.02	
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	2.00	0.04	0.01	0.02	
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	186.00	1.81	0.42	2.82	
Acer freemanii	Freeman Maple	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	22.00	0.26	0.06	0.36	
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	18.00	0.08	0.02	0.12	
Acer negundo	Boxelder	1.7	7	0.29	0.03	1.00	0.10	0.02	0.19	
Acer nigrum	Black Maple	1.7	3	0.08	0.01	0.00	0.00	0.00	0.08	
Acer palmatum	Japanese Maple	1.7	141	1.83	0.17	95.00	0.72	0.17	1.11	
Acer platanoides	Norway Maple	1.7	7810	192.08	18.18	4460.00	75.09	17.32	116.99	
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	111.00	2.30	0.53	3.58	
Acer rubrum	Red Maple	1.7	4461	71.75	6.79	2699.00	28.05	6.47	43.70	
Acer saccharinum	Silver Maple	1.7	344	7.86	0.74	190.00	3.07	0.71	4.78	
Acer saccharum	Sugar Maple	1.7	968	27.20	2.58	560.00	10.64	2.45	16.57	
Acer sp	Maple	1.7	15	0.17	0.02	6.00	0.05	0.01	0.12	
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	12.00	0.12	0.03	0.16	
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	21.00	0.20	0.05	0.29	
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.20	82.00	0.84	0.19	1.31	
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	18.00	0.59	0.14	1.64	
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	10.00	0.25	0.06	0.17	
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	0.00	0.00	0.00	0.26	
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	0.00	0.00	0.00	3.76	
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	0.00	0.00	0.00	0.03	
Betula nigra	River Birch	1.7	180	2.83	0.27	110.00	1.11	0.26	1.72	
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	0.00	0.00	0.00	0.51	
Betula pendula	European White Birch	1.7	39	0.70	0.07	0.00	0.00	0.00	0.70	
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	0.00	0.00	0.00	0.90	
Betula sp	Birch	1.7	22	0.61	0.06	0.00	0.00	0.00	0.61	
Carpinus betulus	European Hornbeam	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	39.00	0.32	0.07	0.49	
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	30.00	0.62	0.14	0.13	
Carya sp	Hickory	1.0	3	0.04	0.00	0.00	0.00	0.00	0.04	
Castanea dentata	American Chestnut	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	40.00	1.13	0.26	0.22	
Cedrus libani	Cedar of Lebanon	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	88.00	1.03	0.24	1.60	
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	36.00	0.47	0.11	0.72	
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.31	0.00	0.00	0.00	3.29	
Chamaecyparis sp	Falsecypress	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	42.00	0.91	0.21	0.68	
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	90.00	1.07	0.25	1.66	
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	114.00	1.27	0.29	1.97	
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	0.00	0.00	0.00	0.04	
Cornus sp	Dogwood	1.7	4	0.03	0.00	0.00	0.00	0.00	0.03	
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	0.00	0.00	0.00	0.02	
Cotinus sp	Smoketree	1.7	20	0.40	0.04	0.00	0.00	0.00	0.40	
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	32.00	0.36	0.08	0.55	
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	0.00	0.00	0.00	0.31	
Enkianthus campanulatus	Enkianthus	0.3	1	0.00	0.00	0.00	0.00	0.00	0.00	
Eucommia ulmoides	Hardy Rubber Tree	0.3	9	0.01	0.00	6.00	0.01	0.00	0.00	
Fagus grandifolia	American Beech	1.7	10	0.16	0.01	3.00	0.09	0.02	0.06	
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	66.00	1.48	0.34	2.30	
Fraxinus americana	White Ash	1.7	345	11.10	1.05	97.50	2.17	0.50	8.93	1.08
Fraxinus nigra	Black Ash	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.69	405.00	8.04	1.86	20.40	4.02
Fraxinus sp	Ash	1.7	90	2.29	0.22	25.50	0.45	0.10	1.83	0.23
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.69	584.00	5.96	1.37	1.34	
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.33	5576.00	97.54	22.50	74.92	
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	153.00	2.48	0.57	0.56	
Halesia carolina	Carolina Siverbell	0.3	2	0.02	0.00	0.00	0.00	0.00	0.02	
Hamamelis sp	Witchhazel	0.3	5	0.03	0.00	0.00	0.00	0.00	0.03	

Ilex opaca	American Holly	0.3	10	0.38	0.04	4.00	0.18	0.04	0.20
Ilex sp	Holly	0.3	7	0.05	0.00	2.00	0.02	0.00	0.03
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	9.00	0.23	0.05	0.41
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	62.00	0.89	0.21	0.20
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	81.00	0.67	0.15	1.03
Larix laricina	Tamarack	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03
Larix sp	Larch	1.7	4	0.13	0.01	0.00	0.00	0.00	0.13
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.55	241.00	2.27	0.52	3.54
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.61	215.00	3.68	0.85	2.82
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	64.00	1.09	0.25	0.24
Magnolia sp	Magnolia	0.3	196	3.04	0.29	176.00	2.48	0.57	0.56
Magnolia stellata	Star Magnolia	0.3	3	0.02	0.00	0.00	0.00	0.00	0.02
Magnolia x soulangiana	Saucer Magnolia	0.3	3	0.01	0.00	0.00	0.00	0.00	0.01
Malus pumila	Apple	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02
Malus sp	Flowering Crabapple	1.7	458	6.10	0.58	288.00	2.38	0.55	3.71
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	39.00	1.14	0.26	0.24
Morus alba	White Mulberry	1.0	33	1.28	0.12	22.00	0.73	0.17	0.56
Morus rubra	Red Mulberry	1.0	4	0.13	0.01	0.00	0.00	0.00	0.13
Morus sp	Mulberry	1.0	38	1.13	0.11	27.00	0.65	0.15	0.48
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	6.00	0.16	0.04	0.19
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	1.00	0.02	0.00	0.04
Oxydendrum arboreum	Sourwood	1.7	6	0.02	0.00	1.00	0.01	0.00	0.01
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	26.00	0.65	0.15	0.12
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	80.00	1.39	0.32	0.31
Picea abies	Norway Spruce	1.7	40	1.04	0.10	19.00	0.42	0.10	0.63
Picea glauca	White Spruce	1.7	6	0.06	0.01	0.00	0.00	0.00	0.06
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	25.00	0.36	0.08	0.55
Picea sp	Spruce	1.7	5	0.02	0.00	2.00	0.01	0.00	0.01
Pinus banksiana	Jack Pine	1.7	1	0.03	0.00	0.00	0.00	0.00	0.03
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	75.00	0.74	0.17	1.15
Pinus parviflora	Japanese White Pine	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04
Pinus resinosa	Red Pine	1.7	255	4.21	0.40	0.00	0.00	0.00	4.21
Pinus sp	Pine	1.7	101	5.35	0.51	51.00	2.07	0.48	3.28
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.11	263.00	4.57	1.05	7.12
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	3.00	0.07	0.02	0.10
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.43	1209.00	14.15	3.26	22.04
Platanus occidentalis	Sycamore	1.7	964	32.40	3.07	541.00	12.67	2.92	19.73
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.07	10.00	0.26	0.06	0.53
Populus sp	Poplar	1.7	31	0.40	0.04	0.00	0.00	0.00	0.40
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	0.00	0.00	0.00	0.50
Prunus Ã— yedoensis	Yoshino Cherry	1.0	7	0.08	0.01	0.00	0.00	0.00	0.08
Prunus pennsylvanica	Pin Cherry	1.7	3	0.04	0.00	0.00	0.00	0.00	0.04
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.24	0.00	0.00	0.00	2.55
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	4.00	0.24	0.06	0.34
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	0.00	0.00	0.00	2.39
Prunus sp	Cherry	1.0	277	3.75	0.36	0.00	0.00	0.00	3.75
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	0.00	0.00	0.00	1.03
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	0.00	0.00	0.00	0.64
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	0.00	0.00	0.00	0.97
Pseudotsuga menziesii	Douglas Fir	1.0	2	0.02	0.00	0.00	0.00	0.00	0.02
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.23	0.00	0.00	0.00	23.60
Pyrus sp	Pear	1.7	13	0.10	0.01	0.00	0.00	0.00	0.10
Quercus alba	White Oak	1.7	130	3.33	0.32	71.00	1.30	0.30	2.03
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.76	220.00	3.15	0.73	4.91
Quercus coccinea	Scarlet Oak	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02
Quercus imbricaria	Shingle Oak	1.7	2	0.00	0.00	0.00	0.00	0.00	0.00
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	0.00	0.00	0.00	0.19
Quercus palustris	Pin Oak	1.7	3676	107.61	10.19	2107.00	42.07	9.70	65.54
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	2.00	0.24	0.06	0.14
Quercus robur	English Oak	1.0	11	0.17	0.02	4.00	0.10	0.02	0.06
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.78	1260.00	28.00	6.46	43.62
Quercus sp	Oak	1.7	38	0.54	0.05	19.00	0.22	0.05	0.32
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.46	101.00	1.92	0.44	2.99
Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.06	0.00	0.00	0.00	0.68
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	34.00	1.30	0.30	0.40

Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	104.00	3.43	0.79	0.77
Salix alba	White Willow	1.7	1	0.01	0.00	0.00	0.00	0.00	0.01
Salix babylonica	Weeping Willow	1.7	56	1.42	0.13	30.00	0.57	0.13	0.86
Salix sp	Willow	1.7	51	1.31	0.12	26.00	0.55	0.13	0.75
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	0.00	0.00	0.00	0.08
Sorbus alnifolia	Korean Mountain Ash	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03
Stewartia sp	Stewartia	0.3	4	0.03	0.00	0.00	0.00	0.00	0.03
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.48	0.00	0.00	0.00	5.11
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	0.00	0.00	0.00	5.23
Taxus sp	Yew	1.0	11	0.07	0.01	4.00	0.05	0.01	0.03
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	8.00	0.16	0.04	0.03
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	0.00	0.00	0.00	0.14
Tilia americana	Basswood	1.7	550	13.79	1.31	310.00	5.39	1.24	8.40
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.26	1141.00	13.46	3.11	20.97
Tilia europaea	European Linden	1.7	39	1.26	0.12	20.00	0.52	0.12	0.74
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	52.00	0.73	0.17	1.12
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	21.00	0.41	0.10	0.62
Tsuga caroliniana	Carolina Hemlock	1.7	2	0.01	0.00	0.00	0.00	0.00	0.01
Ulmus americana	American Elm	1.7	389	9.95	0.94	231.00	3.89	0.90	6.06
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	107.00	1.68	0.39	2.61
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	21.00	0.39	0.09	0.54
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	12.00	0.25	0.06	0.26
Ulmus sp	Elm	1.7	793	13.52	1.28	499.00	5.29	1.22	8.24
Viburnum sp	Viburnum	0.3	4	0.03	0.00	0.00	0.00	0.00	0.03
Zelkova serrata	Zelkova	0.3	761	16.35	1.55	701.00	13.35	3.08	3.01
Total		***NA***	***NA***	***1056.26***	***NA***	***NA***	***444.19***	***NA***	***622.74***

BASE 2070 TABLE UPPER

Genus/Species Name	Common Name	Annual Canopy Removal Rate (%)	2018 Polygon Count	2018 City Canopy Acres	% of City Canopy in 2018	2070 Polygon Count	2070 City Canopy Acres	% of City Canopy in 2070	Canopy Acres Lost 2018 to 2070	
Abies balsamea	Balsam Fir	1.0	1	0.00	0.00	0.00	0.00	0.00	0.00	
Abies concolor	White Fir	1.0	15	0.27	0.03	6.00	0.12	0.05	0.16	
Abies sp	Fir	1.0	7	0.04	0.00	3.00	0.02	0.01	0.02	
Acer buergerianum	Trident Maple	1.0	5	0.06	0.01	2.00	0.03	0.01	0.03	
Acer campestre	Hedge Maple	1.7	299	4.63	0.44	97.00	0.73	0.33	3.90	
Acer freemanii	Freeman Maple	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	
Acer ginnala	Amur Maple	1.7	39	0.61	0.06	14.00	0.11	0.05	0.50	
Acer griseum	Paperbark Maple	1.7	35	0.21	0.02	9.00	0.04	0.02	0.17	
Acer negundo	Boxelder	1.7	7	0.29	0.03	1.00	0.10	0.05	0.19	
Acer nigrum	Black Maple	1.7	3	0.08	0.01	0.00	0.00	0.00	0.08	
Acer palmatum	Japanese Maple	1.7	141	1.83	0.17	55.00	0.29	0.13	1.54	
Acer platanoides	Norway Maple	1.7	7810	192.08	18.18	2220.00	30.29	13.86	161.79	
Acer pseudoplatanus	Sycamore Maple	1.7	205	5.88	0.56	55.00	0.93	0.43	4.95	
Acer rubrum	Red Maple	1.7	4461	71.75	6.79	1397.00	11.31	5.18	60.43	
Acer saccharinum	Silver Maple	1.7	344	7.86	0.74	92.00	1.24	0.57	6.62	
Acer saccharum	Sugar Maple	1.7	968	27.20	2.58	281.00	4.29	1.96	22.91	
Acer sp	Maple	1.7	15	0.17	0.02	3.00	0.03	0.01	0.14	
Acer tataricum	Tatarian Maple	1.7	23	0.27	0.03	7.00	0.06	0.03	0.22	
Acer x freemanii	Freeman Maple	1.7	40	0.49	0.05	8.00	0.08	0.04	0.41	
Aesculus hippocastanum	Horsechestnut	1.7	138	2.15	0.20	45.00	0.34	0.16	1.81	
Ailanthus altissima	Tree of Heaven	1.0	74	2.23	0.21	12.00	0.31	0.14	1.92	
Alnus glutinosa	Common Alder	1.0	14	0.43	0.04	6.00	0.15	0.07	0.28	
Amelanchier arborea	Downy Serviceberry	0.3	32	0.26	0.02	0.00	0.00	0.00	0.26	
Amelanchier sp	Serviceberry	0.3	222	3.76	0.36	0.00	0.00	0.00	3.76	
Amelanchier x grandiflora	Apple Serviceberry	1.0	10	0.03	0.00	0.00	0.00	0.00	0.03	
Betula nigra	River Birch	1.7	180	2.83	0.27	57.00	0.45	0.21	2.38	
Betula papyrifera	Paper Birch	1.7	44	0.51	0.05	0.00	0.00	0.00	0.51	
Betula pendula	European White Birch	1.7	39	0.70	0.07	0.00	0.00	0.00	0.70	
Betula populifolia	Gray Birch	1.7	43	0.90	0.09	0.00	0.00	0.00	0.90	
Betula sp	Birch	1.7	22	0.61	0.06	0.00	0.00	0.00	0.61	
Carpinus betulus	European Hornbeam	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	
Carpinus caroliniana	American Hornbeam	1.7	70	0.81	0.08	21.00	0.13	0.06	0.68	
Carpinus sp	Hornbeam	0.3	45	0.75	0.07	32.00	0.53	0.24	0.22	
Carya sp	Hickory	1.0	3	0.04	0.00	0.00	0.00	0.00	0.04	
Castanea dentata	American Chestnut	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04	
Catalpa speciosa	Northern Catalpa	0.3	50	1.35	0.13	38.00	0.95	0.43	0.40	
Cedrus libani	Cedar of Lebanon	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	
Celtis occidentalis	Hackberry	1.7	151	2.64	0.25	46.00	0.42	0.19	2.22	
Cercidiphyllum japonicum	Katsuratree	1.7	63	1.19	0.11	21.00	0.19	0.09	1.00	
Cercis canadensis	Eastern Redbud	1.7	182	3.29	0.31	0.00	0.00	0.00	3.29	
Chamaecyparis sp	Falsecypress	0.3	1	0.01	0.00	0.00	0.00	0.00	0.01	
Cladrastis kentukea	Yellowwood	1.0	62	1.58	0.15	31.00	0.54	0.25	1.04	
Cornus florida	Flowering Dogwood	1.7	139	2.72	0.26	46.00	0.43	0.20	2.29	
Cornus kousa	Kousa Dogwood	1.7	200	3.24	0.31	56.00	0.51	0.24	2.73	
Cornus mas	Corneliancherry Dogwood	1.0	2	0.04	0.00	0.00	0.00	0.00	0.04	
Cornus sp	Dogwood	1.7	4	0.03	0.00	0.00	0.00	0.00	0.03	
Cotinus obovatus	American Smoketree	1.7	4	0.02	0.00	0.00	0.00	0.00	0.02	
Cotinus sp	Smoketree	1.7	20	0.40	0.04	0.00	0.00	0.00	0.40	
Crataegus sp	Hawthorn	1.7	59	0.90	0.09	18.00	0.15	0.07	0.76	
Elaegnus angustifolia	Russian Olive	0.3	10	0.31	0.03	0.00	0.00	0.00	0.31	
Enkianthus campanulatus	Enkianthus	0.3	1	0.00	0.00	0.00	0.00	0.00	0.00	
Eucommia ulmoides	Hardy Rubber Tree	0.3	9	0.01	0.00	6.00	0.01	0.00	0.00	
Fagus grandifolia	American Beech	1.7	10	0.16	0.01	2.00	0.03	0.01	0.13	
Fagus sylvatica	European Beech	1.7	122	3.78	0.36	32.00	0.60	0.27	3.18	
Fraxinus americana	White Ash	1.7	345	11.10	1.05	47.00	1.75	0.80	9.35	23.5
Fraxinus nigra	Black Ash	1.7	1	0.00	0.00	0.00	0.00	0.00	0.00	0
Fraxinus pennsylvanica	Green Ash	1.0	1100	28.44	2.69	283.50	9.48	4.34	18.96	142
Fraxinus sp	Ash	1.7	90	2.29	0.22	12.50	0.37	0.17	1.92	6.25
Ginkgo biloba	Ginkgo	0.3	618	7.30	0.69	554.00	5.09	2.33	2.21	
Gleditsia triacanthos	Common Thornless Honeylocust	1.0	7504	172.46	16.33	3914.00	57.50	26.31	114.96	
Gymnocladus dioicus	Kentucky Coffeetree	0.3	171	3.04	0.29	142.00	2.12	0.97	0.92	
Halesia carolina	Carolina Silverbell	0.3	2	0.02	0.00	0.00	0.00	0.00	0.02	

Hamamelis sp	Witchhazel	0.3	5	0.03	0.00	0.00	0.00	0.00	0.03
Ilex opaca	American Holly	0.3	10	0.38	0.04	4.00	0.18	0.08	0.20
Ilex sp	Holly	0.3	7	0.05	0.00	2.00	0.02	0.01	0.03
Juglans nigra	Black Walnut	1.7	19	0.63	0.06	4.00	0.10	0.05	0.54
Juniperus virginiana	Eastern Redcedar	0.3	80	1.09	0.10	60.00	0.76	0.35	0.33
Koelreuteria paniculata	Panicled Goldenraintree	1.7	136	1.70	0.16	40.00	0.27	0.12	1.43
Larix laricina	Tamarack	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03
Larix sp	Larch	1.7	4	0.13	0.01	0.00	0.00	0.00	0.13
Liquidambar styraciflua	Sweetgum	1.7	390	5.81	0.55	123.00	0.92	0.42	4.89
Liriodendron tulipifera	Tuliptree	1.0	284	6.50	0.61	155.00	2.17	0.99	4.33
Maackia amurensis	Amur Maackia	0.3	81	1.33	0.13	65.00	0.93	0.42	0.40
Magnolia sp	Magnolia	0.3	196	3.04	0.29	170.00	2.12	0.97	0.92
Magnolia stellata	Star Magnolia	0.3	3	0.02	0.00	0.00	0.00	0.00	0.02
Magnolia x soulangiana	Saucer Magnolia	0.3	3	0.01	0.00	0.00	0.00	0.00	0.01
Malus pumila	Apple	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02
Malus sp	Flowering Crabapple	1.7	458	6.10	0.58	146.00	0.96	0.44	5.14
Metasequoia glyptostroboides	Dawn Redwood	0.3	51	1.38	0.13	41.00	0.97	0.45	0.40
Morus alba	White Mulberry	1.0	33	1.28	0.12	15.00	0.46	0.21	0.82
Morus rubra	Red Mulberry	1.0	4	0.13	0.01	0.00	0.00	0.00	0.13
Morus sp	Mulberry	1.0	38	1.13	0.11	18.00	0.40	0.18	0.73
Nyssa sylvatica	Black Tupelo	1.7	18	0.36	0.03	4.00	0.11	0.05	0.25
Ostrya virginiana	American Hophornbeam	1.7	5	0.06	0.01	1.00	0.01	0.00	0.05
Oxydendrum arboreum	Sourwood	1.7	6	0.02	0.00	1.00	0.01	0.00	0.01
Parrotia persica	Persian Parrotia	0.3	36	0.77	0.07	24.00	0.55	0.25	0.22
Phellodendron amurense	Amur Corktree	0.3	93	1.70	0.16	74.00	1.19	0.55	0.51
Picea abies	Norway Spruce	1.7	40	1.04	0.10	11.00	0.17	0.08	0.87
Picea glauca	White Spruce	1.7	6	0.06	0.01	0.00	0.00	0.00	0.06
Picea pungens	Colorado Spruce	1.7	56	0.91	0.09	13.00	0.15	0.07	0.76
Picea sp	Spruce	1.7	5	0.02	0.00	2.00	0.01	0.00	0.01
Pinus banksiana	Jack Pine	1.7	1	0.03	0.00	0.00	0.00	0.00	0.03
Pinus nigra	Austrian Pine	1.7	129	1.89	0.18	38.00	0.30	0.14	1.59
Pinus parviflora	Japanese White Pine	1.7	2	0.04	0.00	0.00	0.00	0.00	0.04
Pinus resinosa	Red Pine	1.7	255	4.21	0.40	0.00	0.00	0.00	4.21
Pinus sp	Pine	1.7	101	5.35	0.51	26.00	0.84	0.38	4.51
Pinus strobus	Eastern White Pine	1.7	475	11.68	1.11	132.00	1.84	0.84	9.84
Pinus sylvestris	Scotch Pine	1.7	9	0.18	0.02	3.00	0.05	0.02	0.12
Platanus acerifolia	London Planetree	1.7	1986	36.19	3.43	634.00	5.71	2.61	30.48
Platanus occidentalis	Sycamore	1.7	964	32.40	3.07	267.00	5.11	2.34	27.29
Populus deltoides	Eastern Poplar	1.7	21	0.79	0.07	6.00	0.11	0.05	0.68
Populus sp	Poplar	1.7	31	0.40	0.04	0.00	0.00	0.00	0.40
Populus tremuloides	Quaking Aspen	1.7	18	0.50	0.05	0.00	0.00	0.00	0.50
Prunus Ã— yedoensis	Yoshino Cherry	1.0	7	0.08	0.01	0.00	0.00	0.00	0.08
Prunus pennsylvanica	Pin Cherry	1.7	3	0.04	0.00	0.00	0.00	0.00	0.04
Prunus sargentii	Sargent Cherry	1.0	201	2.55	0.24	0.00	0.00	0.00	2.55
Prunus serotina	Black Cherry	1.7	12	0.58	0.06	4.00	0.12	0.05	0.47
Prunus serrulata	Flowering Cherry	1.0	142	2.39	0.23	0.00	0.00	0.00	2.39
Prunus sp	Cherry	1.0	277	3.75	0.36	0.00	0.00	0.00	3.75
Prunus subhirtella	Weeping Cherry	1.0	46	1.03	0.10	0.00	0.00	0.00	1.03
Prunus virginiana	Common Chokecherry	1.7	15	0.64	0.06	0.00	0.00	0.00	0.64
Prunus x incamp	Okame Cherry	1.0	68	0.97	0.09	0.00	0.00	0.00	0.97
Pseudotsuga menziesii	Douglas Fir	1.0	2	0.02	0.00	0.00	0.00	0.00	0.02
Pyrus calleryana	Callery Pear	1.7	1429	23.60	2.23	0.00	0.00	0.00	23.60
Pyrus sp	Pear	1.7	13	0.10	0.01	0.00	0.00	0.00	0.10
Quercus alba	White Oak	1.7	130	3.33	0.32	35.00	0.53	0.24	2.80
Quercus bicolor	Swamp White Oak	1.7	349	8.06	0.76	120.00	1.27	0.58	6.79
Quercus coccinea	Scarlet Oak	1.7	1	0.02	0.00	0.00	0.00	0.00	0.02
Quercus imbricaria	Shingle Oak	1.7	2	0.00	0.00	0.00	0.00	0.00	0.00
Quercus lyrata	Overcup Oak	1.7	2	0.19	0.02	0.00	0.00	0.00	0.19
Quercus palustris	Pin Oak	1.7	3676	107.61	10.19	1064.00	16.97	7.76	90.64
Quercus phellos	Willow Oak	1.7	11	0.38	0.04	1.00	0.12	0.05	0.26
Quercus robur	English Oak	1.0	11	0.17	0.02	3.00	0.10	0.05	0.06
Quercus rubra	Northern Red Oak	1.7	2219	71.62	6.78	630.00	11.29	5.17	60.33
Quercus sp	Oak	1.7	38	0.54	0.05	12.00	0.09	0.04	0.45
Quercus velutina	Eastern Black Oak	1.7	169	4.90	0.46	53.00	0.77	0.35	4.13

Rhamnus cathartica	European Buckthorn	0.3	17	0.68	0.06	0.00	0.00	0.00	0.68
Rhamnus frangula	Glossy Buckthorn	0.3	44	1.70	0.16	33.00	1.11	0.51	0.59
Robinia pseudoacacia	Black Locust	0.3	119	4.20	0.40	97.00	2.94	1.35	1.26
Salix alba	White Willow	1.7	1	0.01	0.00	0.00	0.00	0.00	0.01
Salix babylonica	Weeping Willow	1.7	56	1.42	0.13	17.00	0.23	0.10	1.20
Salix sp	Willow	1.7	51	1.31	0.12	11.00	0.29	0.13	1.02
Sophora japonica	Japanese Pagodatree	0.3	4	0.08	0.01	0.00	0.00	0.00	0.08
Sorbus alnifolia	Korean Mountain Ash	1.7	2	0.03	0.00	0.00	0.00	0.00	0.03
Stewartia sp	Stewartia	0.3	4	0.03	0.00	0.00	0.00	0.00	0.03
Styphnolobium japonicum	Japanese Snowbell	0.3	268	5.11	0.48	0.00	0.00	0.00	5.11
Syringa reticulata	Japanese Lilac Tree	0.3	480	5.23	0.50	0.00	0.00	0.00	5.23
Taxus sp	Yew	1.0	11	0.07	0.01	4.00	0.05	0.02	0.03
Thuja occidentalis	Eastern Arborvitae	0.3	14	0.20	0.02	8.00	0.15	0.07	0.05
Thuja plicata	Western Redcedar	1.0	5	0.14	0.01	0.00	0.00	0.00	0.14
Tilia americana	Basswood	1.7	550	13.79	1.31	154.00	2.18	1.00	11.62
Tilia cordata	Littleleaf Linden	1.7	1907	34.44	3.26	590.00	5.43	2.48	29.01
Tilia europaea	European Linden	1.7	39	1.26	0.12	9.00	0.25	0.11	1.01
Tilia tomentosa	Silver Linden	1.7	90	1.85	0.18	26.00	0.30	0.14	1.55
Tsuga canadensis	Canadian Hemlock	1.7	39	1.04	0.10	12.00	0.17	0.08	0.86
Tsuga caroliniana	Carolina Hemlock	1.7	2	0.01	0.00	0.00	0.00	0.00	0.01
Ulmus americana	American Elm	1.7	389	9.95	0.94	116.00	1.57	0.72	8.38
Ulmus parvifolia	Chinese Elm	1.7	191	4.28	0.41	51.00	0.68	0.31	3.60
Ulmus pumila	Siberian Elm	1.7	36	0.93	0.09	10.00	0.16	0.07	0.77
Ulmus rubra	Slippery Elm	1.7	23	0.52	0.05	6.00	0.12	0.06	0.40
Ulmus sp	Elm	1.7	793	13.52	1.28	267.00	2.13	0.98	11.39
Viburnum sp	Viburnum	0.3	4	0.03	0.00	0.00	0.00	0.00	0.03
Zelkova serrata	Zelkova	0.3	761	16.35	1.55	643.00	11.41	5.22	4.94
Total		***NA***	***NA***	***1056.26***	***NA***	***NA***	***218.57***	***NA***	***837.70***

CAMBRIDGE CANOPY CHANGE MODEL RUN 2 RESULTS

Cambridge Forest Change Statistics by Time Period

Time Period	Canopy Area at Start of Period (ac.)	Canopy Polygon Area Lost in Period (ac.)	Canopy Polygon Area Gained in Period (ac.)	Canopy Area of No Polygon Change in Period (ac.)	Canopy Loss Minus Canopy Gain in Period (ac.)	Loss Minus Gain as Percent of Starting Canopy in Period (%)	Annual Average Loss Minus Gain in Period (ac.)	Annual Negative Compounded Loss Minus Gain Rate in Period (%)	*Table acres at end of period = B-C+D*	*Check: Measured acres in GIS acres at end of period*	*Comment*
2009-2014	1,219.7	216.6	163.7	1,003.1	52.9	4.34	10.6	0.95	1166.8	1182.4	2009-2014 loss rate most similar to 2009-2018 loss rate; City 2014 acres includes ca. 20 acres outside City boundary
2014-2018	1,166.8	335.6	212.0	844.1	123.6	10.59	30.9	2.70	1043.3	1056.3	2014-2018 loss rate appears to be anomalous compared to other two periods
2009-2018	1,219.7	397.2	233.4	822.5	163.8	13.43	18.2	1.55	1055.9	1056.3	

Annual Gross Canopy Loss Rate Estimate (2009-2018)

Year	Acres	0.0155	Annual loss rate
2009	1,219.7		From table above
2010	1,200.8		
2011	1,182.2		
2012	1,163.9		
2013	1,145.8		
2014	1,128.1		
2015	1,110.6		
2016	1,093.4		
2017	1,076.4		
2018	1,059.7	1,055.9	From table above

Annual Gross Canopy Loss Rate Estimate (2014-2018)

Year	Acres	0.027	Annual loss rate
2014	1,166.8		From table above
2015	1,135.3		
2016	1,104.7		
2017	1,074.8		
2018	1,045.8	1,043.3	From table above

Annual Gross Canopy Loss Rate Estimate (2009-2014)

Year	Acres	0.0095	Annual loss rate
2009	1,219.7		From table above
2010	1,208.1		
2011	1,196.6		
2012	1,185.3		
2013	1,174.0		
2014	1,162.8	1,166.8	From table above

Cambridge Forest Change Statistics by Time Period - Upper Bound

Time Period	Canopy Area at Start of Period (ac.)	Canopy Polygon Area Lost in Period (ac.)	Canopy Polygon Area Gained in Period (ac.)	Canopy Area of No Polygon Change in Period (ac.)	Canopy Loss Only in Period (ac.)	Loss Minus Gain as Percent of Starting Canopy in Period (%)	Annual Average Loss Minus Gain in Period (ac.)	Annual Negative Compounded Loss Minus Gain Rate in Period (%)
2009-2014	1,219.7	216.6	163.7	1,003.1	216.6	17.76	43.3	3.80
2014-2018	1,166.8	335.6	212.0	844.1	335.6	28.76	83.9	8.10
2009-2018	1,219.7	397.2	233.4	822.5	397.2	32.57	44.1	4.30

Annual Gross Canopy Loss Rate Estimate (2009-2018)

Year	Acres	0.043	Annual loss rate
2009	1,219.7		From table above
2010	1,167.2		
2011	1,117.1		
2012	1,069.0		
2013	1,023.1		
2014	979.1		
2015	937.0		
2016	896.7		
2017	858.1		
2018	821.2	822.5	From table above

Annual Gross Canopy Loss Rate Estimate (2014-2018)

Year	Acres	0.081	Annual loss rate
2014	1,166.8		From table above
2015	1,072.3		
2016	985.5		
2017	905.6		
2018	832.3	831.3	From table above

Annual Gross Canopy Loss Rate Estimate (2009-2014)

Year	Acres	0.038	Annual loss rate
2009	1,219.7		From table above
2010	1,173.3		
2011	1,128.8		
2012	1,085.9		
2013	1,044.6		
2014	1,004.9	1,003.1	From table above

APPENDIX L: HEAT ISLAND MODEL METHODOLOGY

CUFMP TECHNICAL APPENDIX MEMO 07-18-2019

1 INTRODUCTION

This technical memorandum details the urban heat island (UHI) modeling completed as part of the City of Cambridge Urban Forest Master Plan (UFMP). This memo briefly describes the development of the UHI model as a part of the City's Climate Change Vulnerability Assessment (CCVA). Four tree canopy scenarios were modeled for UHI as part of the Urban Forest Master Plan:

1. Observed 2018 tree canopy from aerial flyover
2. Projected right-of-way and Envision Alewife buildout tree canopy assuming no canopy loss from observed 2018 canopy, additional tree canopy from 12,000 proposed right-of-way trees planted over 10 years and additional tree canopy from Envision Alewife buildout tree planting
3. Projected East Cambridge and Mid Cambridge tree canopy consisting of projected right-of-way and Envision Alewife buildout tree canopy plus additional tree canopy assuming the implementation of neighborhood specific planting strategies
4. Projected 2030 tree canopy assuming accelerated loss rate applied to observed 2018 tree canopy

Modeled temperature results are presented spatially in citywide and neighborhood temperature maps. Temperature changes modeled for the four tree canopy scenarios are summarized quantitatively in tabular format.

2 MODEL DEVELOPMENT

As part of the City's Climate Change Vulnerability Assessment (CCVA)[1], Kleinfelder developed an urban heat island model that was based on using Landsat 5 satellite imagery for identification of localized "hot spots" within the City that experience higher temperatures compared to average temperature in the City due to lack of canopy and high impervious cover. Thermal digital numbers from the satellite imagery data were converted to at-satellite radiance, which was converted to at-satellite temperature. Land surface radiance was then calculated using emissivity and atmospheric estimates, and land surface radiance was used to estimate land surface temperature.

A unique aspect of this model was the conversion of land surface temperature to ambient air temperature. Land surface temperature is typically warmer than the ambient air temperature that is measured by weather stations and felt by humans. Therefore, land surface temperature was adjusted to estimate ambient air temperature. Ambient air temperature under existing conditions was estimated by establishing a relationship between observed ambient air temperature at weather station locations within the City with the corresponding land surface temperature at these same locations from the model. Ambient air temperature was also estimated for the 2030s and 2070s. This involved multiplying the ambient air temperature values for existing conditions by a scaling factor which was simply the ratio of average ambient air temperature for future conditions to average ambient air temperature for existing conditions. Future conditions temperature projections were determined based on a combination of historic extreme heat events in the City and downscaled climate change projections.

Ambient air temperature was compared with tree canopy percentage and the cooling impact of tree canopy was estimated from this relationship. The potential cooling effect of tree planting can be estimated by investigating the spatial relationship between existing-conditions temperature and

1 City of Cambridge. 2015. Climate Change Vulnerability Assessment: Climate Projections and Scenario Development. Report prepared by Kleinfelder, Boston MA.

tree canopy. Because a significant, causal relationship between temperature and trees is well established, the spatial correlation between temperature and tree canopy can be used to estimate the cooling impact of trees to a first approximation.

The initial analysis correlated tree canopy coverage to cooling impact (in terms of ambient air temperature) across the City of Cambridge. A linear regression was developed based on satellite derived temperature and LiDAR tree canopy coverage (Figure 1) which indicated that a 1% increase of tree canopy could yield 0.12 °F of cooling[2].

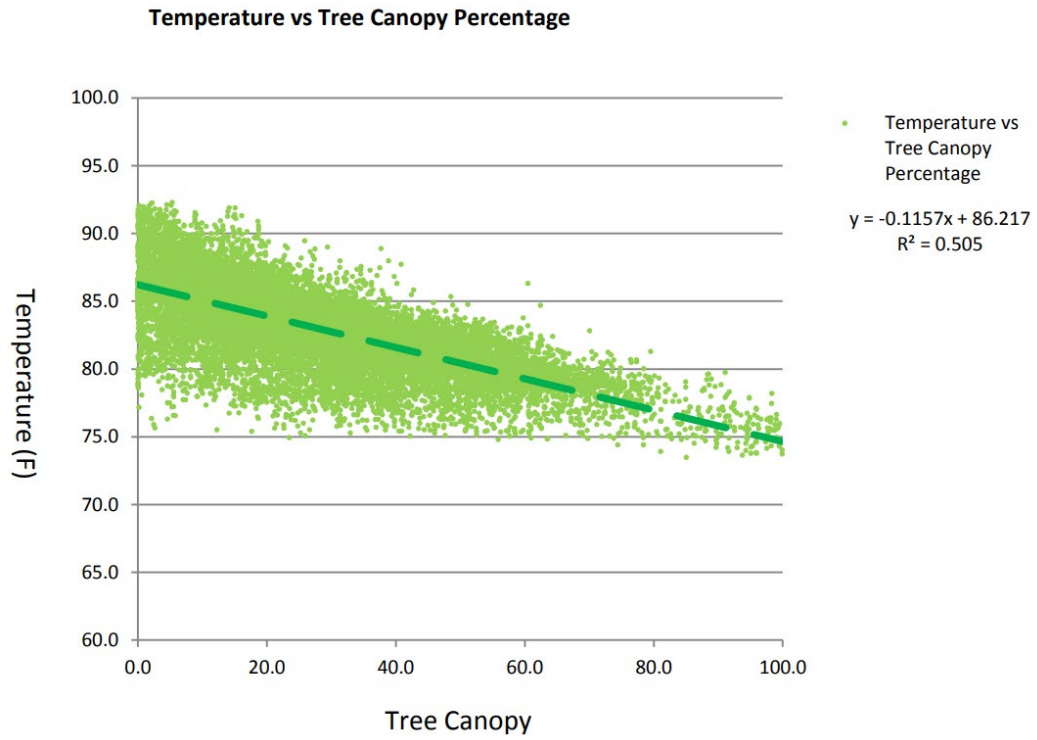


Figure 1 – Temperature vs. tree canopy percentage regression[2]

2 *For more information regarding the development of the UHI model, please refer to "City of Cambridge. 2015. Climate Change Vulnerability Assessment: Appendix D Urban Heat Island Protocol for Mapping Temperature Projections". Report prepared by Kleinfelder, Boston MA*

This relationship however has some limitations. The linear regression correlating temperature and tree canopy produced an R^2 value of about 0.5 indicating that about half of the variation in temperature can be explained by tree canopy. The remaining variation in temperature can be attributed to other factors known to impact temperature such as percentage of impervious area. This analysis also indicated that temperature variance increases with decreased canopy percentage. For areas with high percentages of tree canopy, the analysis indicates that the influence of other factors on temperature is diminished.

For this analysis, the linear temperature change relationship of 0.12 °F of temperature change per 1 % change of tree canopy was used to evaluate the temperature impacts of different tree canopy scenarios. A threshold of greater than 0.5 °F temperature change was chosen to represent a significant temperature change. This threshold was chosen primarily for temperature mapping purposes and to partially account for the limitations of the temperature relationship.

Increasing temperatures have been shown to impact public health in the form of increased heat related mortality and building energy use in the form of increased energy required for cooling. The impact of increased temperatures on public health was quantified in the Public Health Assessment completed as a part of CCVA[3]. The Assessment reports excess heat-related deaths for two different climate projection models with temperature changes from the two climate projections ranging from 0.59-1.32 °C (1.06-2.38 °F) and 2.17-2.33 °C (3.91-4.19 °F), respectively. Even for the more conservative temperature change scenario (1.06-2.38 °F) a significant increase in excess heat-related mortality was reported.

A University of Massachusetts study compared building energy use during the summer months (mid-June to mid-September) before and after a significant removal of trees in a Worcester neighborhood. The study reported an average 1% decrease in canopy cover resulted in an average 1.2% increase in building energy use (reported in kWh per cooling degree day)[4].

3 MODEL PROCESS

GIS spatial analysis was used to evaluate changes in tree canopy at the scale of 30-meter by 30-meter grid cells originally derived from Landsat 5 data during the development of the UHI model. All tree canopy scenarios were compared to the 2009 baseline tree canopy. For this analysis, the 2009 baseline tree canopy was considered to correspond to the baseline ambient air temperature grid created as a part of CCVA from 2010 Landsat data. This is a reasonable assumption considering that the change in tree canopy in one year from 2009 and 2010 was likely minimal.

Equation 1 was used to calculate the percentage canopy for each grid cell for the 2009 baseline tree canopy and for the tree canopy scenario being modeled. Equation 2 was used to calculate the estimated change in ambient air temperature for each grid cell due to change in tree canopy.

Equation 1

$$\%\ Canopy = \frac{Area\ of\ tree\ canopy\ within\ grid\ cell}{30\ meter\ x\ 30\ meter}$$

Equation 2

$$\Delta\ Estimated\ Ambient\ Air\ Temperature,\ ^oF = (\%\ Canopy_{scenario} - \%\ Canopy_{2009}) * \left(\frac{0.1157\ ^oF\ Change}{1\%\ canopy\ change}\right)$$

3 *City of Cambridge. 2015. Climate Change Vulnerability Assessment: Public Health Assessment. Report prepared by Kleinfelder, Boston MA.*

4 *Burncoat Neighborhood Tree Removal/Energy Use Study Worcester, MA. Report prepared by University of Massachusetts, Amherst*

Equation 3 was used to calculate the estimated ambient air temperature under the modeled scenario, where the estimated ambient air temperature, 2030s is the baseline temperature grid used for this analysis.

Equation 3

Estimated Ambient Air Temperature, ºF

= Estimated Ambient Air Temperature, 2030s + Δ Estimated Ambient Air Temperature, ºF

This baseline temperature grid was created as a part of CCVA and corresponds to an average citywide ambient air temperature of 90°F. The 2030s temperature grid was chosen as the baseline for this analysis to account for the time it would take for planting strategies to be implemented and for tree growth to occur. Note that the baseline temperature grid remains the same for all tree canopy scenarios regardless of the time horizon of the tree canopy scenario being modeled.

4 TEMPERATURE MAPS

Figures 2 through 11 present the modeled temperature results for the tree canopy scenarios modeled. Modeled temperature results are presented both in terms of absolute modeled temperature and temperature change from one scenario to another. Note that all maps of absolute modeled temperature are relative to the 2030s temperature baseline, as explained in Section 3 - Model Process of this memorandum.

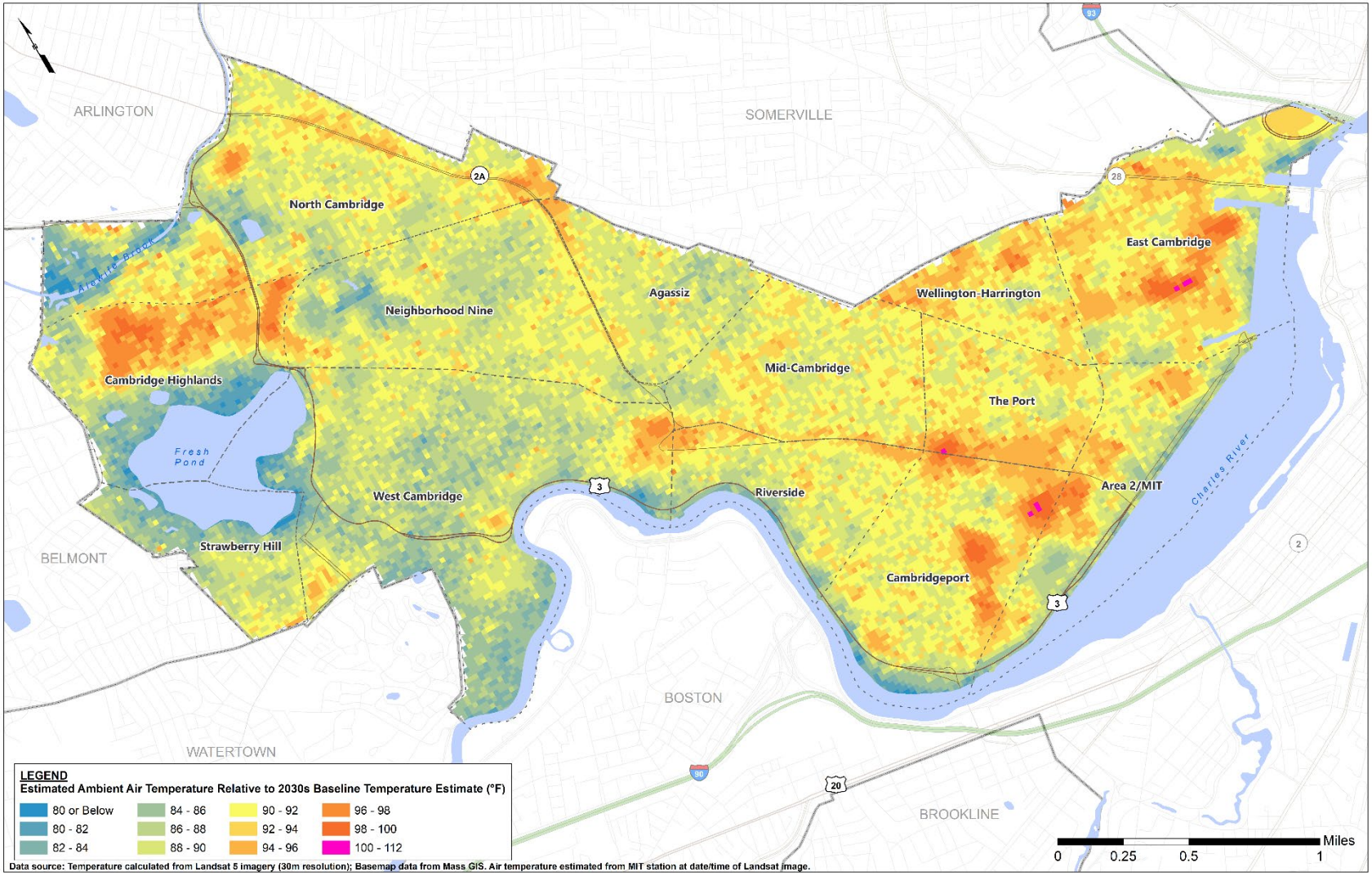


Figure 2 – Estimated ambient air temperature for observed 2018 tree canopy relative to 2030s baseline temperature estimate

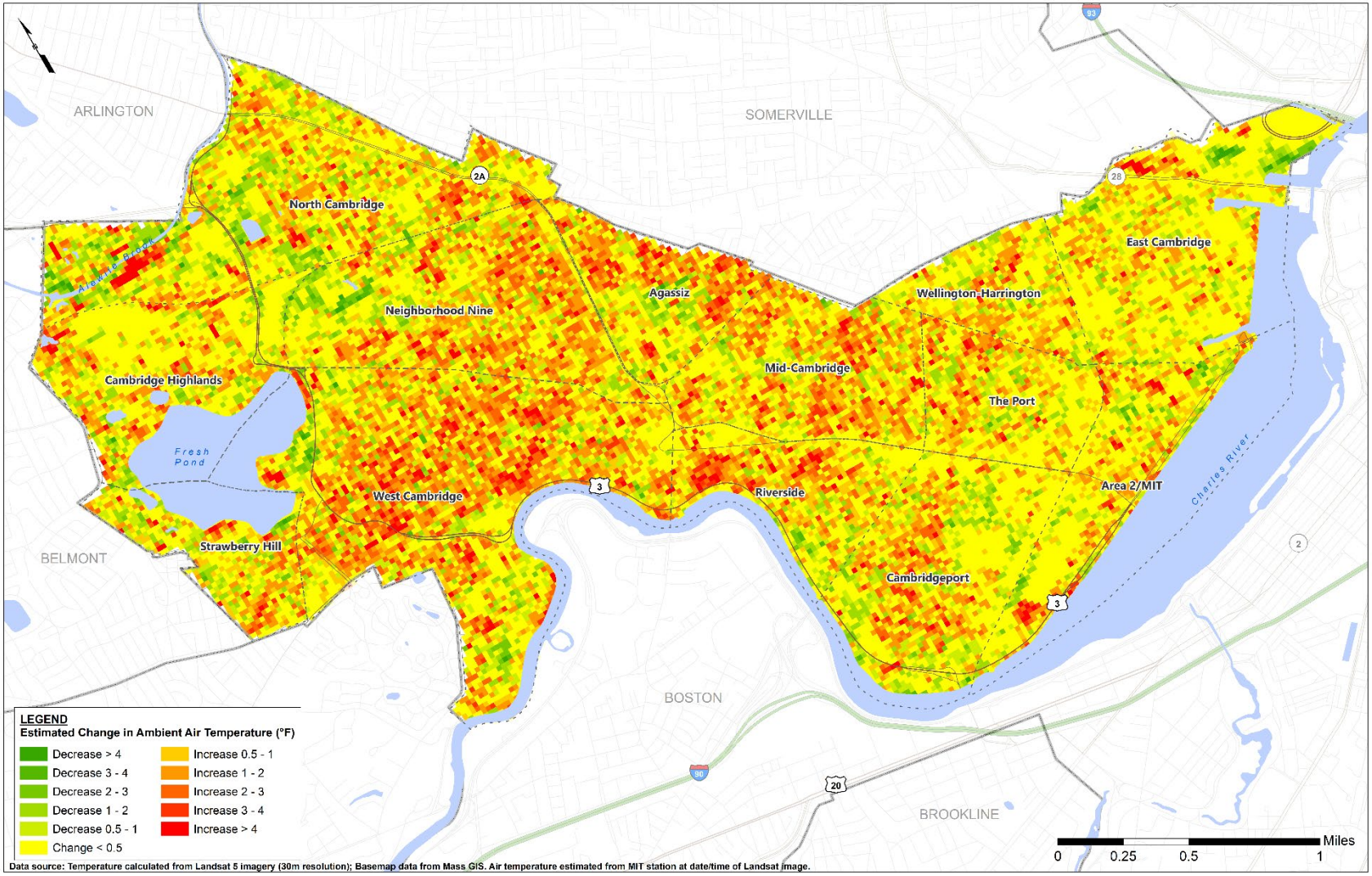


Figure 3 – Estimated ambient air temperature change from 2009 to 2018 observed tree canopy

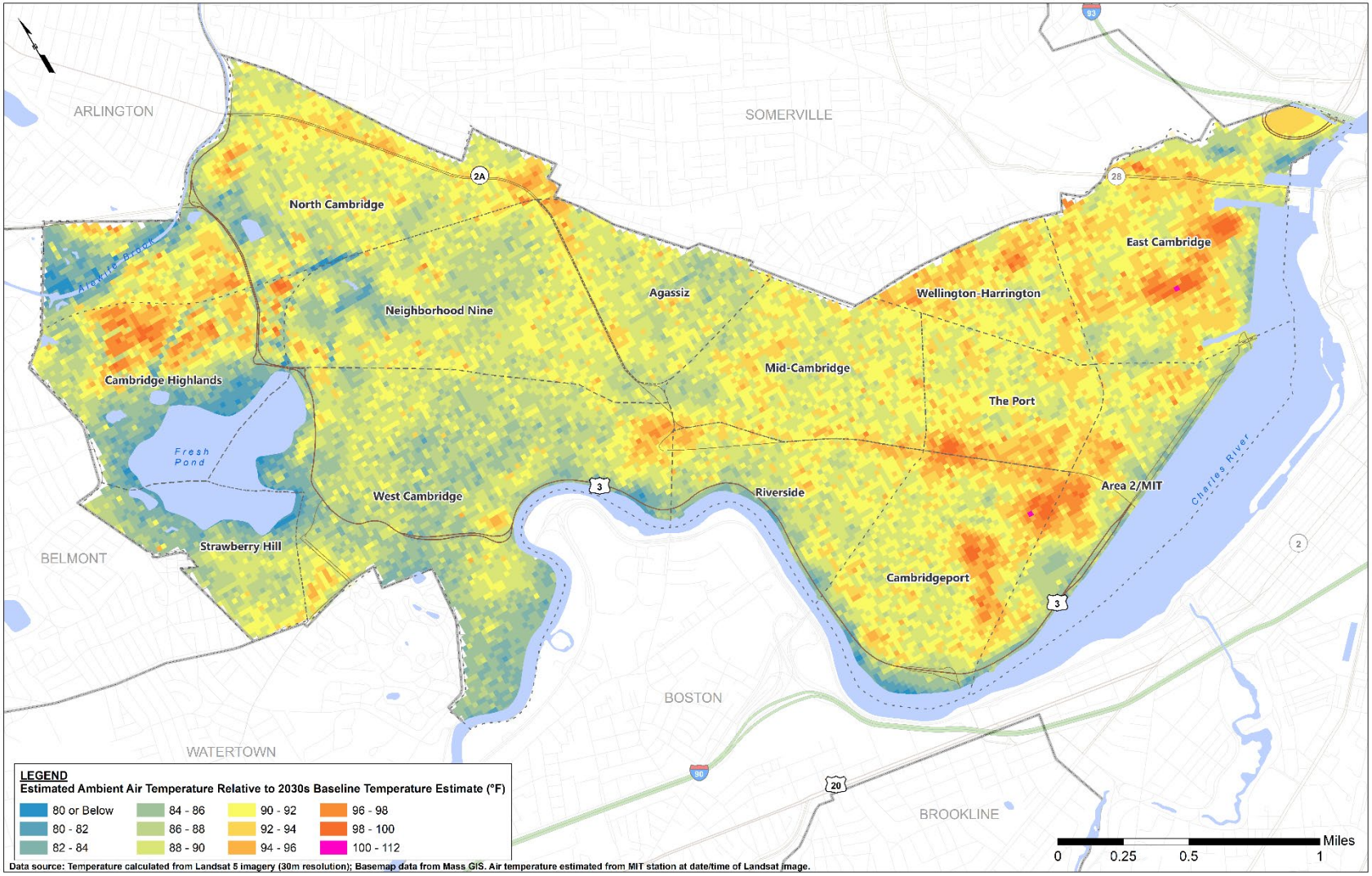


Figure 4 – Estimated ambient air temperature for projected right-of-way and Envision Alewife buildout tree canopy relative to 2030s baseline temperature estimate

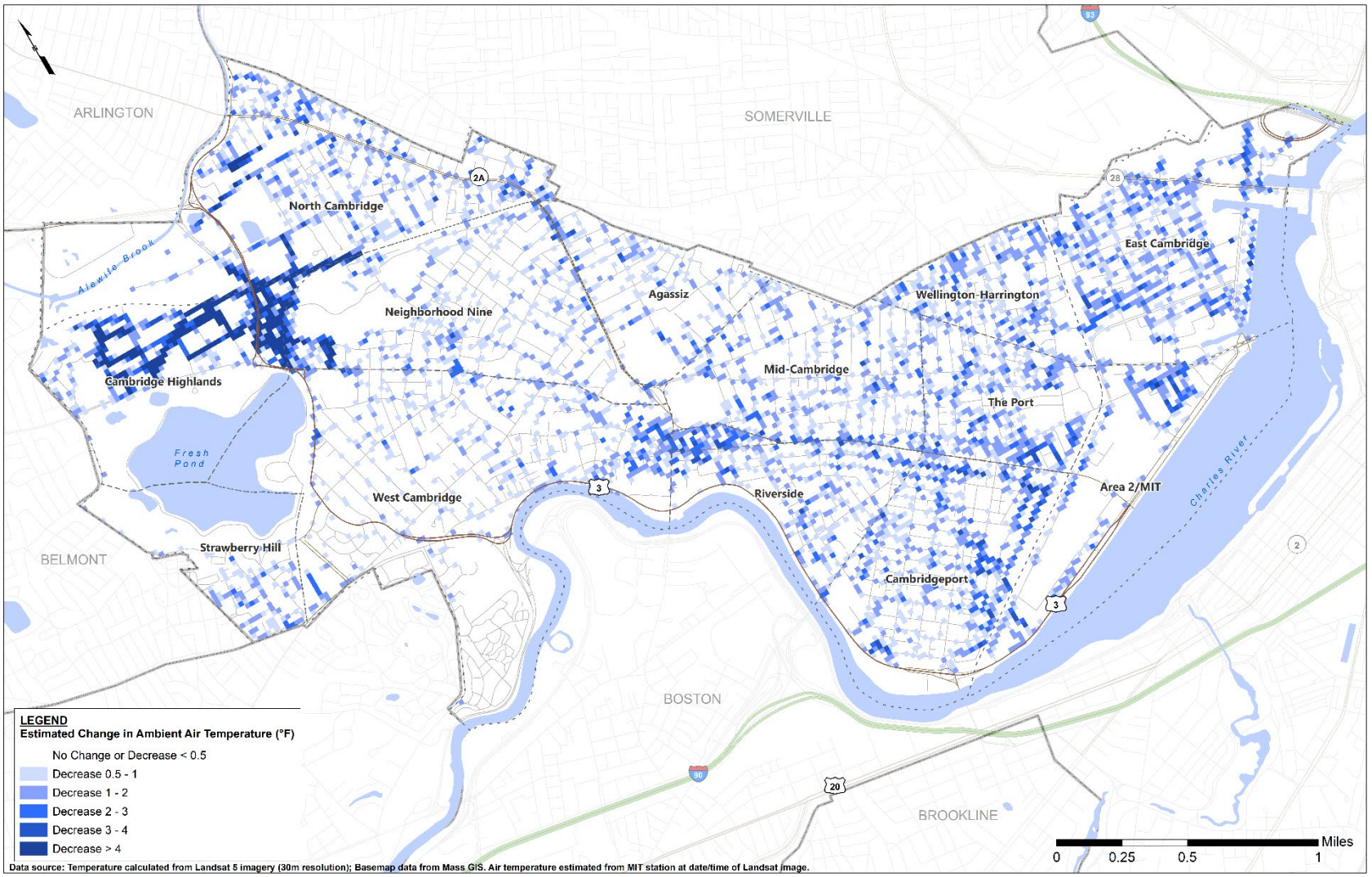


Figure 5 – Estimated ambient air temperature change from 2018 observed to projected right-of-way and Envision Alewife buildout tree canopy

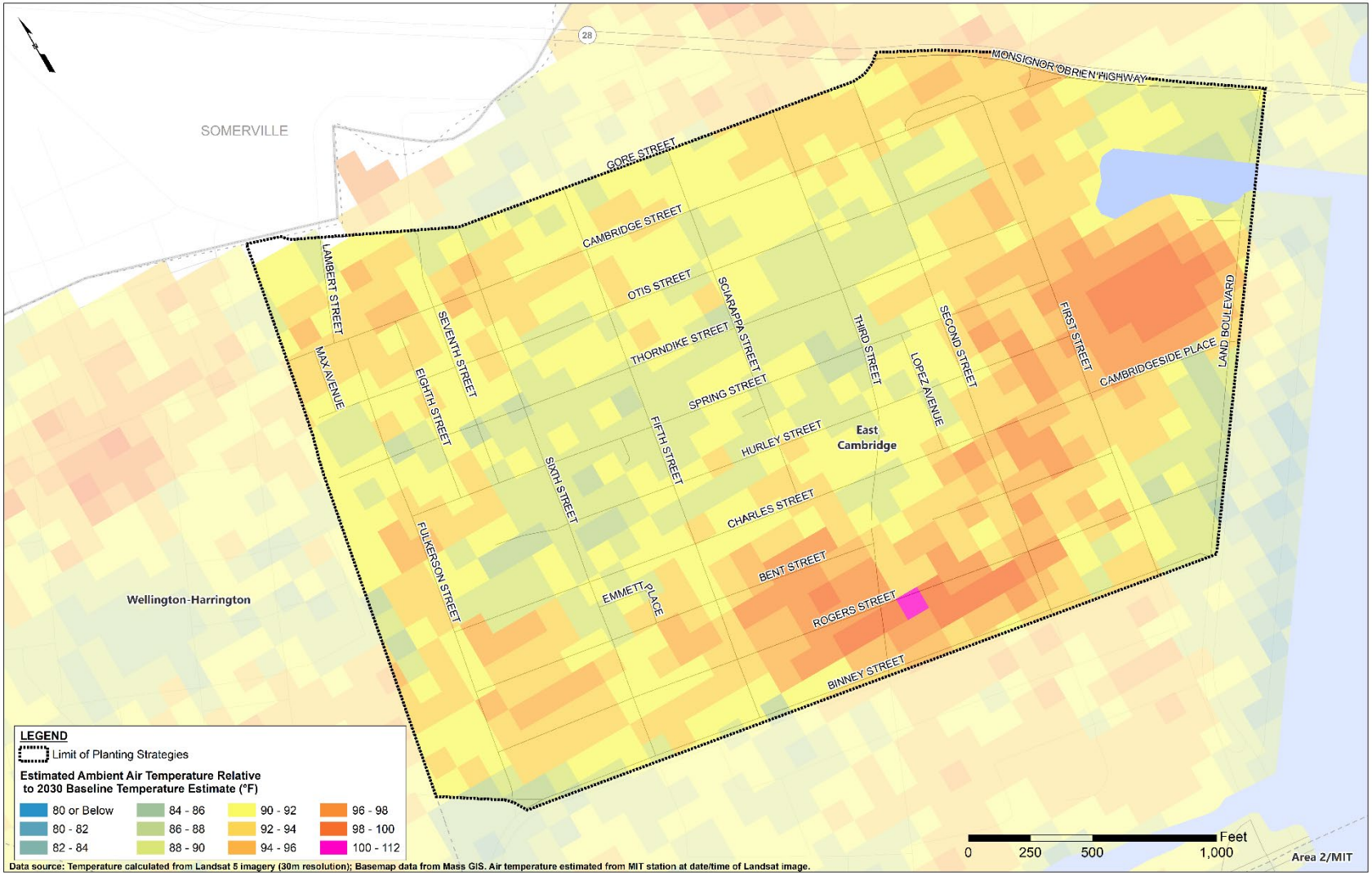


Figure 6 – Estimated ambient air temperature for projected East Cambridge tree canopy relative to 2030s baseline temperature estimate

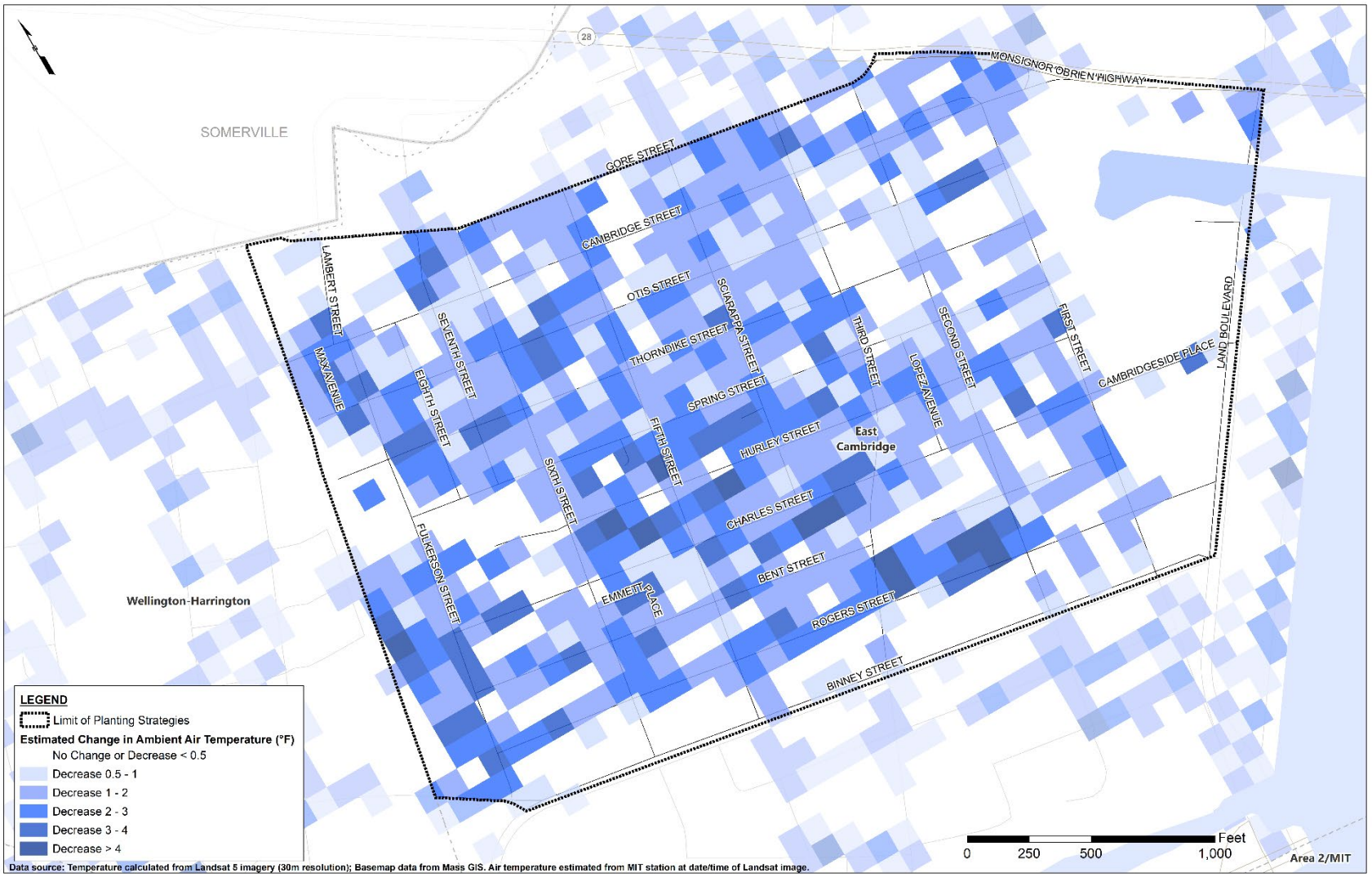


Figure 7 – Estimated ambient air temperature change from 2018 observed to projected East Cambridge tree canopy

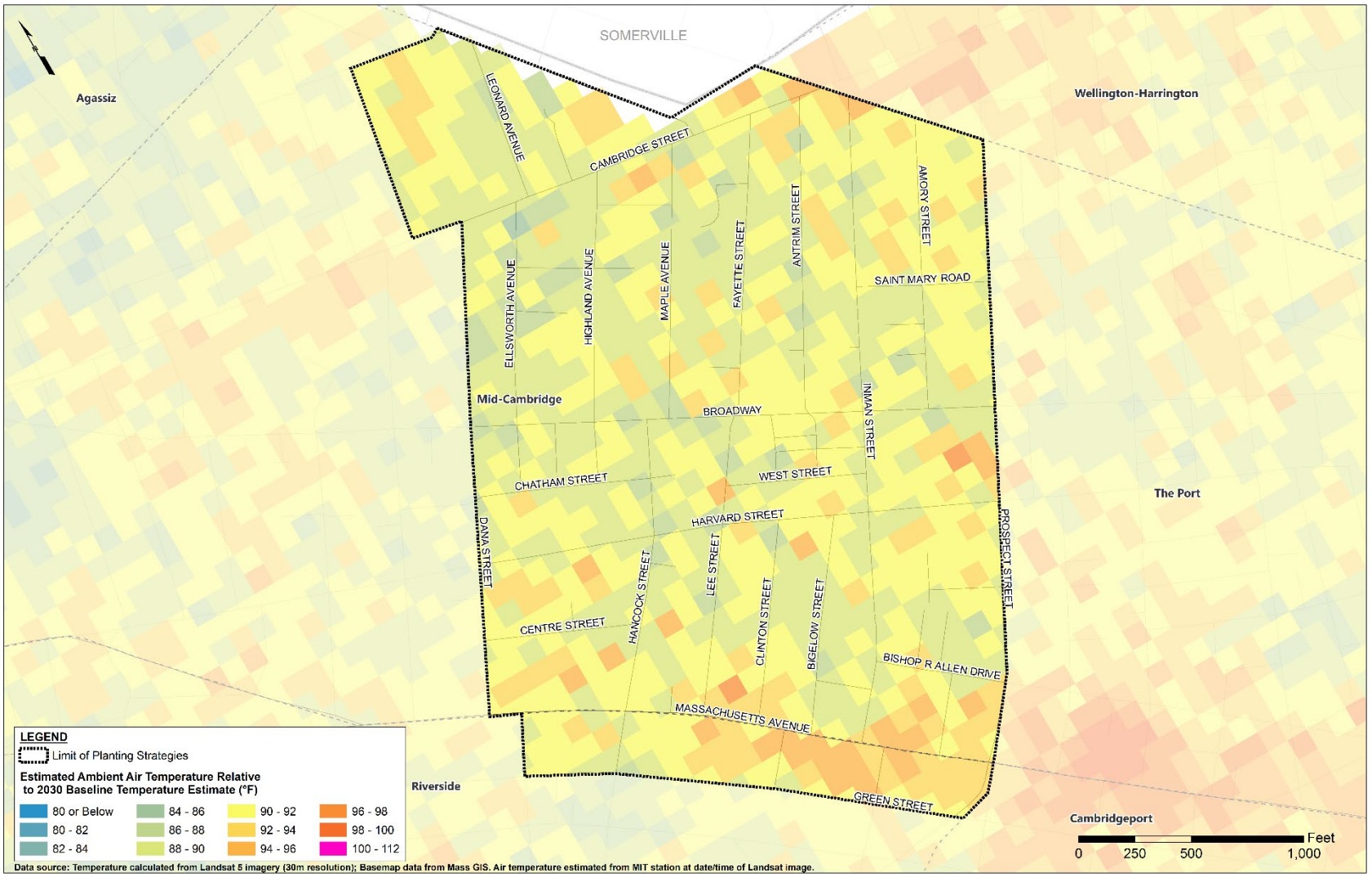


Figure 8 – Estimated ambient air temperature for projected Mid Cambridge tree canopy relative to 2030s baseline temperature estimate

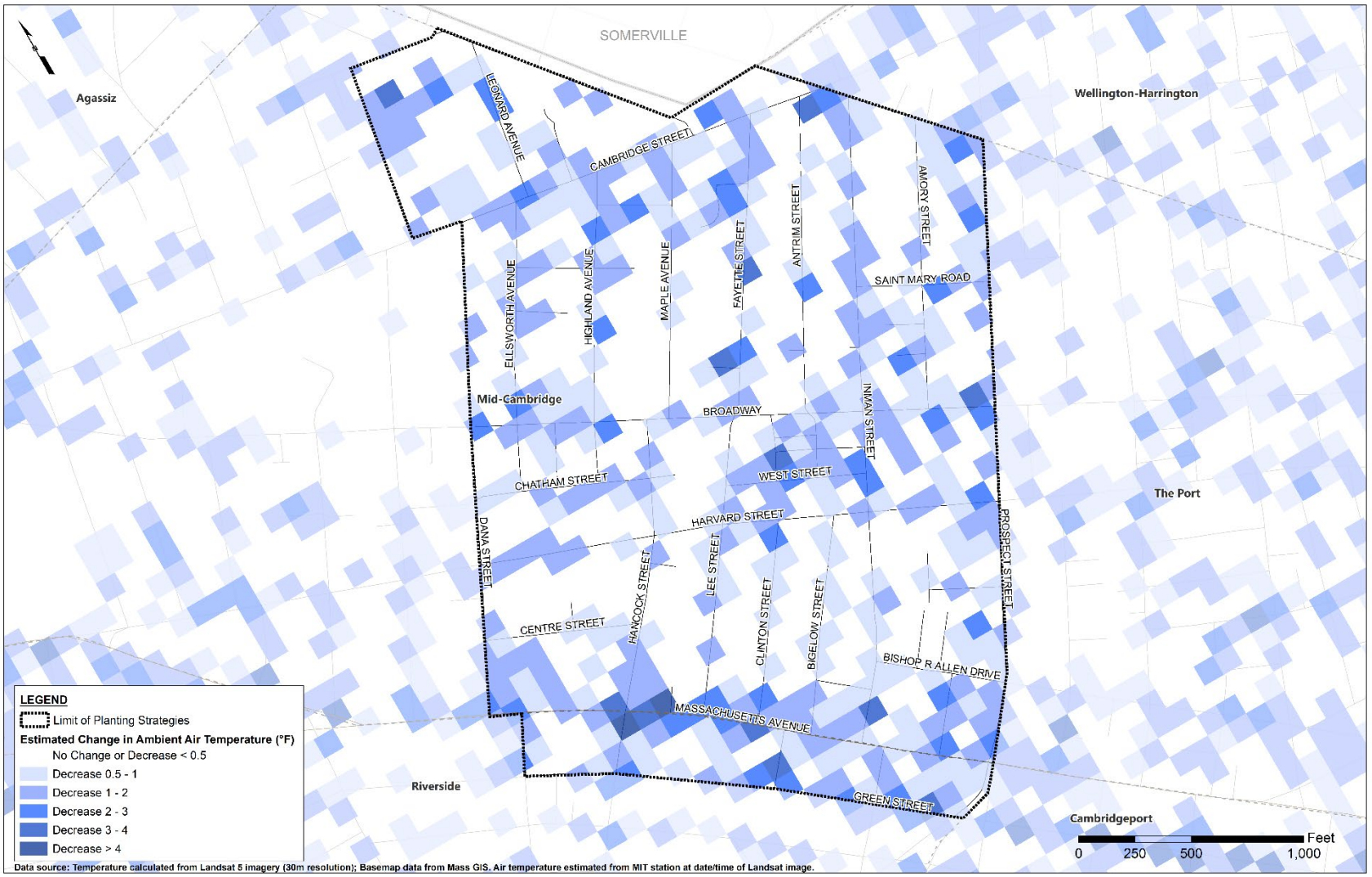


Figure 9 – Estimated ambient air temperature change from 2018 observed to projected Mid Cambridge tree canopy

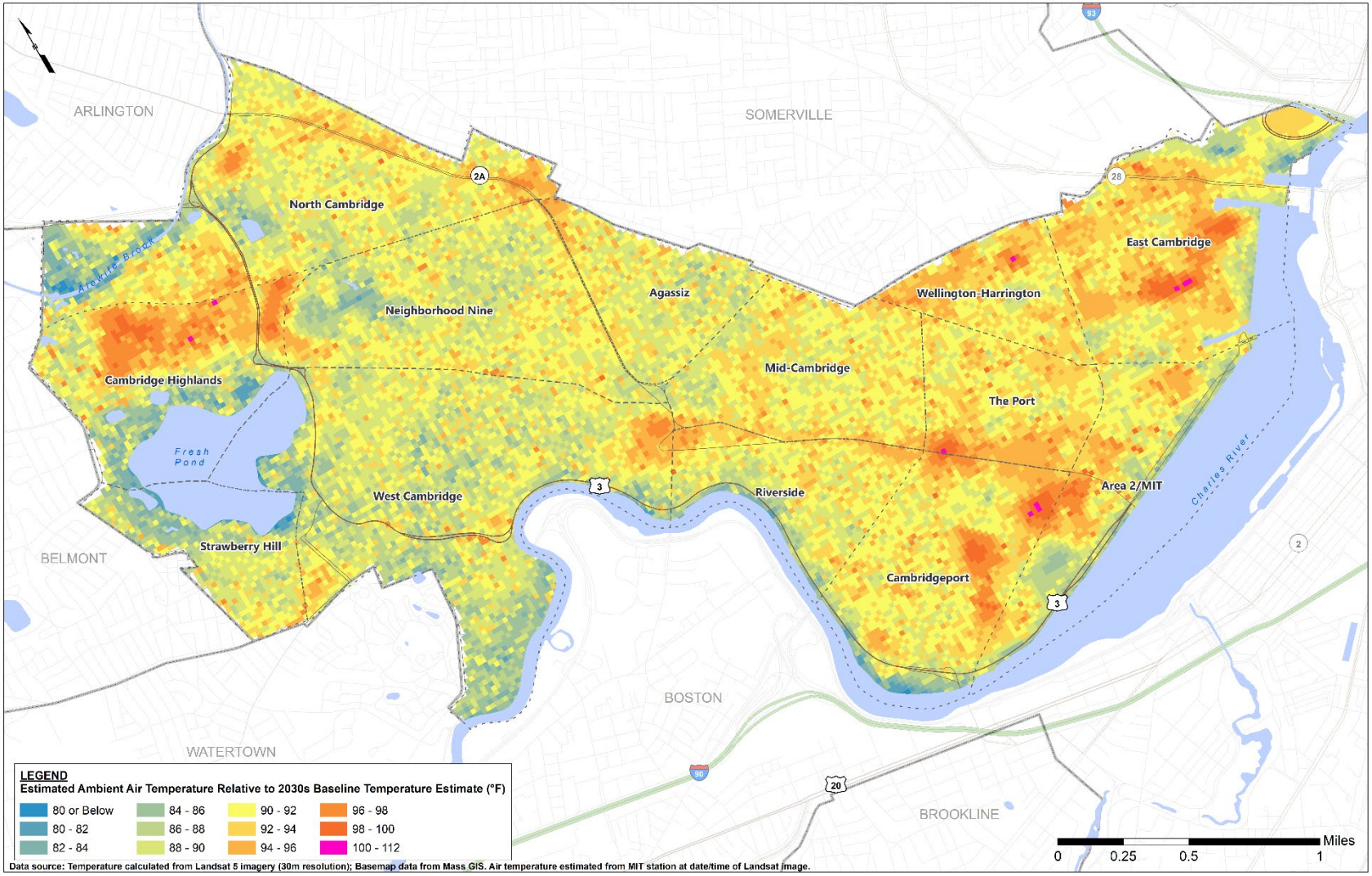


Figure 10 – Estimated ambient air temperature for projected 2030 tree canopy under accelerated canopy loss scenario relative to 2030s baseline temperature estimate

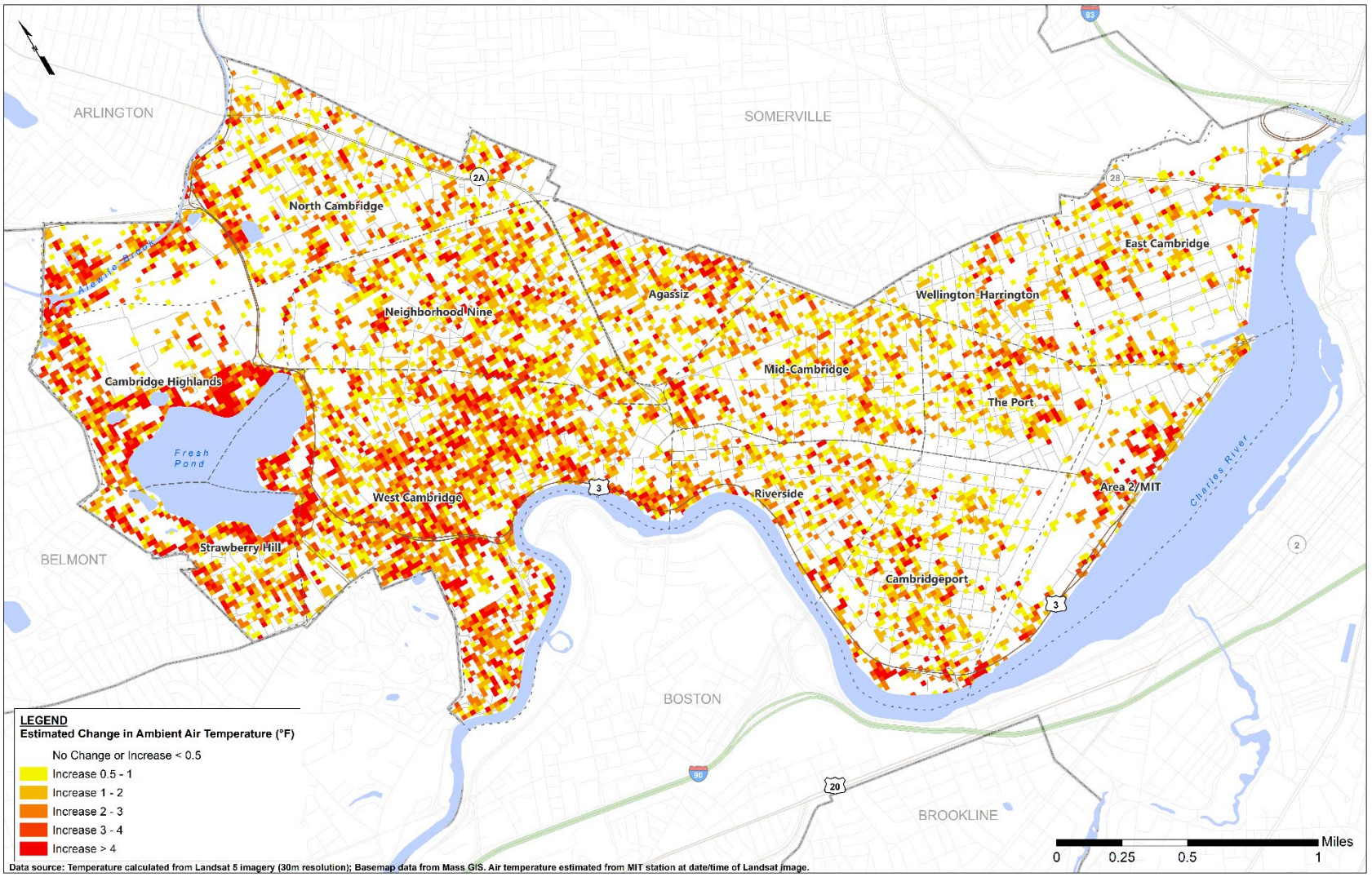


Figure 11 – Estimated ambient air temperature change from 2018 observed to projected 2030 tree canopy under accelerated canopy loss scenario

5 MODEL RESULTS

Table 1 summarizes the modeled temperature changes at the citywide scale for the four modeled tree canopy scenarios and at the neighborhood-wide scale for the East Cambridge and Mid Cambridge planting scenario. Temperature change was evaluated in terms of the percent of city (or neighborhood) area experiencing temperature change. Percentage values are reported for different ranges of temperature change. Table 2 is a simplified version of Table 1 that reports percentage values in terms of areas experiencing an increase in temperature (warming), areas experiencing minimal or no temperature change (change less than 0.5 °F), and areas experiencing a decrease in temperature (cooling). Key findings from the modeled temperature results are summarized below:

- From 2009 to 2018, the model projects that 39% of the city experienced warming, 19% experienced cooling and 42% experienced minimal or no temperature change.
- Under the right-of-way and Envision Alewife buildout scenario, 25% of the city is projected to experience cooling greater than 0.5 °F, with 15% of the city projected to experience cooling greater than 1.0 °F compared to 2018 observed canopy conditions.
- Under the East Cambridge planting scenario, 63% of the neighborhood planting area is projected to experience cooling greater than 0.5 °F, with 49% of the neighborhood planting area projected to experience cooling greater than 1.0 °F compared to 2018 observed canopy conditions.
- Under the Mid Cambridge planting scenario, 51% of the neighborhood planting area is projected to experience cooling greater than 0.5 °F, with 28% of the neighborhood planting area projected to experience cooling greater than 1.0 °F compared to 2018 observed canopy conditions.
- Under the 2030 accelerated canopy loss scenario, 38% of the city is projected to experience warming greater than 0.5 °F, with 27% of the city projected to experience warming greater than 1.0 °F compared to 2018 observed canopy conditions.

Increasing tree canopy in the public right-of-way is projected to provide a significant amount of cooling. However, cooling from public right-of-way planting is localized only to those areas in the public right-of-way and has less of an impact citywide. Additional neighborhood-specific tree planting is projected to provide larger magnitudes of cooling as well as increase the percentage of area experiencing cooling within neighborhoods. Tree canopy loss under the accelerated loss scenario is projected to result in significant temperature increases both in terms of area experiencing warming and magnitude of temperature increases. Areas already experiencing high temperatures under current conditions are projected to experience less warming under the accelerated loss scenario than areas experiencing low temperatures under current conditions.

Table 1 – Percent area experiencing modeled temperature change between modeled tree canopy scenarios[1]

Temperature Change (°F)	Percent Citywide Area				Percent East Cambridge Planting Area	Percent Mid Cambridge Planting Area
	2009 Observed to 2018 Observed	2018 Observed to 2030 Accelerated Loss Scenario	2018 Observed to Right-of-Way, Envision Alewife Buildout Scenario	2018 Observed to East and Mid Cambridge Neighborhood Scenario	2018 Observed to East and Mid Cambridge Neighborhood Scenario	2018 Observed to East and Mid Cambridge Neighborhood Scenario
≤ -4	0%	0%	1%	1%	1%	0%
-4 - -3	1%	0%	1%	1%	6%	1%
-3 - -2	2%	0%	3%	3%	15%	6%
-2 - -1	7%	0%	10%	10%	27%	21%
-1 - -0.5	9%	0%	10%	11%	14%	23%
-0.5 - 0.0001	16%	0%	14%	14%	13%	28%
No Change	8%	46%	61%	59%	25%	21%
0.0001 - 0.5	18%	16%	0%	0%	0%	0%
0.5 - 1	12%	11%	0%	0%	0%	0%
1 - 2	15%	11%	0%	0%	0%	0%
2 - 3	7%	7%	0%	0%	0%	0%
3 - 4	3%	4%	0%	0%	0%	0%
> 4	2%	6%	0%	0%	0%	0%

[1]Percentages may not add up exactly to 100% due to rounding

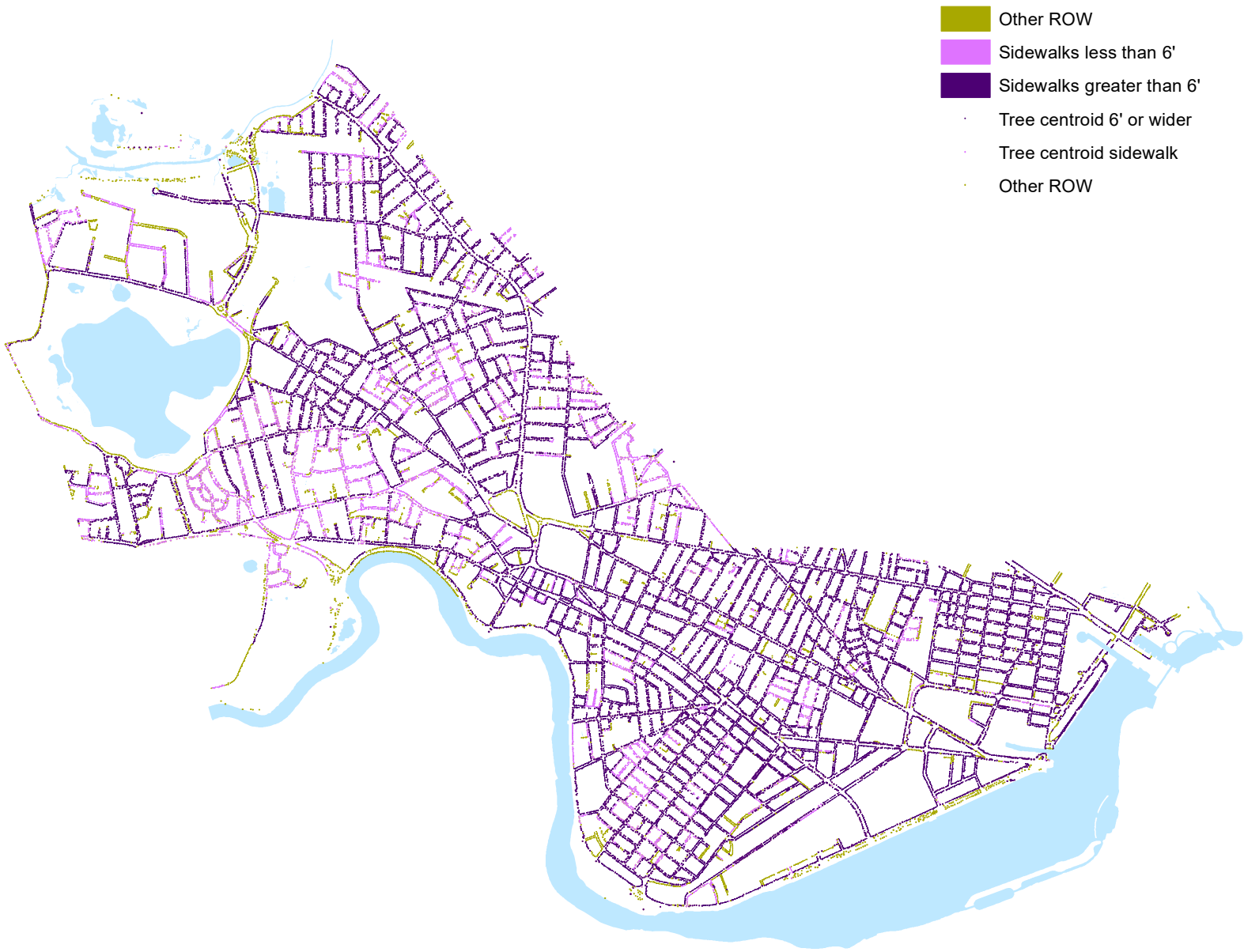
Table 2 – Percent area experiencing modeled warming, cooling and temperature change less than 0.5 °F between modeled tree canopy scenarios

Temperature Change (°F)	Percent Citywide Area				Percent East Cambridge Planting Area	Percent Mid Cambridge Planting Area
	2009 Observed to 2018 Observed	2018 Observed to 2030 Accelerated Loss Scenario	2018 Observed to Right-of-Way, Envision Alewife Buildout Scenario	2018 Observed to East and Mid Cambridge Neighborhood Scenario	2018 Observed to East and Mid Cambridge Neighborhood Scenario	2018 Observed to East and Mid Cambridge Neighborhood Scenario
Temperature Decrease ≥ 0.5	19%	0%	25%	27%	63%	51%
Temperature Change < 0.5	42%	62%	75%	73%	37%	49%
Temperature Increase ≥ 0.5	39%	38%	0%	0%	0%	0%

APPENDIX M: MODELING OF POTENTIAL ROW PLANTING

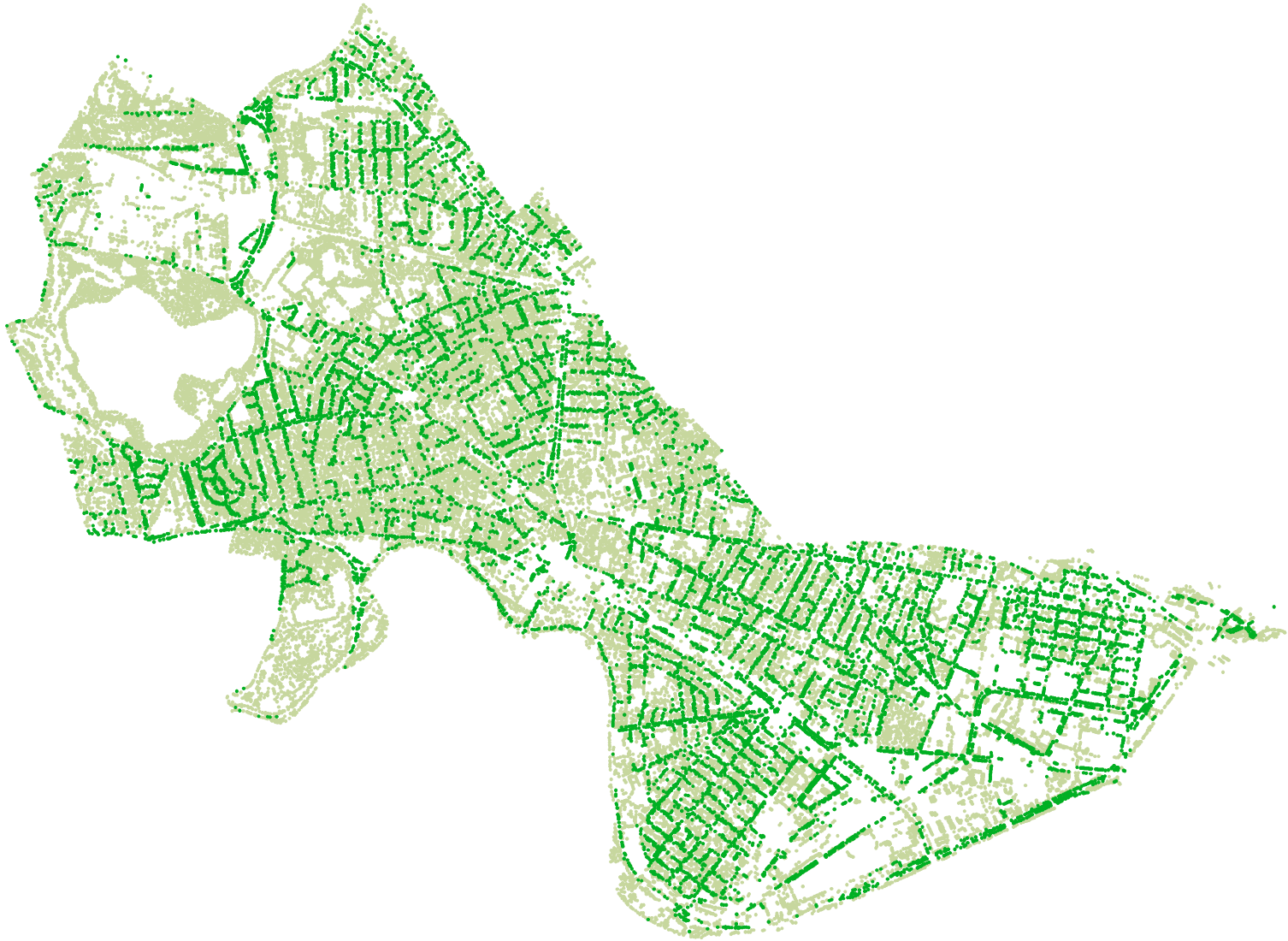
ROW CURRENT

ROW FULL BUILD OUT



ROW PROPOSED

ROW TREES AGAINST OVERALL TREE



APPENDIX N: TREE SPECIES CLIMATE RISK MATRIX

SPECIES MATRIX

NAME								Condition		HARDINESS			ORIGIN		SOIL			SIZE				TYPOLOGIES				TYPOLOGIES			TYPOLOGIES		
Genus	Species		Comm_Name	Flood score	Drought Score	Pest Score	Total score	Condition Score (70% good = 1, 55-70% = 2, lower than 55%=3)	Average Lifespan	Hardiness Zones (Cambridge in Zone 6b)	Outside Hardiness Zone 7a (assume in 2070)?	RUST (Relative Urban Stress Tolerance)	Native	Non-native	Optimal pH (min-max)	Structural Soil	Soil Amount	Typical Range of Mature Crown Width	Small (Mature height less than 35 ft tall)	Medium (Mature height greater than 35 ft but less than 50 ft tall)	Large (Mature height greater than 50 ft tall)	Narrow Street (According to Other Cities' Lists)	Wide Street - Boulevard (According to Other Cities' Lists)	Underwire (According to Other Cities' Lists)	RUST>1 AND MEDIUM SIZE TREE	RUST>1 AND LARGE TREE	CANOPY STREET TREES	CANOPY STREET TREES	UNDERWIRE STREET TREES	UNDERWIRE STREET TREES
Abies	concolor	Abies concolor	Fir-White	1	2	2	4.5	3	150.00	3-7				Yes	5.0-6.0			15-20'		X											
Acer	buergeranum	Acer buergeranum	Maple-Trident	1	2	1	3.5	3	90.00	4b-9		2.18		Yes				20-30'	X					X	FALSE	FALSE	FALSE		TRUE	X
Acer	campestre	Acer campestre	Maple-Hedge	1	3	1	4.5	1	60.00	5-8a		4.14		Yes	5.0-6.5			25-35'	X					X	FALSE	FALSE	FALSE		TRUE	X
Acer	ginnala	Acer ginnala	Maple-Amur	1	2	1	3.5	3	100.00	3-8				Yes				15-25'	X											
Acer	griseum	Acer griseum	Maple-Paperbark	1	2	1	3.5	3	90.00	4-7				Yes	5.0-6.5			15-25'	X					X						
Acer	negundo	Acer negundo	Boxelder	3	3	1	5.5	3	75.00	3-8		1.40	Yes		4.5-6.5			40-50'		X					TRUE	FALSE	TRUE	X	FALSE	
Acer	nigrum	Acer nigrum	Maple-Black	1	2	1	3.5	3	200.00	4-8				Yes				40-50'			X									
Acer	palmatum	Acer palmatum	Maple-Japanese	1	2	1	3.5	1	100.00	5b-8				Yes	6.0-8.0			10-25'	X											
Acer	platanoides	Acer platanoides	Maple-Crimson King Nc	1	3	1	4.5	1	150.00	3b-7				Yes	5.5-6.5			30-45'			X									
Acer	rubrum	Acer rubrum	Maple-Red	3	1	1	3.5	2	130.00	4-9		1.4	Yes		4.5-6.0			20-35'			X	Armstrong'			FALSE	TRUE	TRUE	X	FALSE	
Acer	saccharinum	Acer saccharinum	Maple-Silver	3	2	1	4.5	2	100.00	3-9		1.73	Yes		4.5-7.3			40-60'			X				FALSE	TRUE	TRUE	X	FALSE	
Acer	saccharum	Acer saccharum	Maple-Sugar	2	1	1	3	1	300.00	3-8a		-0.72	Yes		4.5-7.0			30-50'			X	Goldspire'			FALSE	FALSE	FALSE		FALSE	
Acer	tataricum	Acer tataricum	Maple-Tatarian	1	3	1	4.5	3	70.00	3-8				Yes				15-20'	X					X						
Acer	x freemanii	Acer x freemanii	Maple-Freeman	2	2	1	4	3	60.00	5-8				Yes	5.0-7.0			35-40'			X	Celebration', 'Scarlet sentinel'									
Aesculus	glabra	Aesculus glabra	Buckeye-Ohio	2	1	1	3	1	90.00	4-7a		1.68		Yes	5.0-7.5			40-50'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Aesculus	hippocastanum	Aesculus hippocastanum	Horsechestnut	2	2	1	4	2	75.00	4-7				Yes	5.0-7.0			40-50'			X		X							
Aesculus	x carnea	Aesculus x carnea	Horsechestnut-Red	2	2	1	4	1	75.00	5-7		0		Yes	6.0-7.5			30-40'		X					FALSE	FALSE	FALSE		FALSE	
Alnus	glutinosa	Alnus glutinosa	Alder-Common	2	2	2	5	1	100.00	3-7		1.21		Yes	4.5-7.0			15-20'			X				FALSE	TRUE	TRUE	X	FALSE	
Amelanchier	arborea	Amelanchier arborea	Serviceberry-Downy	2	1	3	5	1	40.00	5-8		0.72	Yes		5.0-7.0			10-20'	X					X	FALSE	FALSE	FALSE		FALSE	
Amelanchier	x grandiflora	Amelanchier x grandiflora	Serviceberry-Apple	2	2	3	6	3	40.00	4-7				Yes				15-25'	X					X						
Betula	nigra	Betula nigra	Birch-River	2	2	1	4	1	70.00	4-9a		3.03	Yes		4.0-6.5			40-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Betula	papyrifera	Betula papyrifera	Birch-Paper	2	1	1	3	2	30.00	3-6	Yes	2.95	Yes		4.5-7.0			25-50'			X				FALSE	TRUE	TRUE	X	FALSE	
Betula	pendula	Betula pendula	Birch-European White	1	1	1	2.5	1	30.00	3-6	Yes			Yes	4.5-7.0			15-30'		X										
Betula	populifolia	Betula populifolia	Birch-Gray	1	1	1	2.5	1	50.00	4-6	Yes	1.43	Yes		4.0-6.5			10-20'		X					TRUE	FALSE	TRUE	X	FALSE	
Carpinus	betulus	Carpinus betulus	Hornbeam-European	2	3	3	7	1	80.00	4-7		0.12		Yes	4.5-7.0			35-40'		X		Columnaris', 'Fastigiata'			FALSE	FALSE	FALSE		FALSE	
Carpinus	caroliniana	Carpinus caroliniana	Hornbeam-American	2	1	1	3	1	80.00	3-9a		1.82	Yes		4.5-6.5			15-30'		X					TRUE	FALSE	TRUE	X	FALSE	
Carya	ovata	Carya ovata	Hickory-Shagbark	1	2	2	4.5	1	250.00	5-8a		4.11	Yes		4.0-7.0			50-75'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Carya	tomentosa	Carya tomentosa	Hickory-Mockernut	1	3	2	5.5	1	200.00	4-9		1.72	Yes		6.0-7.0			50-75'			X				FALSE	TRUE	TRUE	X	FALSE	
Castanea	dentata	Castanea dentata	Chestnut-American	1	2	1	3.5	3	100.00	4-8				Yes				50-75'			X									
Cedrus	atlantica	Cedrus atlantica	Cedar-Atlas	1	3	3	6.5	3	300.00	6-8				Yes	5.0-6.5			40-60'			X									
Cedrus	libani	Cedrus libani	Cedar of Lebanon	1	3	3	6.5	3	300.00	5b-10a				Yes				40-60'			X									
Celtis	occidentalis	Celtis occidentalis	Hackberry	3	3	1	5.5	1	150.00	3-9		2.27	Yes		6.0-8.0			25-60'			X				FALSE	TRUE	TRUE	X	FALSE	
Cercidiphyllum	japonicum	Cercidiphyllum japonicum	Katsuratree	1	2	1	3.5	3	60.00	4b-8		0.82		Yes	5.0-6.5			35-60'			X				FALSE	FALSE	FALSE		FALSE	
Cercis	canadensis	Cercis canadensis	Redbud-Eastern	1	3	1	4.5	1	30.00	4b-9a		2.38		Yes	4.5-7.5			25-35'	X					X	FALSE	FALSE	FALSE		TRUE	X
Chamaecyparis	obtusa	Chamaecyparis obtusa	Falsecypress-Hinoki	2	2	3	6	1	100.00	5-8a				Yes	5.5-6.0			15-25'			X									
Chamaecyparis	pisifera	Chamaecyparis pisifera	Falsecypress-Sawara	2	2	3	6	1	100.00	5-8a				Yes	5.5-7.0			10-20'	X											
Chionanthus	virginicus	Chionanthus virginicus	Fringetree-White	2	2	3	6	3	30.00	3-9		2.46		Yes				5-15'	X						FALSE	FALSE	FALSE		TRUE	X
Cladrastis	kentukea	Cladrastis kentukea	Yellowwood	1	2	3	5.5	1	250.00	4-8			Yes		5.5-8.0			40-55'		X										

NAME								Condition		HARDINESS			ORIGIN		SOIL			SIZE				TYPOLOGIES					TYPOLOGIES		
Genus	Species		Comm_Name	Flood score	Drought Score	Pest Score	Total score	Condition Score (70% good = 1, 55-70% = 2, lower than 55%=3)	Average Lifespan	Hardiness Zones (Cambridge in Zone 6b)	Outside Hardiness Zone 7a (assume in 2070)?	RUST (Relative Urban Stress Tolerance)	Native	Non-native	Optimal pH (min-max)	Structural Soil	Soil Amount	Typical Range of Mature Crown Width	Small (Mature height less than 35 ft tall)	Medium (Mature height greater than 35 ft but less than 50 ft tall)	Large (Mature height greater than 50 ft tall)	Narrow Street (According to Other Cities' Lists)	Wide Street - Boulevard (According to Other Cities' Lists)	Underwire (According to Other Cities' Lists)	RUST>1 AND MEDIUM SIZE TREE	RUST>1 AND LARGE TREE	CANOPY STREET TREES	CANOPY STREET TREES	UNDERWIRE STREET TREES	UNDERWIRE STREET TREES
Cornus	alternifolia	Cornus alternifolia	Dogwood-Pagoda	1	2	1	3.5	3	100.00	3-7				Yes				20-32'	X											
Cornus	florida	Cornus florida	Dogwood-Flowering	1	1	1	2.5	1	125.00	5-9a		-1.78	Yes		5.0-7.0			15-30'	X						FALSE	FALSE	FALSE		FALSE	
Cornus	kousa	Cornus kousa	Dogwood-Kousa	1	2	1	3.5	2	100.00	5-8				Yes	4.5-7.0			10-30'	X											
Cornus	mas	Cornus mas	Dogwood-Cornelianche	1	2	1	3.5	3	100.00	5-8a				Yes				15-20'	X					X						
Cotinus	coggygria	Cotinus coggygria	Smoketree-Common	2	3	3	7	1	20.00	5b-8				Yes	6.0-8.0			10-15'	X											
Cotinus	obovatus	Cotinus obovatus	Smoketree-American	2	3	1	5	3	20.00	5-8				Yes	6.0-8.0			10-25'	X											
Crataegus	sp	Crataegus sp	Hawthorn	1	3	1	4.5	3	100.00					Yes	5-6.5				X					X						
Enkianthus	campanulatus	Enkianthus campanulatus	Enkianthus	1	2	3	5.5	3	25.00	4-7				Yes				4-6'	X											
Eucommia	ulmoides	Eucommia ulmoides	Rubber Tree-Hardy	1	3	3	6.5	3	60.00	4b-7				Yes				30-50'			X									
Fagus	grandifolia	Fagus grandifolia	Beech-American	3	1	1	3.5	1	300.00	3-8		2.05	Yes		6.0-7.0			50-70'			X				FALSE	TRUE	TRUE	X	FALSE	
Fagus	sylvatica	Fagus sylvatica	Beech-European	3	2	1	4.5	1	225.00	4-7		-0.74		Yes	6.0-7.0			35-50'			X	Fastigiata'			FALSE	FALSE	FALSE		FALSE	
Fraxinus	americana	Fraxinus americana	Ash-White	2	1	1	3	3	260.00	3-9a		2.3	Yes		5.0-7.5			30-60'			X				FALSE	TRUE	TRUE	X	FALSE	
Fraxinus	pennsylvanica	Fraxinus pennsylvanica	Ash-Green	3	2	1	4.5	3	120.00	3-9a		1.63	Yes		5.0-8.0			40-50'			X				FALSE	TRUE	TRUE	X	FALSE	
Ginkgo	biloba	Ginkgo biloba	Ginkgo	1	3	3	6.5	1	250.00	3-8a		3.45		Yes	5.5-7.0			30-60'			X	Magyar', 'Princeton sentry'			FALSE	TRUE	TRUE	X	FALSE	
Gleditsia	triacanthos	Gleditsia triacanthos	Honeylocust-Thornless	2	3	2	6	1	120.00	3-8a		3.67		Yes	5.0-7.5			30-50'			X				FALSE	TRUE	TRUE	X	FALSE	
Gymnocladus	dioicus	Gymnocladus dioicus	Coffeetree-Kentucky	1	2	3	5.5	1	250.00	3b-8		4.2		Yes	6.0-8.0			40-55'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Halesia	carolina	Halesia carolina	Silverbell-Carolina	1	1	3	4.5	1	100.00	5-8				Yes	4.5-6.0			20-35'		X										
Hydrangea	arborescens	Hydrangea arborescens	Hydrangea	2	2	3	6	3	50.00	4-9				Yes	4.5-6.5			3-5'	X											
Ilex	opaca	Ilex opaca	Holly-American	2	2	3	6	1	100.00	5b-9		5.4	Yes		5.0-6.0			15-25'		X					TRUE	FALSE	TRUE	X	FALSE	
Juglans	nigra	Juglans nigra	Walnut-Black	2	2	1	4	1	150.00	5-9a		2.68	Yes		6.0-8.0			50-70'			X				FALSE	TRUE	TRUE	X	FALSE	
Juglans	regia	Juglans regia	Walnut-English	1	2	1	3.5	1	100.00	5-9				Yes	6.0-8.0			40-60'			X									
Juniperus	virginiana	Juniperus virginiana	Redcedar-Eastern	2	3	3	7	3	150.00	2-9		3.1	Yes		5.5-6.5			10-20'		X			X		TRUE	FALSE	TRUE	X	FALSE	
Koelreuteria	paniculata	Koelreuteria paniculata	Goldenraintree-Panicle	1	2	1	3.5	2	100.00	5b-9		3.75		Yes	5.5-6.5			20-40'		X		Fastigiata'			TRUE	FALSE	TRUE	X	FALSE	
Laburnum	anagryroides	Laburnum anagryroides	Common Laburnum	1	2	3	5.5	3	20.00	5b-7				Yes				15-25'												
Liquidambar	styraciflua	Liquidambar styraciflua	Sweetgum	3	2	1	4.5	1	200.00	5b-10a		3.87		Yes	5.5-7.0			40-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Liriodendron	tulipifera	Liriodendron tulipifera	Tuliptree	1	2	2	4.5	1	250.00	5-9a		0.71	Yes		4.5-6.5			30-60'			X	Fastigiatum'	X		FALSE	FALSE	FALSE		FALSE	
Maackia	amurensis	Maackia amurensis	Maackia-Amur	1	3	3	6.5	1	100.00	3-7		1.95		Yes	4.5-7.5			20-30'		X				X	TRUE	FALSE	TRUE	X	FALSE	
Magnolia	macrophylla	Magnolia macrophylla	Magnolia-Bigleaf	1	2	3	5.5	1	60.00	5b-8				Yes	5.0-6.0			30-40'		X										
Magnolia	x soulangeana	Magnolia x soulangeana	Magnolia-Saucer	1	1	3	4.5	1	250.00	5-9a				Yes	5.0-6.0			10-30'		X										
Magnolia	x stellata	Magnolia x stellata	Magnolia-Star	1	1	3	4.5	1	250.00	4-9				Yes	5.0-6.0			15-20'	X											
Malus	pumila	Malus pumila	Apple	2	2	1	4	3	100.00	4-8		1.38		Yes	5.0-6.5			12-15'	X					X	FALSE	FALSE	FALSE		TRUE	X
Metasequoia	glyptostroboides	Metasequoia glyptostrobo	Redwood-Dawn	1	2	3	5.5	3	250.00	5-8				Yes				25-30'			X		X		FALSE	FALSE	FALSE		FALSE	
Morus	rubra	Morus rubra	Mulberry-Red	2	3	2	6	2	125.00	5-9		-0.67	Yes		5.5-6.5			20-50'		X					FALSE	FALSE	FALSE		FALSE	
Nyssa	sylvatica	Nyssa sylvatica	Tupelo-Black	2	2	1	4	1	250.00	4b-9		2.88	Yes		5.0-7.0			20-35'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Ostrya	virginiana	Ostrya virginiana	Hophornbeam-America	2	2	1	4	1	140.00	3-9a		3.65	Yes		4.2-7.6			10-30'		X					TRUE	FALSE	TRUE	X	FALSE	
Oxydendrum	arboreum	Oxydendrum arboreum	Sourwood	1	2	1	3.5	3	100.00	5-9a		1.88		Yes				20-30'		X					TRUE	FALSE	TRUE	X	FALSE	
Parrotia	persica	Parrotia persica	Parrotia-Persian	1	3	3	6.5	3	60.00	5-8				Yes				20-35'		X										
Picea	abies	Picea abies	Spruce-Norway	1	2	1	3.5	2	175.00	2b-7a		1.52		Yes	5.0-7.5			25-30'		X					TRUE	FALSE	TRUE	X	FALSE	
Picea	orientalis	Picea orientalis	Spruce-Oriental	1	2	1	3.5	1	100.00	5-7				Yes	5.0-6.5			15-25'			X									
Picea	pungens	Picea pungens	Spruce-Colorado	1	2	1	3.5	3	150.00	4-7		0.73		Yes	5.5-7.0			10-20'		X					FALSE	FALSE	FALSE		FALSE	
Pinus	mugo	Pinus mugo	Pine-Mugo	1	2	1	3.5	1	250.00	2-7		2.15		Yes	5.0-6.5			25-30'	X						FALSE	FALSE	FALSE		TRUE	X
Pinus	nigra	Pinus nigra	Pine-Austrian	1	2	1	3.5	2	200.00	5-8a		0.31		Yes	4.0-7.0			20-40'			X				FALSE	FALSE	FALSE		FALSE	
Pinus	parviflora	Pinus parviflora	Pine-Japanese White	1	2	1	3.5	3	100.00	4b-7a				Yes				20-50'		X										

NAME								Condition		HARDINESS			ORIGIN		SOIL			SIZE				TYPOLOGIES					TYPOLOGIES		
Genus	Species		Comm_Name	Flood score	Drought Score	Pest Score	Total score	Condition Score (70% good = 1, 55-70% = 2, lower than 55%=3)	Average Lifespan	Hardiness Zones (Cambridge in Zone 6b)	Outside Hardiness Zone 7a (assume in 2070)?	RUST (Relative Urban Stress Tolerance)	Native	Non-native	Optimal pH (min-max)	Structural Soil	Soil Amount	Typical Range of Mature Crown Width	Small (Mature height less than 35 ft tall)	Medium (Mature height greater than 35 ft but less than 50 ft tall)	Large (Mature height greater than 50 ft tall)	Narrow Street (According to Other Cities' Lists)	Wide Street - Boulevard (According to Other Cities' Lists)	Underwire (According to Other Cities' Lists)	RUST>1 AND MEDIUM SIZE TREE	RUST>1 AND LARGE TREE	CANOPY STREET TREES	CANOPY STREET TREES	UNDERWIRE STREET TREES	UNDERWIRE STREET TREES
Pinus	strobus	Pinus strobus	Pine-Eastern White	1	1	1	2.5	2	200.00	3b-7		-1.39	Yes		4.5-6.5			20-40'			X				FALSE	FALSE	FALSE		FALSE	
Pinus	sylvestris	Pinus sylvestris	Pine-Scotch	2	1	1	3	1	200.00	3-8a		0.31		Yes	5.0-6.5			30-40'		X					FALSE	FALSE	FALSE		FALSE	
Platanus	occidentalis	Platanus occidentalis	Sycamore	3	2	1	4.5	1	250.00	4b-9a		2.48	Yes		6.0-7.5			30-70'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Platanus	x acerifolia	Platanus x acerifolia	Planetree-London	2	3	1	5	3	100.00	5-9a		2.97		Yes	6.0-8.0			20-80'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Populus	deltoides	Populus deltoides	Poplar-Eastern	3	2	1	4.5	2	60.00	3-9		3.82	Yes		5.0-7.3			20-75'			X				FALSE	TRUE	TRUE	X	FALSE	
Populus	nigra	Populus nigra	Poplar-Black	1	1	1	2.5	3	20.00	3-9a				Yes				10-15'			X									
Prunus	cerasifera	Prunus cerasifera	Plum-Purple Leaf	1	2	1	3.5	1	20.00	5b-8a				Yes	6.0-7.5			10-25'	X					X						
Prunus	persica	Prunus persica	Peach	1	2	2	4.5	3	15.00	5b-8				Yes				10-15'	X					X						
Prunus	sargentii	Prunus sargentii	Cherry-Sargent	1	3	2	5.5	3	20.00	5-8a				Yes				20-30'	X			Spire'		X						
Prunus	serotina	Prunus serotina	Cherry-Black	1	2	1	3.5	3	100.00	3b-9a		1.9	Yes		6.0-7.0			15-50'			X				FALSE	TRUE	TRUE	X	FALSE	
Prunus	serrulata	Prunus serrulata	Cherry-Flowering	1	2	2	4.5	3	20.00	5b-9a				Yes	6.0-7.0			20-30'	X					X						
Prunus	subhirtella	Prunus subhirtella	Cherry-Weeping	1	2	2	4.5	1	30.00	5-8				Yes	5.5-6.5			15-25'	X					X						
Prunus	x yedoensis	Prunus x yedoensis	Cherry-Yoshino	1	2	2	4.5	3	20.00	5b-8a				Yes				20-40'	X					X						
Prunus	x incamp	Prunus x incamp	Cherry-Okame	1	2	2	4.5	3	20.00	6b-9				Yes				15-20'	X					X						
Ptelea	trifoliata	Ptelea trifoliata	Ash-Wafer	1	3	3	6.5	3	250.00	4-9a				Yes				15-20'	X											
Pyrus	calleryana	Pyrus calleryana	Pear-Callery	1	2	1	3.5	2	30.00	5-9a				Yes	5.0-6.5			13-16'	X											
Pyrus	communis	Pyrus communis	Pear-Common	1	2	1	3.5	1	50.00	4-8				Yes	6.0-7.5			35-45'	X											
Quercus	alba	Quercus alba	Oak-White	1	1	1	2.5	2	300.00	3b-8		2.9	Yes		5.0-6.5			30-80'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	bicolor	Quercus bicolor	Oak-Swamp White	2	2	1	4	1	300.00	4-8		3.87	Yes		5.0-6.5			30-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	coccinea	Quercus coccinea	Oak-Scarlet	1	1	1	2.5	3	80.00	5-8		1.63	Yes		6.0-7.0			30-50'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	imbricaria	Quercus imbricaria	Oak-Shingle	1	2	1	3.5	3	100.00	5-8a		3.95		Yes				40-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	lyrata	Quercus lyrata	Oak-Overcup	3	2	1	4.5	3	300.00	6-9a		1.53		Yes				30-45'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	palustris	Quercus palustris	Oak-Pin	3	2	1	4.5	1	100.00	4-8a		3.35	Yes		5.0-6.0			20-50'			X	Pingreen'	X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	phellos	Quercus phellos	Oak-Willow	3	2	1	4.5	1	250.00	6-9		1.93		Yes	4.5-6.0			30-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	prinus	Quercus prinus	Oak-Chestnut	1	2	1	3.5	1	300.00	5-9a		0.62	Yes		4.5-6.0			30-60'			X		X		FALSE	FALSE	FALSE		FALSE	
Quercus	robur	Quercus robur	Oak-English	1	3	1	4.5	1	75.00	5-8		0.24		Yes	6.0-8.0			40-60'			X	Fastigiata'	X		FALSE	FALSE	FALSE		FALSE	
Quercus	rubra	Quercus rubra	Oak-Northern Red	1	1	1	2.5	2	200.00	5-8a		2.32	Yes		4.5-6.0			30-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Quercus	stellata	Quercus stellata	Oak-Post	1	3	1	4.5	3	250.00	6-9a				Yes				35-40'		X										
Quercus	velutina	Quercus velutina	Oak-Eastern Black	1	1	1	2.5	3	100.00	3-9		1.65	Yes		5.0-7.0			50-60'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Salix	alba	Salix alba	Willow-White	3	1	1	3.5	3	70.00	2-8				Yes	5.0-7.5			40-70'		X										
Salix	babylonica	Salix babylonica	Willow-Weeping	3	3	1	5.5	1	70.00	6-8				Yes	5.0-7.0			20-70'		X										
Salix	discolor	Salix discolor	Willow-Pussy	3	1	1	3.5	3	70.00	2-7			Yes		5.5-6.5			4-12'	X											
Salix	nigra	Salix nigra	Willow-Black	3	2	1	4.5	3	70.00	4-9		0.75		Yes				30-40'		X					FALSE	FALSE	FALSE		FALSE	
Sassafras	albidum	Sassafras albidum	Sassafras	1	3	3	6.5	3	100.00	5-9a		3.3		Yes				20-40'			X				FALSE	TRUE	TRUE	X	FALSE	
Sciadopitys	verticillata	Sciadopitys verticillata	Pine-Umbrella	1	2	3	5.5	3	80.00	5-8a				Yes				15-20'		X										
Sophora	japonica	Sophora japonica	Pagodatree-Japanese	2	3	3	7	1	35.00	5-8a				Yes	5.0-7.0			50-75'			X									
Sorbus	alnifolia	Sorbus alnifolia	Mountain Ash-Korean	1	2	1	3.5	3	25.00	4-7a				Yes				20-25'		X										
Stewartia	sp	Stewartia sp	Stewartia	1	2	3	5.5	3	50.00					Yes						X										
Styrax	japonicus	Styrax japonicus	Snowbell-Japanese	1	2	3	5.5	3	30.00	5-9				Yes				20-30'	X					X						
Syringa	reticulata	Syringa reticulata	Lilac-Japanese Tree	1	2	3	5.5	3	45.00	4-7a		1.9		Yes	5.5-7.0			15-20'	X					X	FALSE	FALSE	FALSE		TRUE	X
Syringa	vulgaris	Syringa vulgaris	Lilac-Common	1	2	3	5.5	1	100.00	3-7				Yes	6.0-7.5			6-12'	X											
Taxus	cuspidata	Taxus cuspidata	Yew-Japanese	1	2	2	4.5	1	100.00	4-7				Yes	4.5-7.5			5-10'		X										
Thuja	occidentalis	Thuja occidentalis	Arborvitae-Eastern	1	1	3	4.5	1	300.00	2-7		3.15	Yes		5.5-8.0			10-15'	X						FALSE	FALSE	FALSE		TRUE	X

NAME								Condition		HARDINESS			ORIGIN		SOIL			SIZE				TYPOLOGIES					TYPOLOGIES		
Genus	Species		Comm_Name	Flood score	Drought Score	Pest Score	Total score	Condition Score (70% good = 1, 55-70% = 2, lower than 55%=3)	Average Lifespan	Hardiness Zones (Cambridge in Zone 6b)	Outside Hardiness Zone 7a (assume in 2070)?	RUST (Relative Urban Stress Tolerance)	Native	Non-native	Optimal pH (min-max)	Structural Soil	Soil Amount	Typical Range of Mature Crown Width	Small (Mature height less than 35 ft tall)	Medium (Mature height greater than 35 ft but less than 50 ft tall)	Large (Mature height greater than 50 ft tall)	Narrow Street (According to Other Cities' Lists)	Wide Street - Boulevard (According to Other Cities' Lists)	Underwire (According to Other Cities' Lists)	RUST>1 AND MEDIUM SIZE TREE	RUST>1 AND LARGE TREE	CANOPY STREET TREES	CANOPY STREET TREES	UNDERWIRE STREET TREES	UNDERWIRE STREET TREES
Thuja	plicata	Thuja plicata	Redcedar-Western	1	2	3	5.5	1	1000.00	6-8a				Yes	5.5-6.5			15-20'		X										
Tilia	americana	Tilia americana	Basswood	1	1	1	2.5	1	100.00	3-8		1.09	Yes		5.0-7.5			35-50'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Tilia	cordata	Tilia cordata	Linden-Littleleaf	2	2	1	4	1	100.00	4-7a		-1.14		Yes	4.8-7.2			35-50'			X				FALSE	FALSE	FALSE		FALSE	
Tilia	europaea	Tilia europaea	Linden-European	1	2	1	3.5	3	75.00	3-7				Yes				30-50'			X									
Tilia	tomentosa	Tilia tomentosa	Linden-Silver	1	2	1	3.5	3	75.00	4b-8a		0.97		Yes	5.5-6.5			30-50'			X		X		FALSE	FALSE	FALSE		FALSE	
Tsuga	canadensis	Tsuga canadensis	Hemlock-Canadian	1	1	1	2.5	2	450.00	4-7a		-1.63	Yes		4.5-6.0			30-50'		X					FALSE	FALSE	FALSE		FALSE	
Tsuga	caroliniana	Tsuga caroliniana	Hemlock-Carolina	1	1	1	2.5	3	100.00	6-7				Yes				20-25'			X									
Ulmus	americana	Ulmus americana	Elm-American	2	3	1	5	2	175.00	2-9		4.2	Yes		5.5-8.0			30-70'			X		X		FALSE	TRUE	TRUE	X	FALSE	
Ulmus	japonica x wilsoniana	Ulmus japonica x wilsonia	Elm	3	3	1	5.5	3	100.00	5-8				Yes				25-40'			X									
Ulmus	parvifolia	Ulmus parvifolia	Elm-Chinese	2	2	1	4	3	100.00	5b-10a		2.31		Yes	5.5-8.0			30-50'			X				FALSE	TRUE	TRUE	X	FALSE	
Ulmus	pumila	Ulmus pumila	Elm-Siberian	1	3	1	4.5	1	150.00	5-9		1.41		Yes	5.5-8.0			40-70'			X				FALSE	TRUE	TRUE	X	FALSE	
Ulmus	rubra	Ulmus rubra	Elm-Slippery	2	2	1	4	2	200.00	3-9		4.98	Yes		5.5-6.5			30-50'			X				FALSE	TRUE	TRUE	X	FALSE	
Zelkova	serrata	Zelkova serrata	Zelkova	1	2	3	5.5	1	250.00	5-8		2.3		Yes				30-75'			X				FALSE	TRUE	TRUE	X	FALSE	

APPENDIX O: DRAFT TREE PROTECTION ORDINANCE RECOMMENDATIONS

DRAFT FOR DISCUSSION

VALUES TO ORDINANCE

Trees are a shared resource
Everyone is subject to the Tree Ordinance

Trees provide tangible benefits to the City
Voluntary removals necessitate a fee that reflects the value of the lost resource

Large trees provide greater benefits and take longer to regrow
Mitigation requirements are proportionately higher for larger trees, and
The City's largest trees receive special protection

The process should be simple and objective
Homeowners can use a streamlined replacement formula, and all other projects
Use an industry standard valuation formula

Not all trees are equal
Fees are computed based on health, location, and species of tree

The process should be equitable
Owner-occupied properties have reduced mitigation requirements,
Those on financial assistance have all fees waived, and
Mitigation requirements should not be overly onerous.

Replanting in kind is preferred, but not all sites and project types are equal
The Ordinance encourages on-site replacement,
Allows off-site mitigation planting, and
Makes fees paid to the Tree Fund the most expensive option

PROPOSAL DETAILS

1. Tree canopy is a shared resource and a vital component of the infrastructure of the city.
    - Protect more trees by defining "Significant Trees" as those over 6" DBH
    - Expand the Ordinance to apply to all property types at all times
        - Private landowners making a voluntary removal must plant replacement trees (see Replacement Tree Table below) or pay a fee
        - Utility Companies and the City must replace trees damaged or removed because utility infrastructure projects
        - Large Projects going through the Special Permit process must replant either on site, off site, or pay a fee

2. Large canopy trees provide the greatest ecosystem services value and are thus the most important to protect as their loss will take decades to recover with new planting. To deter large canopy tree removal:
    - Create an "Exceptional Tree" category for trees > 30" dbh, with steeper fees for removing these trees
    - Change the tree valuation method from trunk diameter to the industry standard Trunk Area Formula, which values larger trees substantially higher than smaller trees

3. Forests are dynamic ecosystems and loss and growth are part of their natural processes. To take the long view of forests and to encourage new tree planting:
    - For general voluntary removals:
        - Encourage replanting on site by making tree planting much less costly than paying Fees
        - Create a mechanism such as a Tree Trust where replacement trees can be provided at no cost to an owner
    - For special permits/large project review voluntary removals:
        - Encourage replanting on site by making mitigation through tree planting much less costly than mitigation through Fees
        - Create a mechanism for mitigation through tree planting offsite, which is also less costly than mitigation through the Fees. (ie., The City would manage a database of planting areas that could be used for this purpose. The proponent could work with the City to identify new planting opportunities within the City that might otherwise not be planted (parking lots, vacant parcels, remnant spaces). For this to be successful, the negotiation process for tree mitigation must be part of the Special Permitting Process.

4. Tree protection measures should not disproportionately impact low-income residents. To ensure costs of tree removal are equitable:
    - Waive fees for those on Federal assistance
    - Provide replacement trees at no cost for those on Federal assistance

5. The methodology for valuing trees should recognize differing tree conditions and reflect the City's priorities. To accommodate the complex conditions of the City, tree values should be mediated by the following factors:

- Location Rating: TBD - Factor in the tree's relative ecosystem benefit to the community, i.e. Trees that provide more direct public services such as shading the sidewalks/bike lanes should be valued higher
- Condition Rating: Use an accepted measure of tree condition such as Jerry Bond's method of tree health evaluation, to value healthy high performing trees more than unhealthy or failing trees.
- Species Rating: Recognize that some species are long-lived, resilient, and provide high habitat value, while others are invasive, short-lived or weak wooded, and therefore have different long-term value to the City. Use the New England ISA species rating.
- This valuation should be conducted by an independent certified arborist.

6. Additional protections may have the unintended consequence of reducing incentives for people to plant new trees, fearing future fees for potential removal. To ensure the Ordinance is functioning as intended:

- Monitor and review metrics for permits, removals, and planting on a 5-year cycle and make necessary adjustments
    - If residential losses slow by the target rate after 5 yrs, some fees could be suspended
    - If planting targets on private property are not being met after 5 years, changes to the Fee structure should be considered
    - If losses have not sufficiently curbed to meet the targets after 5 years, further mitigation requirements or a moratorium could be considered

Tree Protection Ordinance Recommendations __ DRAFT

RECOMMENDATION SUMMARY TABLES

Homeowner Tree Replacement Table

DBH of Voluntarily Removed Tree	# trees to be replanted
6" to <14"	1
14" to <18"	2
18" to <21"	3
21" to <24"	4
24" to <26"	5
26" to <28"	6
28" to <30"	7
30" or greater	Use Trunk Area Formula with Residential Exception

Multi-Track Approach

	Tree Removal Permit	Homeowner Tree Removal Permit	Special Permit/Large Project Review
Trees ≥ 6" DBH	Trees can be removed without permit	Trees can be removed without permit	Trees can be removed without permit
Significant Trees (6" DBH to < 30" DBH)	Mitigate per trunk-area formula valuation.	Refer to Tree Replacement Table for required number of trees to be replanted. If required number of trees cannot be planted, mitigate remainder through trunk-area formula valuation.	Mitigate per trunk-area formula valuation.
Exceptional trees (≥ 30" DBH)	Mitigate per trunk-area formula valuation.	Mitigate per trunk-area formula valuation with residential exemption.	Mitigate per trunk-area formula valuation.

DRAFT FOR DISCUSSION

Mitigation Fee Calculation Table

This table returns two possible values: 1) The number of trunk area inches that need to be replaced using the trunk area valuation or 2) The value in dollars that will be charged in fees by the City and deposited in the Tree Fund. An applicant may combine on-site replacement, off-site planting, and fee payment in any combination to offset the total value of the tree(s) removed.

	Description	**Value / Multiplier**
Base Calculation	Area of trunk @ Breast Height	Square Inch
Tree Valuation Factors	Species Rating[1]	.1 – 1 (range)
	Location Rating[2]	.1 – 1 (range)
	Condition Rating[3]	.1 – 1 (range)
Exemption Credits	Owner Occupied Residence	For Fee: 0.3 for exceptional trees and 0.15 for all other trees For Planting: 0.2 for exceptional trees and 0.1 for all other trees
	Federal Assistance	No fee applied
Mitigation Credits	On site	.75
	Off site	.9
	Fee/Tree Fund Payment	$541/SQ IN (typical cost of replacement tree installed)

1 Tree Species Rating Guide for New England, 2nd Edition, New England ISA
2 ISA Trunk Formula Method from *Guide for Plant Appraisal, 10th Edition*, Council of Tree and Landscape Appraisers
3 Adapted from *Urban Tree Health – A Practical and Precise Estimation Method*, Jerry Bond, 2012.

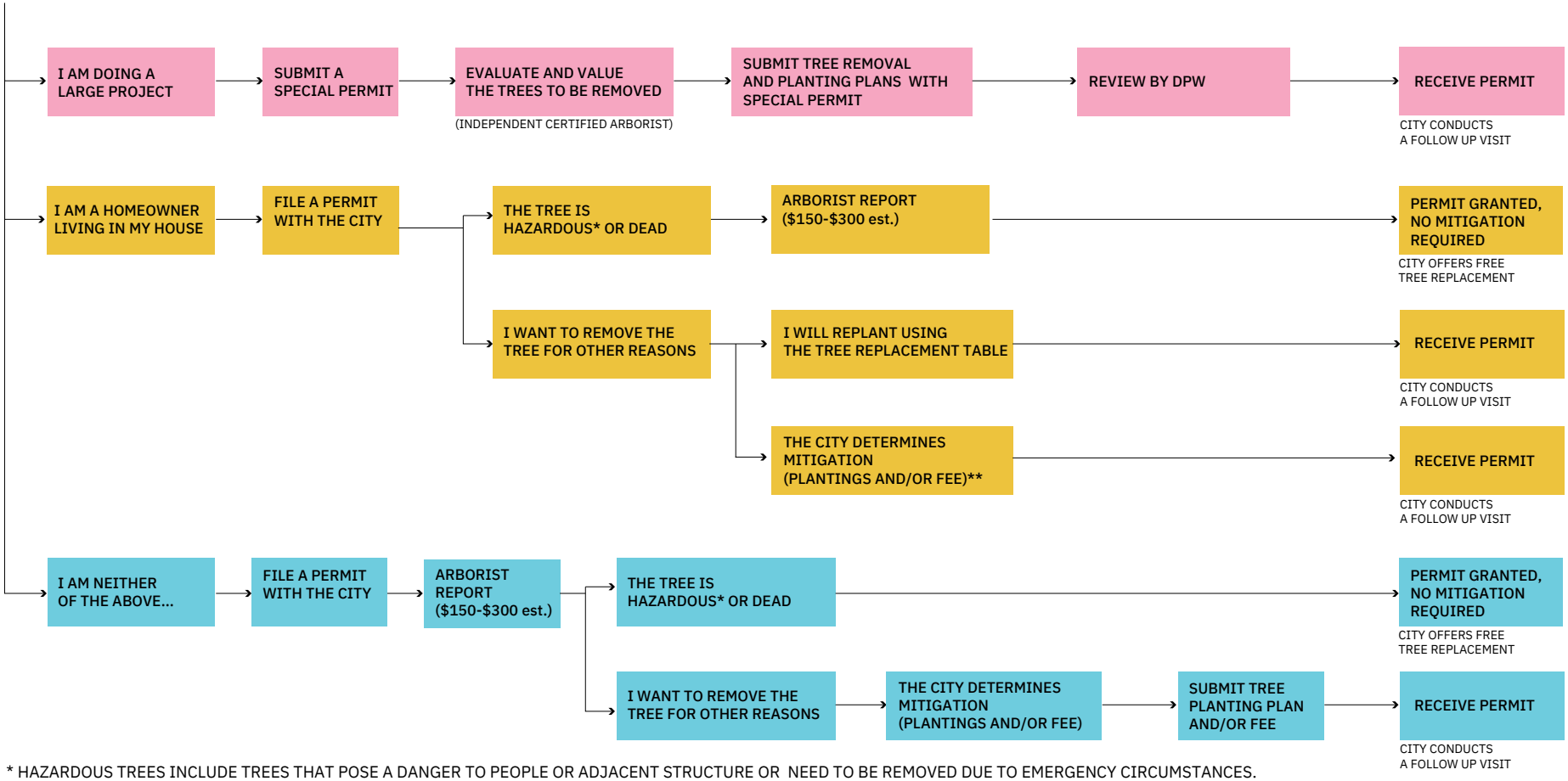
Cost comparison

	PROPOSED: Cost through trunk area			EXISTING: Cost through diameter formula	
	Cost for residential owner*	Cost for federal assistance	Cost for all others	Cost for special permits	Cost for all others
Remove 1 red oak at 12"	$2,099	$0	$20,989	$10,200	$0
Remove 1 red oak at 18"	$4,722	$0	$47,225	$15,300	$0
Remove 1 red oak at 30"	$52,472	$0	$131,180	$25,500	$0

*Exemption: 15% of trunk area for significant trees
30% of trunk area for exceptional trees

TREE PROTECTION ORDINANCE

I WANT TO REMOVE A TREE 6” DBH OR MORE

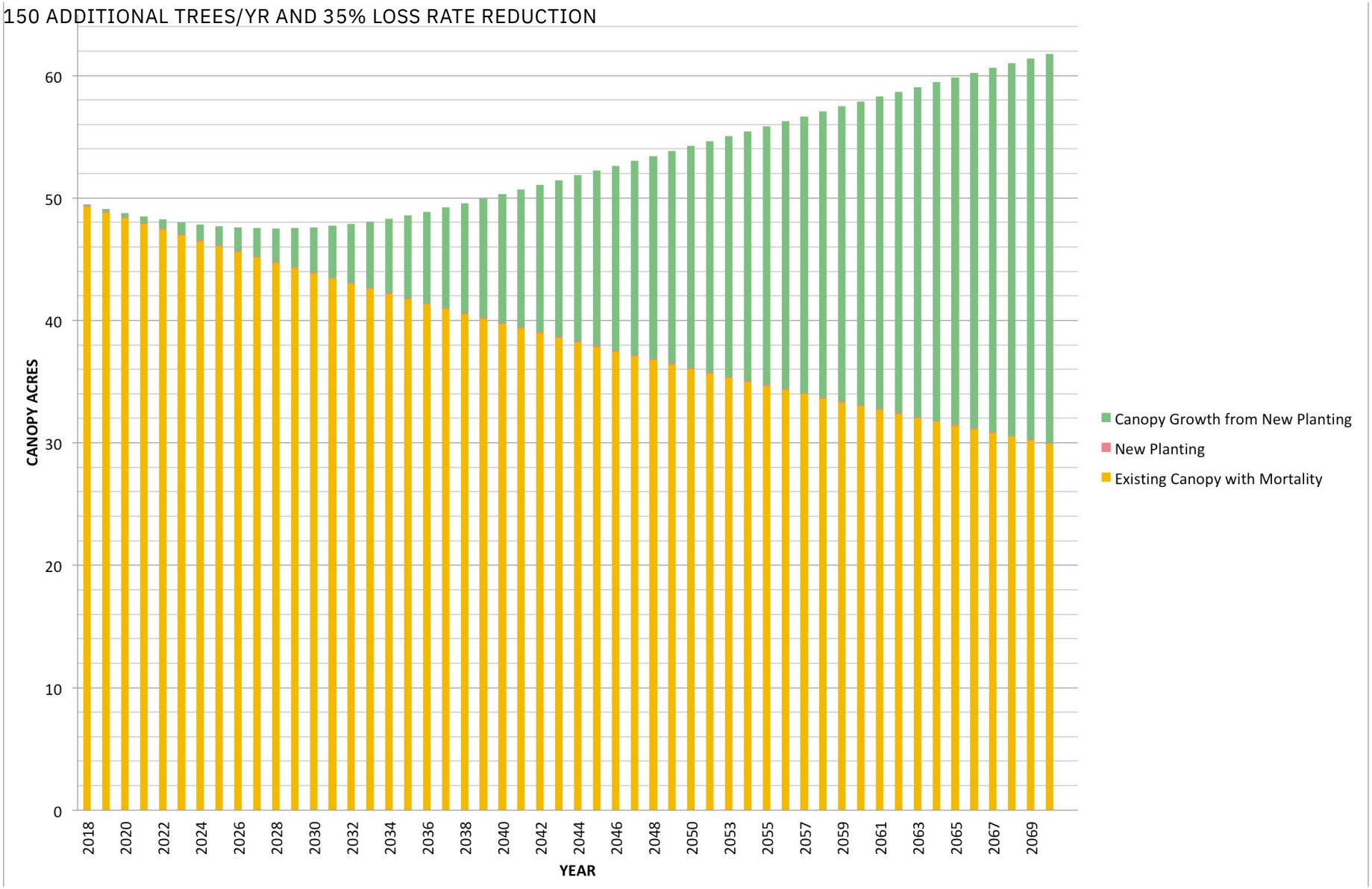


* HAZARDOUS TREES INCLUDE TREES THAT POSE A DANGER TO PEOPLE OR ADJACENT STRUCTURE OR NEED TO BE REMOVED DUE TO EMERGENCY CIRCUMSTANCES.
** THOSE ON FEDERAL ASSISTANCE ARE OFFERED FREE REPLACEMENT TREES THROUGH THE TREE TRUST AND/OR DO NOT NEED TO PAY A FEE

APPENDIX P: TARGETS METHODOLOGY, CHARTS, GROW/CURB LOSS BY LAND OWNERSHIP TYPE SPREADSHEETS

COMMERCIAL TARGET CHART

150 ADDITIONAL TREES/YR AND 35% LOSS RATE REDUCTION



INSTITUTIONAL TARGET CHART

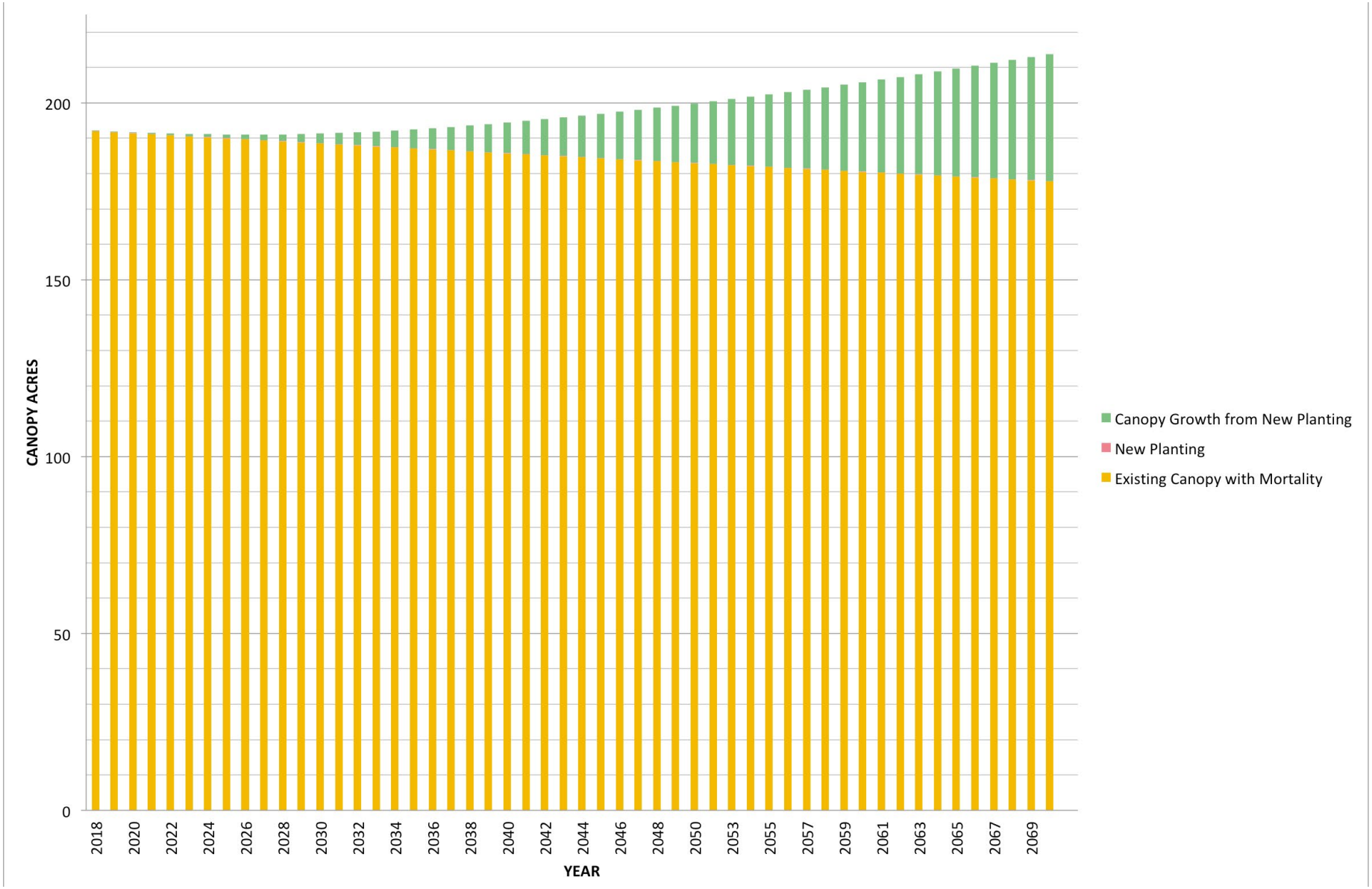
350 ADDITIONAL TREES/YR AND 25% LOSS RATE REDUCTION

ROW TARGET CHART

650 ADDITIONAL TREES/YR AND 25% LOSS RATE REDUCTION

OPEN SPACE TARGET CHART

100 ADDITIONAL TREES/YR AND 25% LOSS RATE REDUCTION

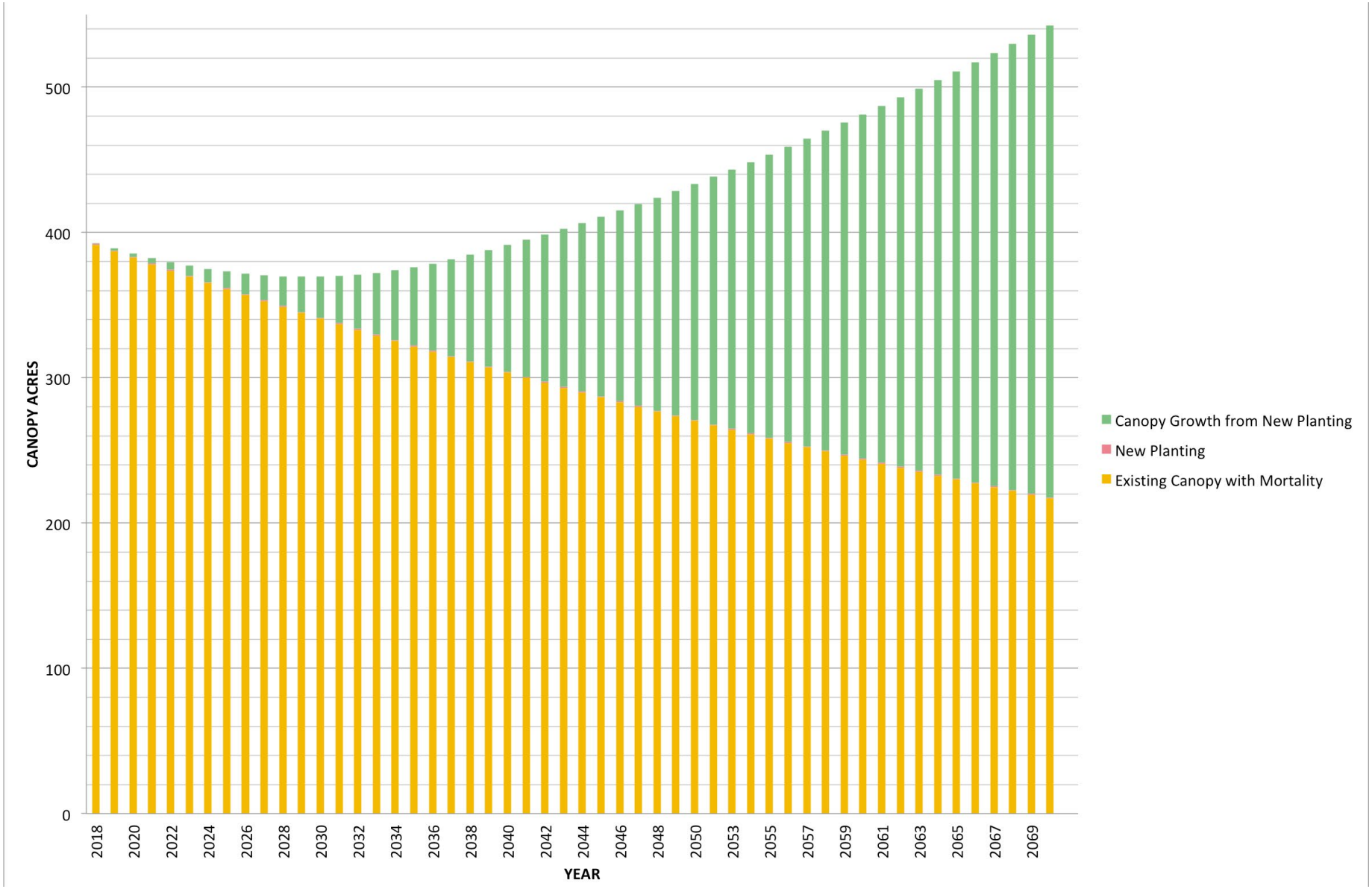


RESIDENTIAL NO SETBACKS TARGET CHART

100 ADDITIONAL TREES/YR AND 50% LOSS RATE REDUCTION

RESIDENTIAL WITH SETBACKS TARGET CHART

1025 ADDITIONAL TREES/YR AND 50% LOSS RATE REDUCTION



Land Use Category	Existing net loss rate (2009-2018)	Existing Canopy %	Canopy target % per shared responsibility goal	If loss is curbed by 25%, how many additional trees should be planted annually to reach the canopy target by 2050?	If loss is curbed by 50%, how many additional trees should be planted annually to reach the canopy target by 2050?	If loss is curbed by 25%, how many additional trees should be planted annually to reach the canopy target by 2070?	If loss is curbed by 50%, how many additional trees should be planted annually to reach the canopy target by 2070?
ROW	0.2%	28%	34%	665	625	345	325
Open space - publicly owned	0.2%	44%	49%	290	230	135	125
Residential- no setbacks	2.3%	16%	19%	180	145	105	85
Residential - 10' or more setback	2.3%	29%	33%	2150	1710	1280	1030
Institutional	1.6%	20%	25%	550	470	345	285
Commercial & Industrial	1.3%	9%	10%	235	190	170	135
TOTAL				4070	3370	2380	1985

HEAT ISLAND HOTSPOTS

	# grids	SF	Acres	% city
Total land area of Cambridge (acres)			4066	
City above average ambient temperature	7320	9687.5	1628	40%
City as a hotspot (92 degrees)	4561	9687.5	1014	25%

	Acres	% ROW
ROW land area	812	
ROW hotspots in 2018	213	26%
ROW hotspots with 12,000 trees	176	22%
Projected change from 2018		-17%
Projected area of ROW cooling with 12,000 trees	167.8	21%
Projected area of ROW cooling in hotspots with 12,000 trees	19.1	11%

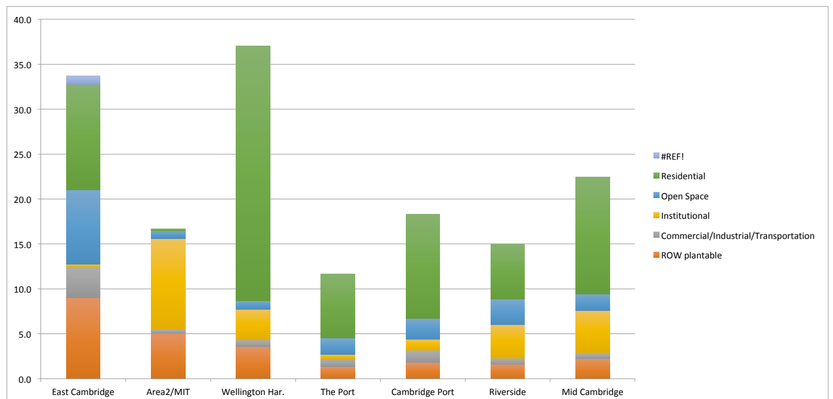
NEIGHBORHOOD TARGETS

includes rogers field and railroad new parks

NEIGHBORHO	CANOPY ACRES*		Difference	ROW plantable - without roac	Plantable percent - without	ROW- roadway planta	total plantable ROW		plantable area by percent		Commercial/Industrial/Tr	plantable area by	Institutional		plantable area by	Open Space		plantable area by	Residential		plantable area by	Total additional plantable area	Total canopy		Neighborhood acres	Canopy cover	Difference		Total plantable area	
East Cambridg	52.8		48.68	12.2	6.1	13.6	25.8		9.0		23.1	3.5	1.0		0.3	16.6		8.3	39.0		11.703002	32.7	85.5		405.9	21%	-15.9		25%	-4%	
Area2/MIT	38.8		19.13	8.6	4.3	5.9	14.5		5.1		3.0	0.4	33.6		10.1	1.8		0.9	0.7		0.21	16.7	55.5		231.7	24%	-2.4		25%	-1%	
Wellington Ha	25.8		12.1	8.9	3.5	1.4	10.3		3.6		5.0	0.7	11.1		3.3	2.0		1.0	94.5		28.33668006	37.0	62.8		151.6	41%	24.9		25%	16%	
The Port	36.6		11.3	1.1	0.5	2.8	3.9		1.4		5.9	0.9	1.5		0.4	3.7		1.9	23.8		7.138695505	11.7	48.3		191.6	25%	0.4		25%	0%	
Cambridge Po	70		15.33	3.1	1.2	2.0	5.2		1.8		9.1	1.4	4.2		1.3	4.6		2.3	38.7		11.60101742	18.3	88.3		341.3	26%	3.0		25%	1%	
Riverside	47.4		3.03	1.8	0.7	2.8	4.6		1.6		4.7	0.7	12.3		3.7	5.7		2.9	20.3		6.10181716	15.0	62.4		201.7	31%	11.9		25%	6%	
Mid Cambridg	73.5		0.97	2.5	1.0	3.8	6.3		2.2		4.8	0.7	15.6		4.7	3.7		1.9	43.3		12.98524696	22.4	95.9		297.9	32%	21.5		26%	6%	
			110.54																											

FINAL NUMBERS FOR CHART

NEIGHBORHO	Existing Canopy Acres	ROW plantable	Commercial/Industrial/Trans	Institutional			Open Space	Residential	Total plantable	difference
East Cambridg	52.8	9.0	3.5	0.3			8.3	11.7	32.7	15.9
Area2/MIT	38.8	5.1	0.4	10.1			0.9	0.2	16.7	2.4
Wellington Ha	25.8	3.6	0.7	3.3			1.0	28.3	37.0	-24.9
The Port	36.6	1.4	0.9	0.4			1.9	7.1	11.7	-0.4
Cambridge Po	70	1.8	1.4	1.3			2.3	11.6	18.3	-3.0
Riverside	47.4	1.6	0.7	3.7			2.9	6.1	15.0	-11.9
Mid Cambridg	73.5	2.2	0.7	4.7			1.9	13.0	22.4	-21.5
		24.7	8.3	23.8			19.0	78.1		



FOR ROW/Sidewalk

NEIGHBORHO	Canopy area (acres) over ROW	ROW area (acres)	% cover	Canopy acres over sidewalk	Sidewalk area	% canopy over sidewalk	ROW minus sidewalk	ROW minus sidewalk cov	% cover over road	assume 35% of RC	difference	sidewalk plantable
East Cambridg	21.7	102.4	21.2%	6.9	21.3	32%	81.1	14.8	18%	28.385	13.585	14.4
Area2/MIT	11.65	51.3	22.7%	2.5	8.3	30%	43	9.15	21%	15.05	5.9	5.8
Wellington Ha	11.3	36.5	31.0%	3.5	10.1	35%	26.4	7.8	30%	9.24	1.44	6.6
The Port	13.1	45.8	28.6%	4.7	13.72	34%	32.08	8.4	26%	11.228	2.828	9.02
Cambridge Po	22.3	76.1	29.3%	4.7	20	24%	56.1	17.6	31%	19.635	2.035	15.3
Riverside	14.2	48.6	29.2%	4.6	13.1	35%	35.5	9.6	27%	12.425	2.825	8.5
Mid Cambridg	19.7	63.8	30.9%	7.7	18.7	41%	45.1	12	27%	15.785	3.785	11

TREE CANOPY LOSS AND GAIN

Assumptions	at planting	at year 20	after year 20	annnual loss rate (net)	0.016
Canopy Spread	5	20'		annual loss rate (fross)	0.037
Canopy growth rate per year (radius ofcanopy) in feet		0.789		0.3945	
Canopy in 2018	86.3				

Number of trees	600	450
Mortality Rate	0.01215	based on draft canopy loss layer (the reality may be lower)
Canopy growth of 2018 trees	0	based on draft canopy gain layer removing new planting that can be identified (the reality may be lower)
Mortality Rate of New Trees	0.02775	

possible combos			
less change	current draft layer with barlett numbe	current draft layer v rate (ft/yr) for 5' to 20' in 20 years	
	0.046	0.076	0.3947
	0.013	0.043	
1" dia growth per year	3.36" dia per year	4.46"	4.7364

Max out canopy at 40'

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22
individual growth rate for new trees	5.00	5.79	6.58	7.367	8.156	8.945	9.734	10.523	11.312	12.101	12.89	13.679	14.468	15.257	16.046	16.835	17.624	18.413	19.202	19.991	20.3855	20.78
individual growth rate for 2018 trees	13.15	13.15	13.15	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757
change for 2018 trees		0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
growth rate for reference		16%	14%	11.99%	10.71%	9.67%	8.82%	8.11%	7.50%	6.97%	6.52%	6.12%	5.77%	5.45%	5.17%	4.92%		4.48%	4.29%	4.11%	1.97%	1.94%

New Planting at X rate

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22
yearly canopy spread per tree using set diameter	2.5	2.9	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.1	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0	10.2	10.4
canopy area per tree (sq ft)	19.6	26.3	34.0	42.6	52.3	62.8	74.4	87.0	100.5	115.0	130.5	147.0	164.4	182.8	202.2	222.6	244.0	266.3	289.6	313.9	326.4	339.2
number of trees surviving after X years	600.0	583.4	567.2	551.4	536.1	521.2	506.8	492.7	479.0	465.7	452.8	440.3	428.0	416.2	404.6	393.4	382.5	371.9	361.5	351.5	341.8	332.3
canopy area for all trees (acres)	0.3	0.4	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.6

New Planting at another number

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22
yearly canopy spread per tree using set diameter	2.5	2.9	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.1	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0	10.2	10.4
canopy area per tree (sq ft)	19.6	26.3	34.0	42.6	52.3	62.8	74.4	87.0	100.5	115.0	130.5	147.0	164.4	182.8	202.2	222.6	244.0	266.3	289.6	313.9	326.4	339.2
number of trees surviving after X years	450.0	437.5	425.4	413.6	402.1	390.9	380.1	369.5	359.3	349.3	339.6	330.2	321.0	312.1	303.5	295.0	286.9	278.9	271.2	263.6	256.3	249.2
canopy area for all trees (acres)	0.3	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.9	1.9

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22
Canopy Gain Additive - total for first planting rate	0.3	0.6	1.1	1.6	2.2	3.0	3.9	4.8	6.0	7.2	8.3	9.4	10.6	11.8	13.0	14.3	15.6	16.8	18.1	19.4	20.7	21.8
Canopy Gain Additive - total for second planting rate											0.3	0.5	0.9	1.3	1.8	2.3	3.0	3.7	4.5	5.5	6.5	7.6
TOTAL CANOPY GAIN	0.3	0.6	1.1	1.6	2.2	3.0	3.9	4.8	6.0	7.2	8.5	9.9	11.4	13.1	14.8	16.6	18.5	20.5	22.7	24.9	27.1	29.3
Canopy Gain by canopy growth previous year	0.0	0.4	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.6
Canopy Gain by canopy growth other years	0.0	0.0	0.4	0.8	1.3	2.0	2.7	3.6	4.6	5.7	6.6	7.6	8.7	9.8	10.9	12.0	13.1	14.3	15.5	16.6	17.8	18.9
Canopy Gain without differientation	0.0	0.4	0.8	1.3	2.0	2.7	3.6	4.6	5.7	6.9	8.0	9.1	10.3	11.5	12.7	14.0	15.3	16.6	17.9	19.2	20.4	21.5
Canopy Gain by new planting	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

			-0.01215	-1.048545	85.2																	
year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
existing canopy with mortality		86.3	85.2	84.2	83.2	82.2	81.2	80.2	79.2	78.2	77.3	76.4	75.4	74.5	73.6	72.7	71.8	71.0	70.1	69.2	68.4	67.6
year		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Mortality gross		1.048545	1.048397378	1.035659349	1.023076088	1.010645714	0.998366368	0.986236217	0.974253447	0.962416268	0.95072291	0.939171627	0.927760691	0.916488399	0.905353065	0.894353025	0.883486636	0.872752273	0.862148333	0.851673231	0.841325401	0.831103297
Existing Canopy - with mortality		86.3	85.3	84.2	83.2	82.2	81.2	80.2	79.2	78.3	77.3	76.4	75.4	74.5	73.6	72.7	71.8	71.0	70.1	69.3	68.4	67.6

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	year 16	year 17	year 18	year 19	year 20
TOTAL CANOPY ACRES	85.5	84.8	84.3	83.8	83.4	83.2	83.1	83.1	83.3	83.6	84.0	84.5	85.1	85.8	86.6	87.6	88.6	89.8	91.1	92.5
% CANOPY	10.5%	10.4%	10.4%	10.3%	10.3%	10.2%	10.2%	10.2%	10.3%	10.3%	10.3%	10.4%	10.5%	10.6%	10.7%	10.8%	10.9%	11.1%	11.2%	11.4%
Total number of trees	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1000	1000	1000	1000	1000	1000	1000	1000	1000

Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40											
21.1745	21.569	21.9635	22.358	22.7525	23.147	23.5415	23.936	24.3305	24.725	25.1195	25.514	25.9085	26.303	26.6975	27.092	27.4865	27.881	28.2755	28.67	29.0645	29.459	29.8535	30.248	30.6425	31.037	31.4315	31.826	32.2205	32.615
13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757	13.14845757												
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
1.90%	1.86%	1.83%	1.80%	1.76%	1.73%	1.70%	1.68%	1.65%	1.62%	1.60%	1.57%	1.55%	1.52%	1.50%	1.48%	1.46%	1.44%	5%										

Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40											
10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.3	13.5	13.7	13.9	14.1	14.3	14.5	14.7	14.9	15.1	15.3	15.5	15.7	15.9	16.1	16.3
352.2	365.4	378.9	392.6	406.6	420.8	435.3	450.0	465.0	480.2	495.6	511.3	527.3	543.4	559.9	576.5	593.4	610.6	628.0	645.6	663.5	681.7	700.0	718.7	737.5	756.6	776.0	795.6	815.4	835.5
323.0	314.1	305.4	296.9	288.7	280.6	272.9	265.3	257.9	250.8	243.8	237.0	230.5	224.1	217.8	211.8	205.9	200.2	194.7	189.3	184.0	178.9	173.9	169.1	164.4	159.9	155.4	151.1	146.9	142.8
2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.7

Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40											
10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.3	13.5	13.7	13.9	14.1	14.3	14.5	14.7	14.9	15.1	15.3	15.5	15.7	15.9	16.1	16.3
352.2	365.4	378.9	392.6	406.6	420.8	435.3	450.0	465.0	480.2	495.6	511.3	527.3	543.4	559.9	576.5	593.4	610.6	628.0	645.6	663.5	681.7	700.0	718.7	737.5	756.6	776.0	795.6	815.4	835.5
242.3	235.6	229.0	222.7	216.5	210.5	204.6	199.0	193.4	188.1	182.9	177.8	172.8	168.1	163.4	158.9	154.4	150.2	146.0	141.9	138.0	134.2	130.4	126.8	123.3	119.9	116.6	113.3	110.2	107.1
2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1

Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40	Year 41	Year 42	Year 43	Year 44	Year 45	Year 46	Year 47	Year 48	Year 49	Year 50	Year 51	Year 52	
22.7	23.6	24.4	25.1	25.6	26.1	26.4	26.6	26.8	27.0	27.1	27.3	27.4	27.5	27.6	27.7	27.8	27.9	27.9	28.0	28.0	28.0	28.0	28.0	28.0	28.0	27.9	27.9	27.8	27.8	
8.8	10.1	11.5	13.0	14.6	16.3	18.1	20.0	22.0	23.9	25.9	27.8	29.8	31.8	33.9	35.9	37.9	40.0	42.1	44.1	46.2	48.3	50.4	52.5	54.6	56.7	58.8	60.9	63.0	65.1	
31.5	33.7	35.9	38.1	40.3	42.4	44.5	46.6	48.8	50.9	53.0	55.1	57.2	59.4	61.5	63.6	65.7	67.9	70.0	72.1	74.2	76.3	78.4	80.5	82.6	84.7	86.7	88.8	90.8	92.9	
2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.7	
19.9	20.7	21.5	22.1	22.7	23.1	23.4	23.6	23.8	23.9	24.1	24.2	24.4	24.5	24.6	24.7	24.7	24.8	24.9	24.9	24.9	24.9	25.0	25.0	24.9	24.9	24.9	24.9	24.8	24.8	-0.3
22.5	23.4	24.1	24.8	25.4	25.8	26.1	26.3	26.5	26.7	26.9	27.0	27.1	27.3	27.4	27.5	27.5	27.6	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.6	27.6	27.5	
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070
66.8	65.9	65.1	64.3	63.6	62.8	62.0	61.3	60.5	59.8	59.1	58.4	57.6	56.9	56.3	55.6	54.9	54.2	53.6	52.9	52.3	51.6	51.0	50.4	49.8	49.2	48.6	48.0	47.4	46.8	46.3
2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070
0.821005392	0.811030177	0.80117616	0.79144187	0.781825851	0.772326667	0.762942898	0.753673142	0.744516013	0.735470144	0.726534181	0.717706791	0.708986654	0.700372466	0.69186294	0.683456806	0.675152805	0.666949699	0.65884626	0.650841278	0.64293356	0.63512191	0.62740518	0.61978221	0.61225186	0.604813	0.59746452	0.59020532	0.58303433	0.57595046	0.56895266
66.8	66.0	65.1	64.4	63.6	62.8	62.0	61.3	60.5	59.8	59.1	58.4	57.7	57.0	56.3	55.6	54.9	54.2	53.6	52.9	52.3	51.6	51.0	50.4	49.8	49.2	48.6	48.0	47.4	46.8	46.3

year 21	year 22	year 23	year 24	year 25	year 26	year 27	year 28	year 29	year 30	year 31	year 32	year 33	year 34	year 35	year 36	year 37	year 38	year 39	year 40	year 41	year 42	year 43	year 44	year 45	year 46	year 47	year 48	year 49	year 50	year 51
93.9	95.3	96.7	98.1	99.5	100.9	102.3	103.7	105.1	106.4	107.8	109.2	110.6	112.1	113.5	114.9	116.4	117.9	119.3	120.8	122.3	123.7	125.2	126.7	128.2	129.7	131.2	132.7	134.1	135.6	137.1
11.6%	11.7%	11.9%	12.1%	12.3%	12.4%	12.6%	12.8%	12.9%	13.1%	13.3%	13.5%	13.6%	13.8%	14.0%	14.2%	14.3%	14.5%	14.7%	14.9%	15.1%	15.2%	15.4%	15.6%	15.8%	16.0%	16.2%	16.3%	16.5%	16.7%	16.9%
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
										36000																				56000

Assumptions

What to set new canopy growth rate?

Two options 1. based on a set increase in diameter of nursery info 5" cal to 20" cal in 20 years (average of 0.3947' in radius expansion)
2. Based on research - good condition tree is 0.5" growth per year for a street tree

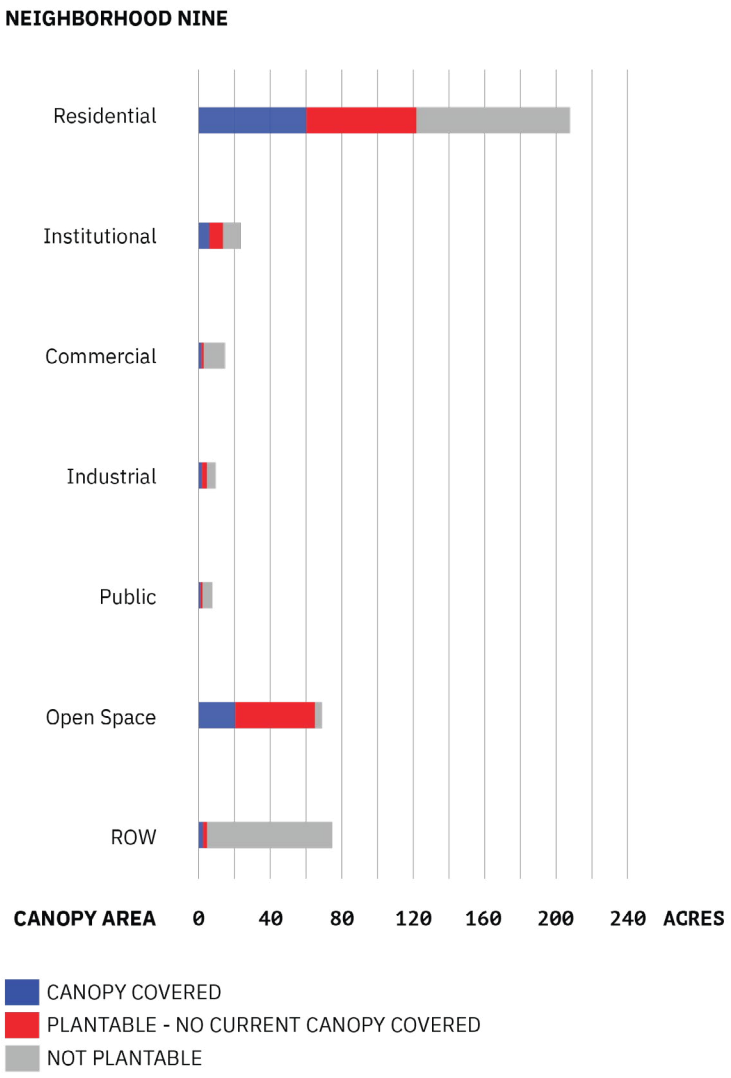
Bartlett extrapolation of number of trees	82360
AES number of trees	46696
Earthwatch	

Calculations for canopy radius gain

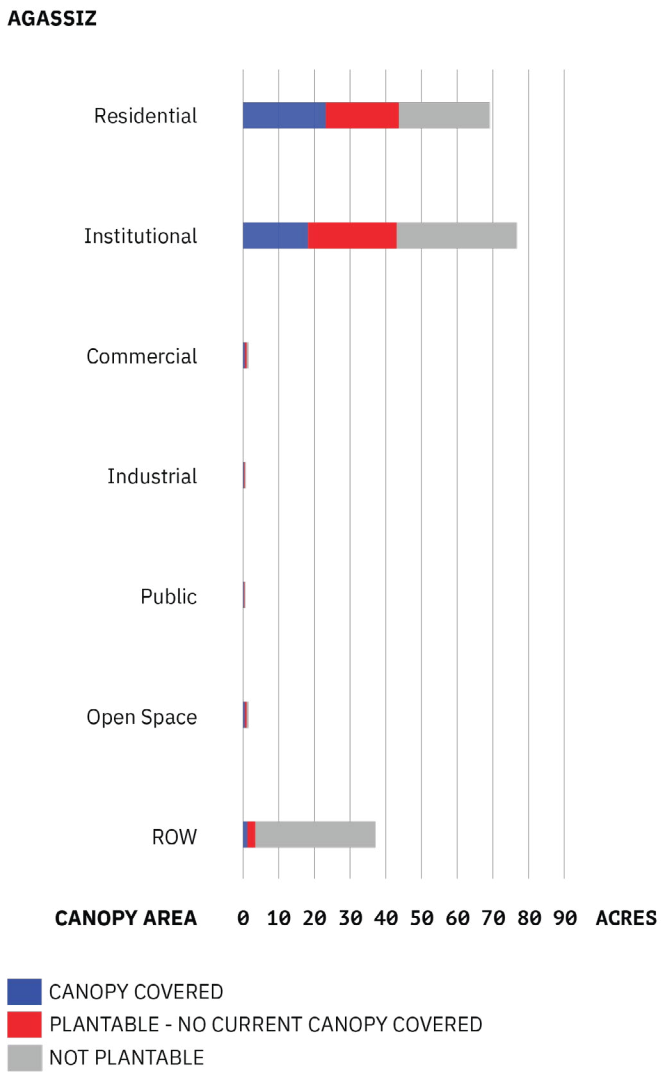
From Tree Canopy Layer		
AVERAGE CANOPY PER TREE	543.1777562	SF FT PER TREE
	13.14845757	AVERAGE SPREAD in radius
	0	AVERAGE GROWTH PER TREE
	13.14845757	NEXT YEAR SPREAD in radius
	0	Change in radius

APPENDIX Q: PLANTABLE AREA BY NEIGHBORHOOD

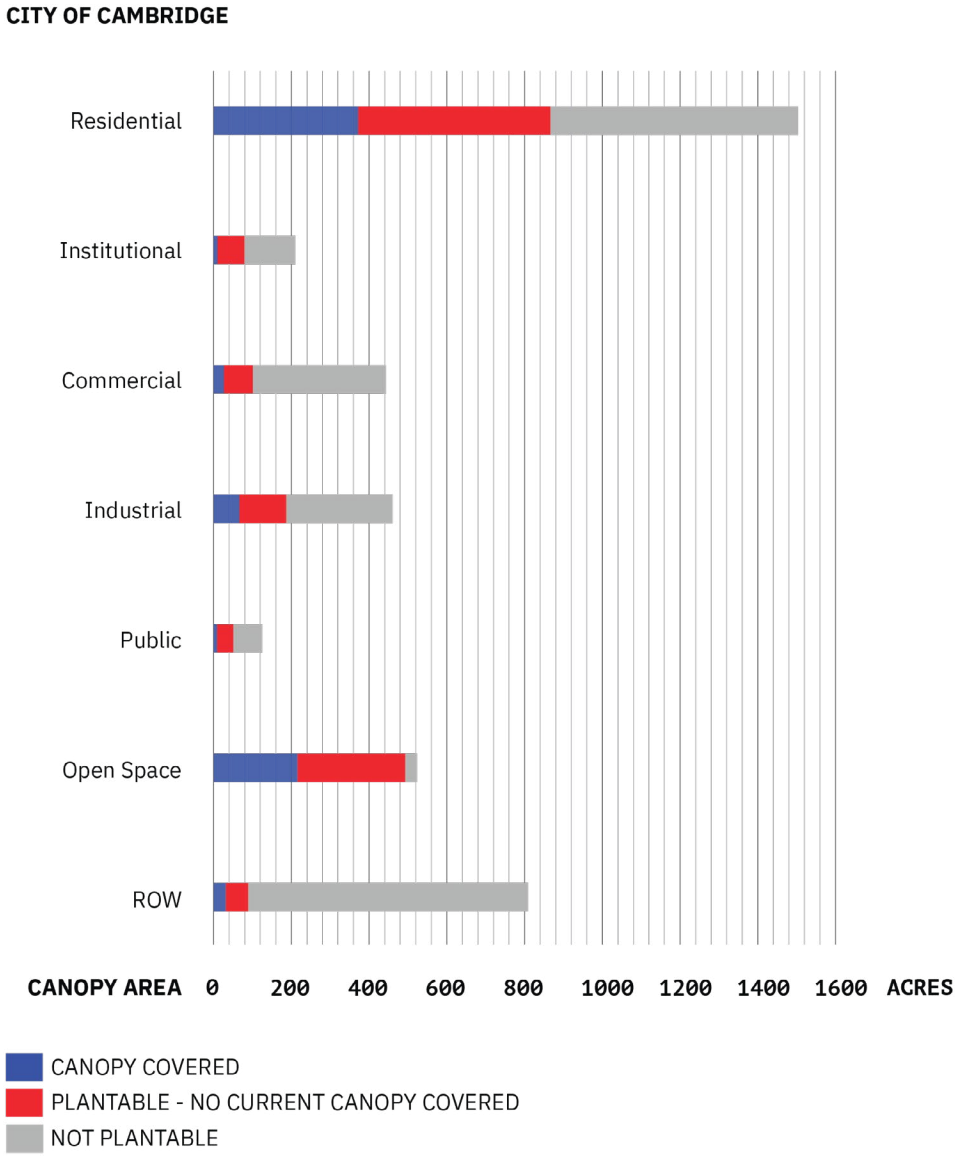
LAND USE PLANTABLE



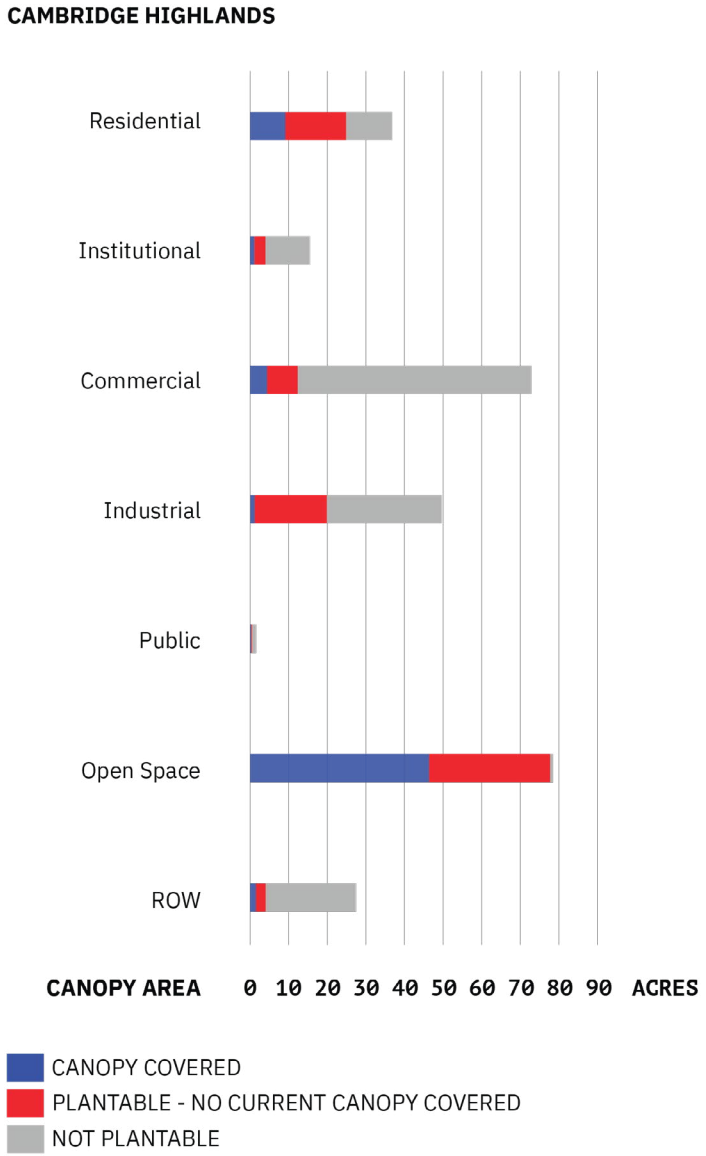
LAND USE PLANTABLE - AGASSIZ



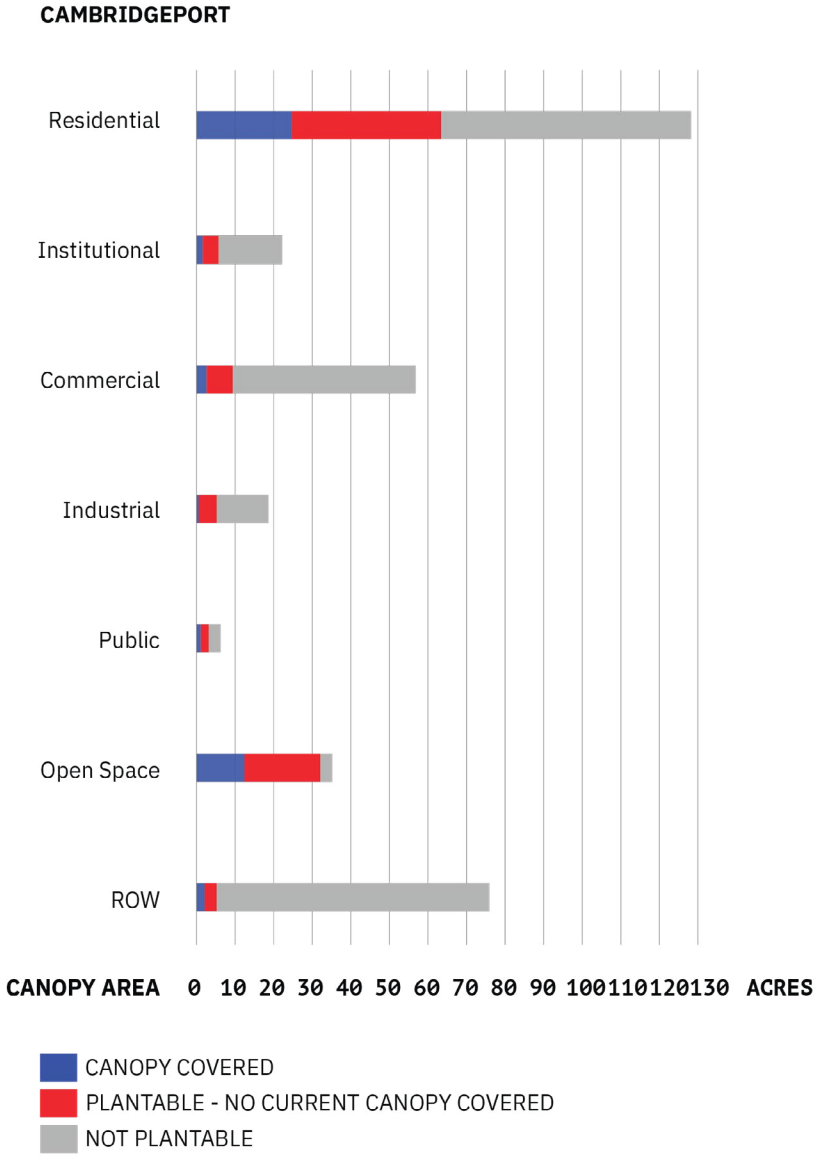
LAND USE PLANTABLE - CAMBRDIGE CITY



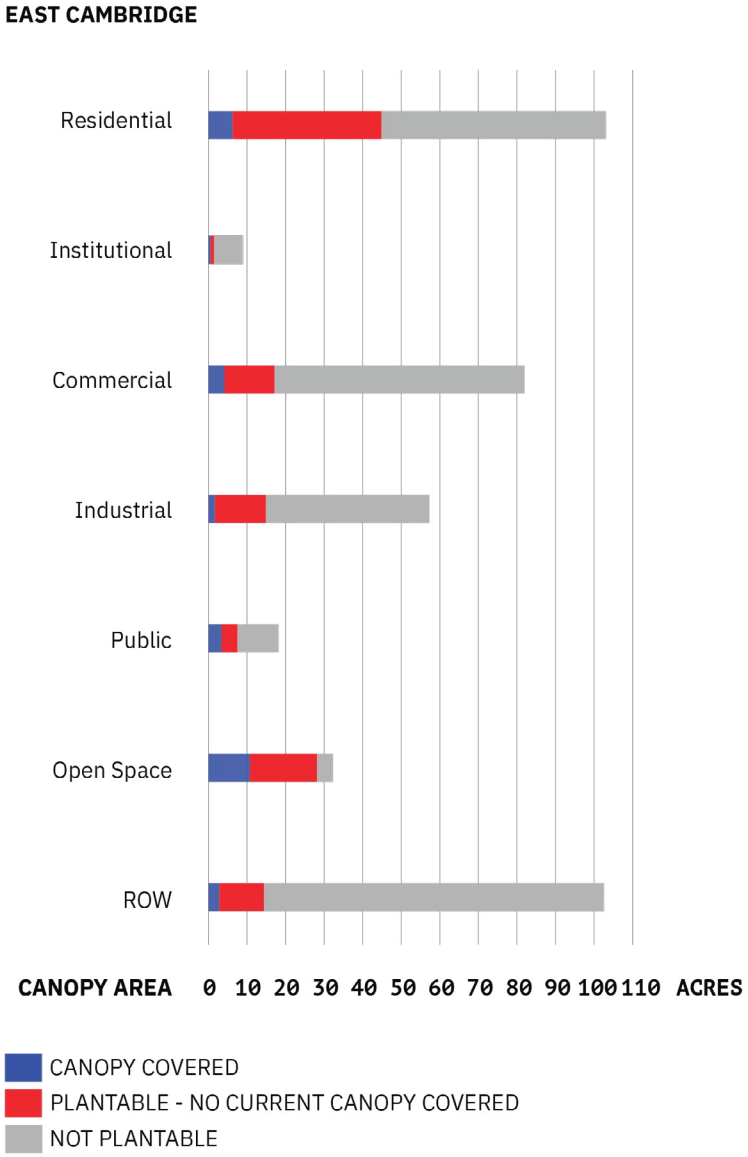
LAND USE PLANTABLE - CAMBRIDGE HIGHLANDS



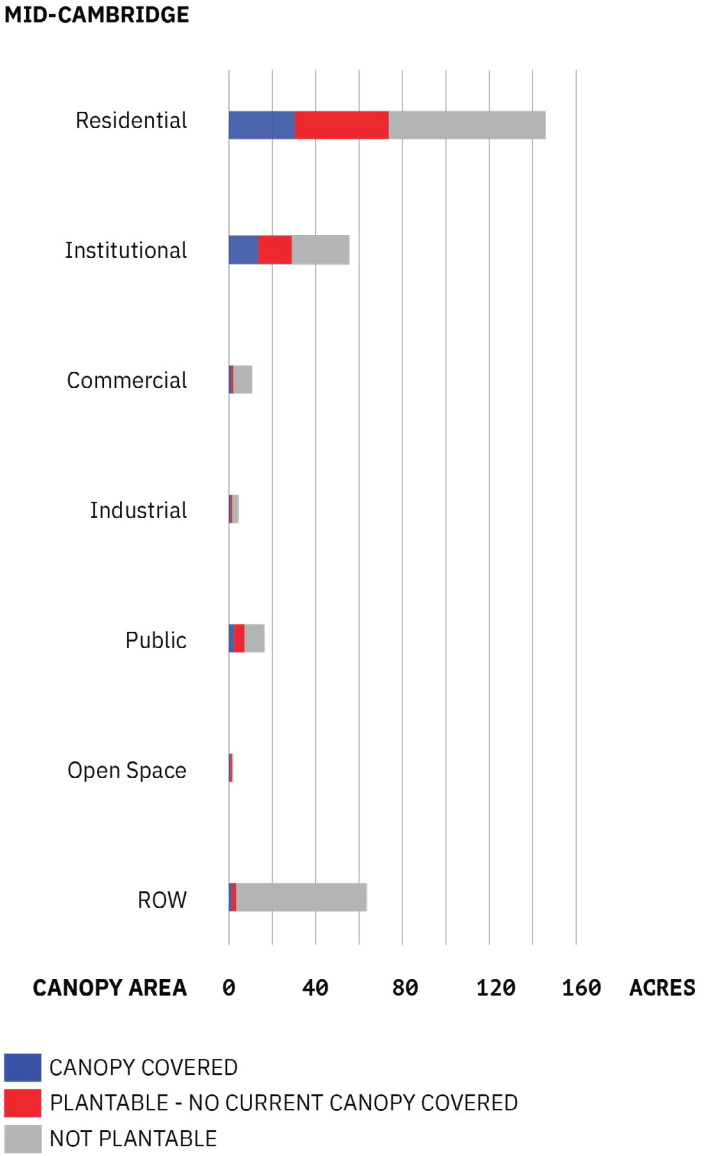
LAND USE PLANTABLE - CAMBRDIGEPORT



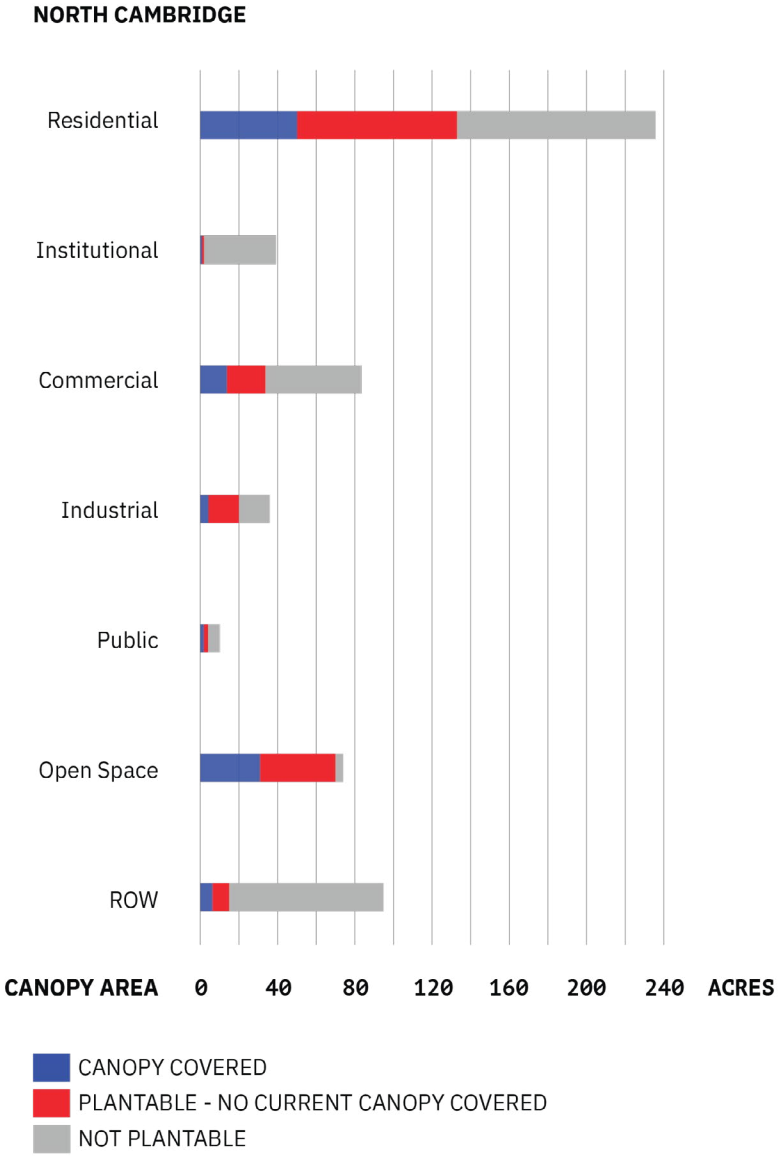
LAND USE PLANTABLE - EAST CAMBRIDGE



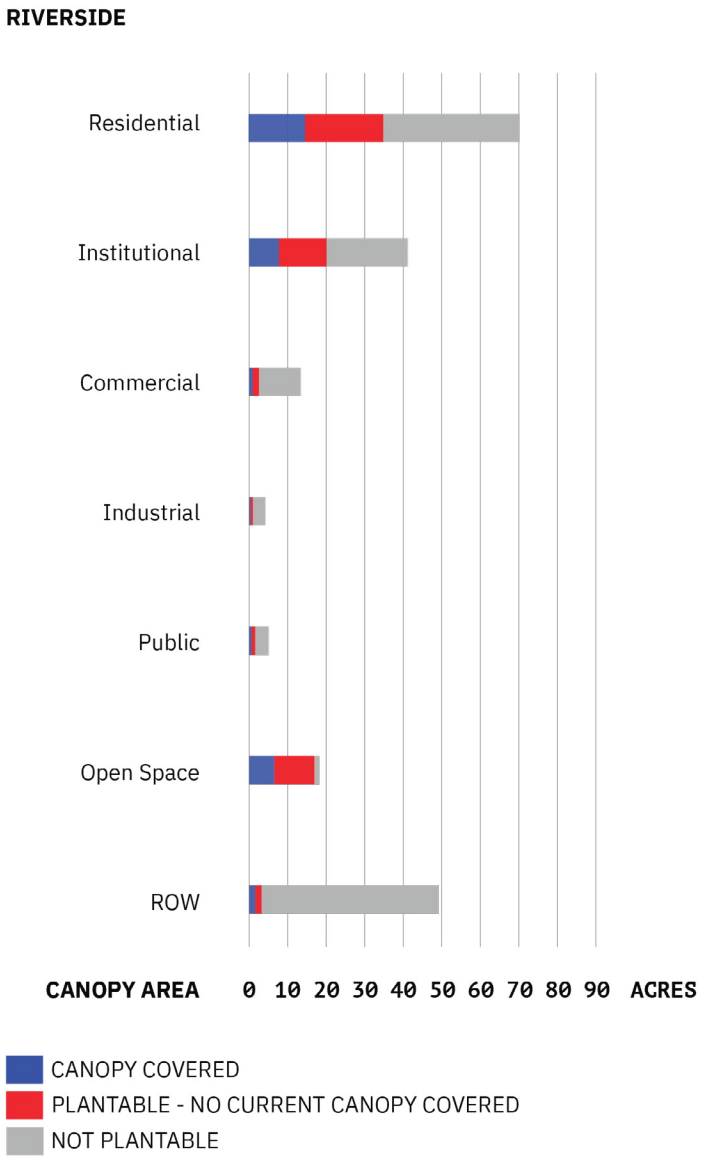
LAND USE PLANTABLE - MIDCAMBRDIGE



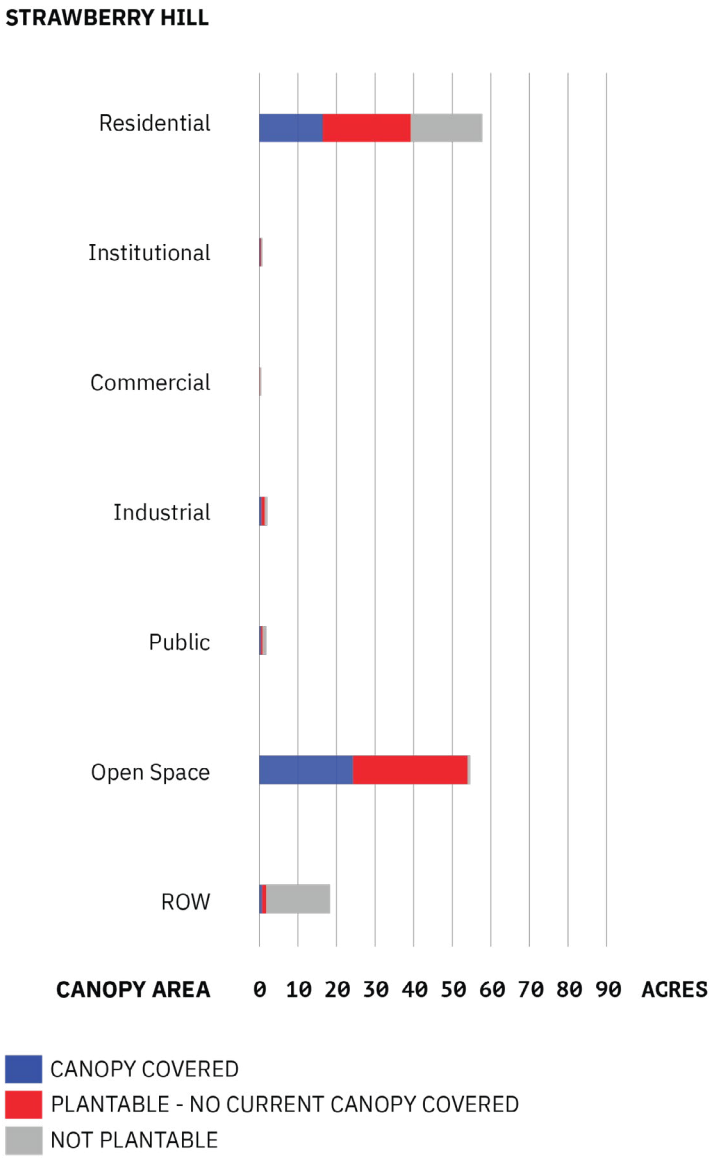
LAND USE PLANTABLE - NORTH CAMBRIDGE



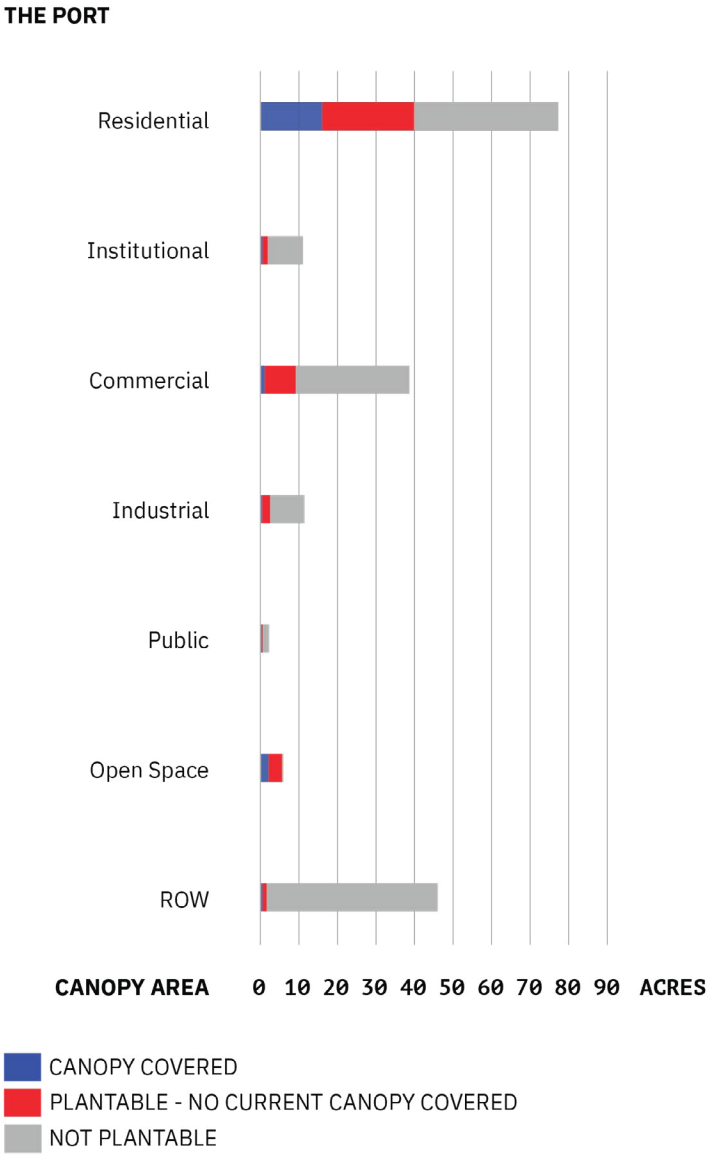
LAND USE PLANTABLE - RIVERSIDE



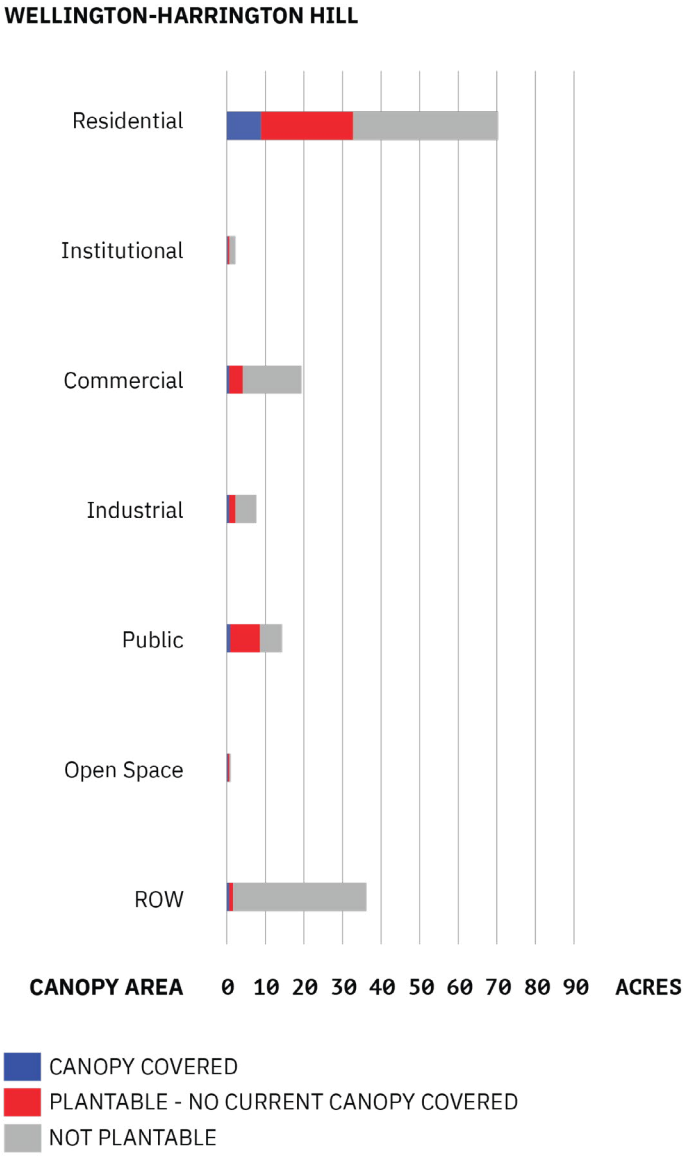
LAND USE PLANTABLE - STRAWBERRY HILL



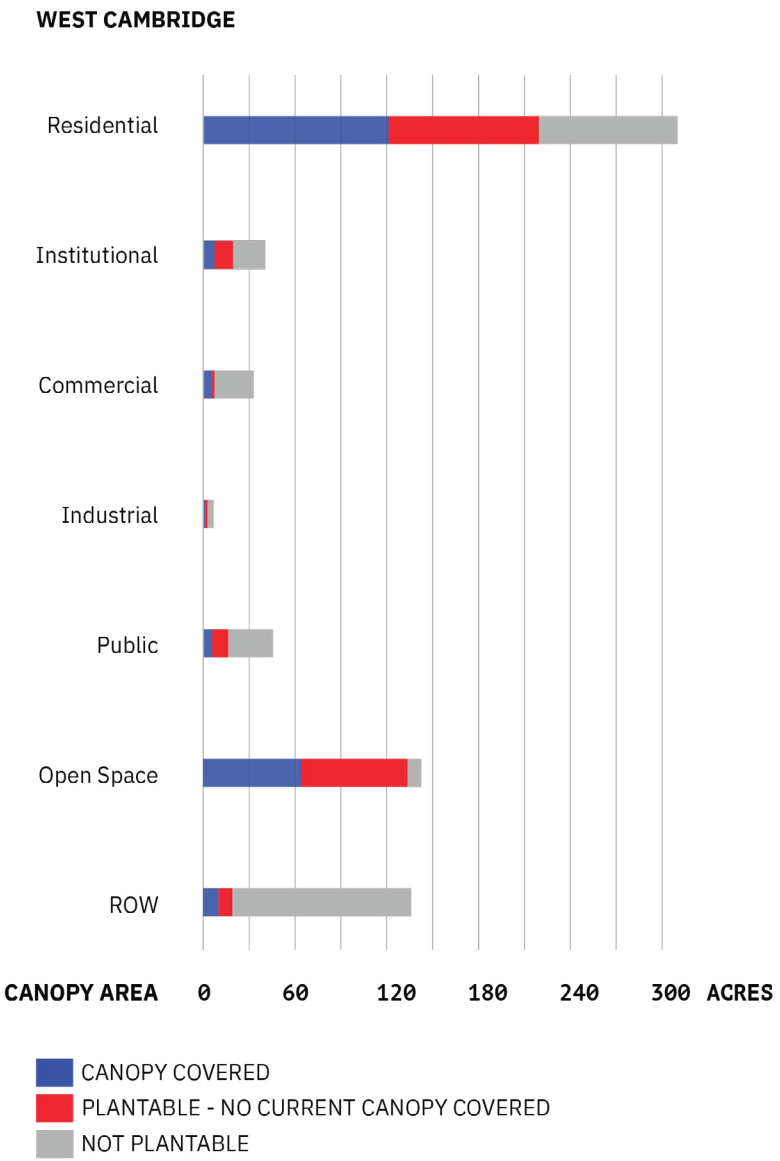
LAND USE PLANTABLE - THE PORT



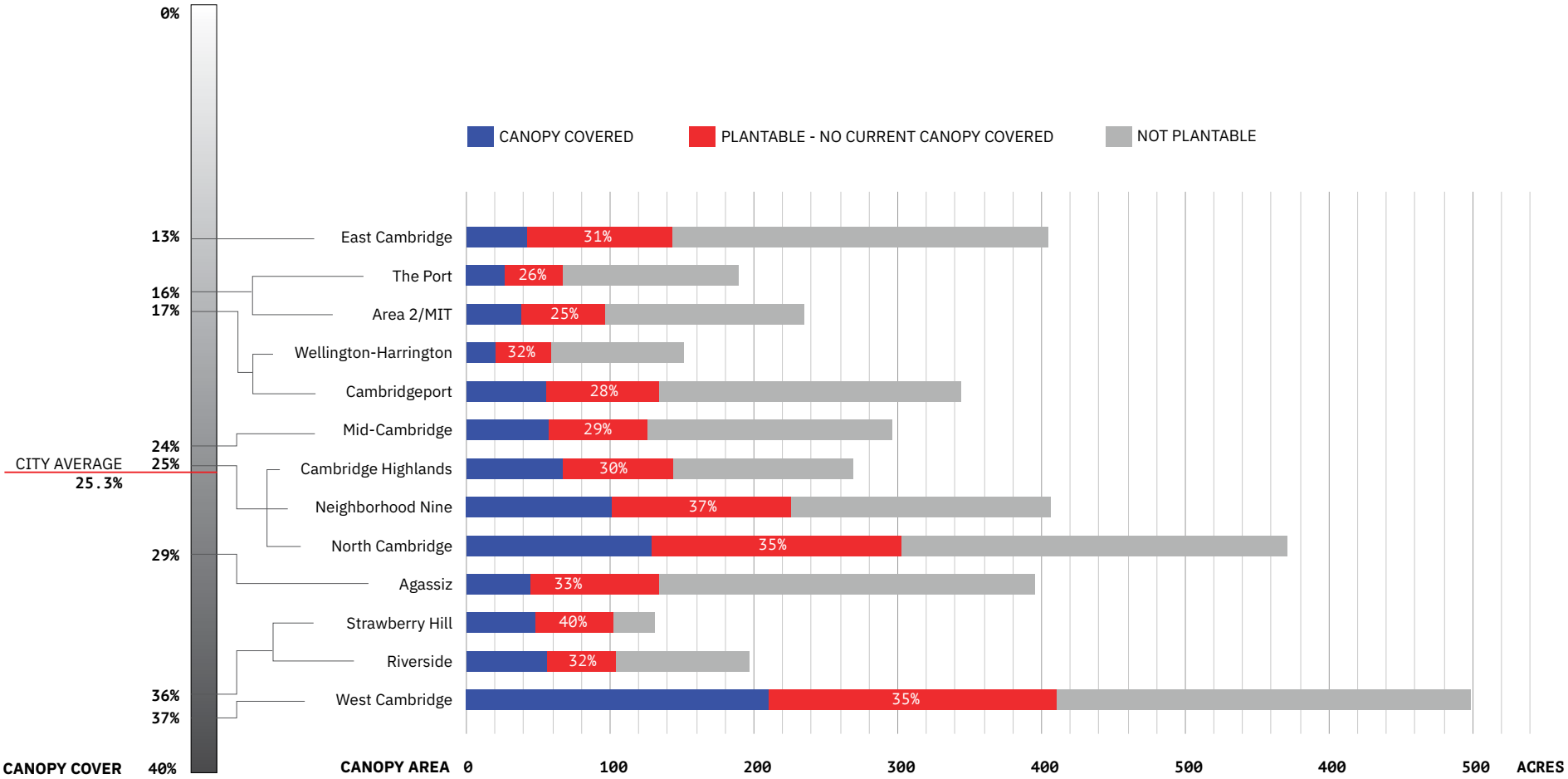
LAND USE PLANTABLE - WELLINGTON- HARRINGTON HILL



LAND USE PLANTABLE - WEST CAMBRIDGE



NEIGHBORHOOD PLANTABLE



APPENDIX R: DECISION SUPPORT FRAMEWORK

CAMBRIDGE URBAN FOREST MASTER PLAN
DECISION SUPPORT FRAMEWORK

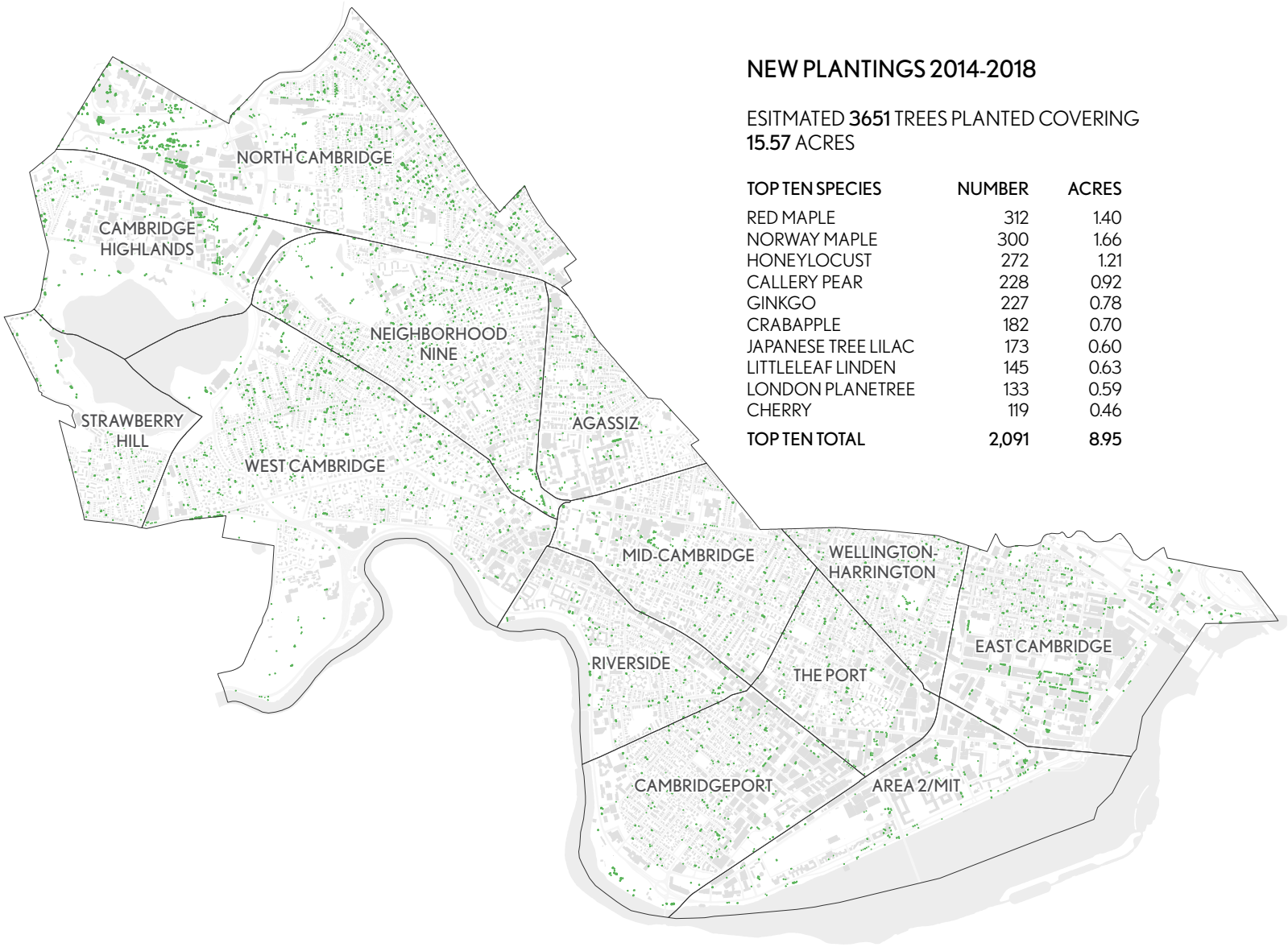
Vision	Goals		Evaluative Criteria	Baseline	2030 Target	2070 Target
To build, maintain, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.	PEOPLE: A forest that contributes to residents' well-being and residents who contribute to the forest well-being	Enhance shading and cooling				
		Improve pedestrian thermal comfort	Ambient sidewalk temperatures, Connectivity			
		Reduce urban heat island effects	Degrees relative to city avg			
		Increase equity in distribution of canopy cover	Canopy cover by vulnerable population			
		Create pleasing environments	Well-being / stress levels (survey)			
		Increase residents' awareness of value of trees	Engagement, program adoption (survey)			
		Enhance citywide stormwater management	Rainfall interception			
		Increase carbon sequestration	Carbon capture rates			
	TREES: A healthy forest whose trees live longer and thrive during predicted changing climate conditions	Improve soils health	Soil quality index			
		Improve tree health	% trees in good health			
		Improve street tree lifespan	Avg life of street tree			
	FOREST: A forest that supports a resilient, connected ecosystem	Enhance habitat	Canopy connectivity, species census			
		Diversify forest composition	City diversity index			
		Improve disaster response (noreaster, drought)	Projected impact and recovery rates			

This Support Framework was a tool developed with the Urban Forest Task Force by which to help define values and assess the relative impacts and potential success of alternative strategies.

How do we Evaluate alternative approaches?

Early in the study, the Urban Forest Task Force requested that the team articulate a clear statement of purpose and develop a framework for evaluating the effectiveness of proposals against agreed goals. The matrix here sets forth a hierarchy of broad goals and values statements which were referenced frequently during the study. During the study a more specific and refined set of tools has developed and constitute the centerpiece of the master plan. Nevertheless, this initial framework is a valuable window into the process.

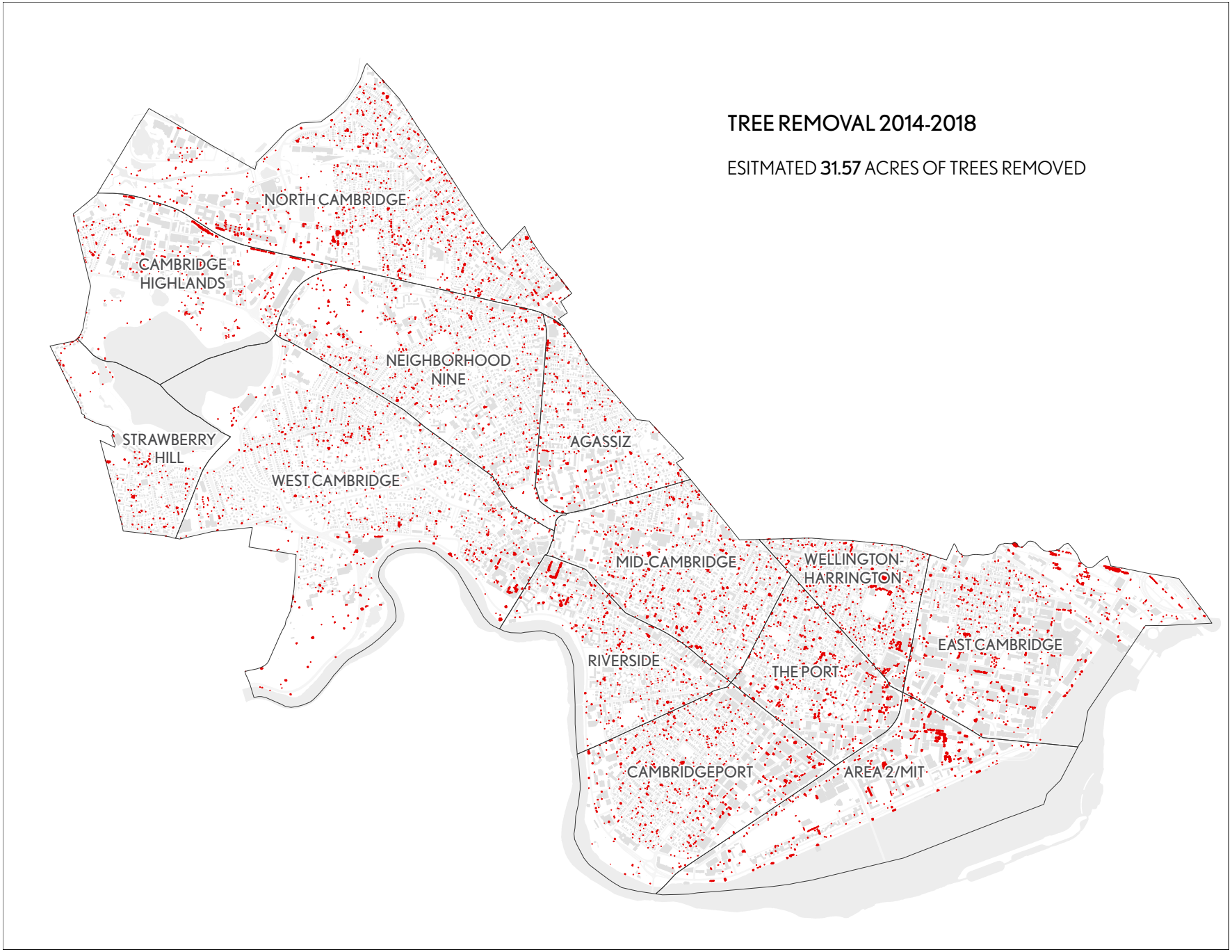
APPENDIX S: NEW PLANTING ANALYSIS

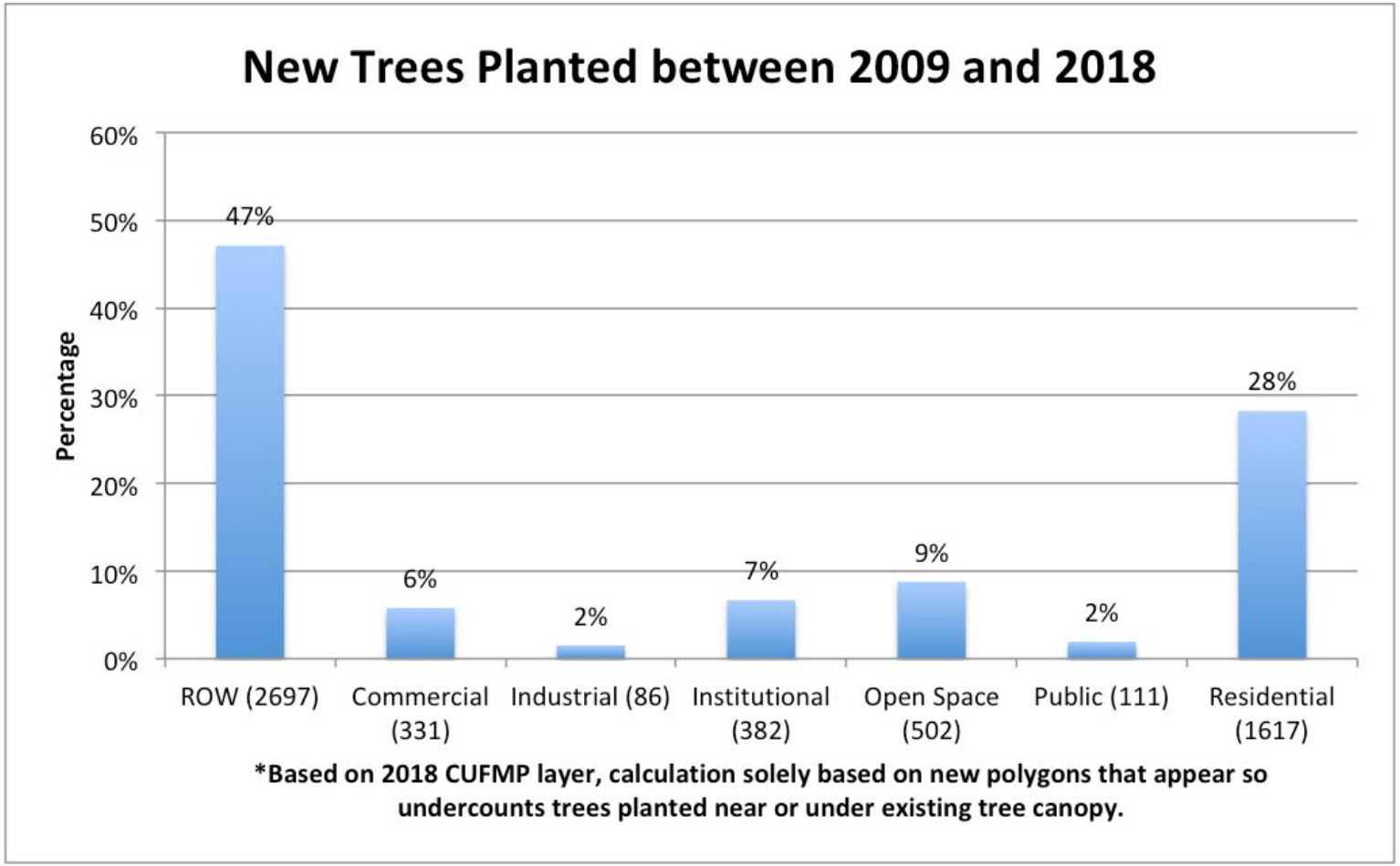


NEW PLANTINGS 2014-2018

ESITMATED **3651** TREES PLANTED COVERING **15.57** ACRES

TOP TEN SPECIES	NUMBER	ACRES
RED MAPLE	312	1.40
NORWAY MAPLE	300	1.66
HONEYLOCUST	272	1.21
CALLERY PEAR	228	0.92
GINKGO	227	0.78
CRABAPPLE	182	0.70
JAPANESE TREE LILAC	173	0.60
LITTLELEAF LINDEN	145	0.63
LONDON PLANETREE	133	0.59
CHERRY	119	0.46
TOP TEN TOTAL	**2,091**	**8.95**


TREE REMOVAL 2014-2018
ESITMATED 31.57 ACRES OF TREES REMOVED
NORTH CAMBRIDGE
CAMBRIDGE HIGHLANDS
NEIGHBORHOOD NINE
STRAWBERRY HILL
WEST CAMBRIDGE
AGASSIZ
MID-CAMBRIDGE
WELLINGTON-HARRINGTON
EAST CAMBRIDGE
RIVERSIDE
THE PORT
CAMBRIDGEPORT
AREA 2/MIT



If all of the plantable area in the City were canopy covered, this would be 51% of the City area.

	Targets					Plantable				Zoning	
Land use	additional % increase target	Total acres of land use	Canopy acres	canopy acres target in 2050	2050 target canopy cover within land use type	Total Plantable area	Canopy acres on plantable area	Additional available plantable area for canopy	Current canopy cover	(Zoning rec) Canopy cover goal	Canopy acres if built out by canopy cover zoning goal
ROW	20%	812	229	275	34%	93	37	56	28%	35%	284
Open space - publically owned	10%	433	192	211	49%	303	170	133	44%	50%	217
Residential- no setbacks	15%	192	31	36	19%	60	16	44	16%	25%	48
Residential - 10' or more setback	15%	1363	392	450	33%	806	366	440	29%	35%	477
Institutional - ttal	25%	436	86	108	25%	186	76	111	20%	30%	131
large blocks	15%	558	49	57	10%	154	28	126	9%	15%	84
Total		3794		**1211**		1765		**1006**			**1240**

Land Use	Count New Trees from 2009 to 2018	%	# trees/yr	Sum that overlap with 2014 new trees which means planted between 2009 and 2014	2014 to 2018 New Trees	%	Total				Mortality
ROW	1720	44	191	946	1751	48	2697	47	% of canopy	% of city area	774
Commercial	281	7	31	130	201	6	331	6	44.34046889	20	151
Industrial	78	2	9	34	52	1	86	2	4.527518566	11	44
Institutional	372	9	41	142	240	7	382	7	1.548795148	5	230
Open Space	407	10	45	201	301	8	502	9	5.778222749	11	206
Public	88	2	10	45	66	2	111	2	14.15493814	13	43
Residential	972	25	108	598	1019	28	1617	28	1.675377826	3	374
Grand Total	3918		435	2096	3630		5726		27.97467868	37	1822

ROW (2697)	47%
Commercial (331)	6%
Industrial (86)	2%
Institutional (382)	7%
Open Space (502)	9%
Public (111)	2%
Residential (1617)	28%

APPENDIX T: TASK FORCE PRESENTATIONS

TASK FORCE MEETING 1

OPENING REMARKS

DESIGN TEAM PRESENTATION

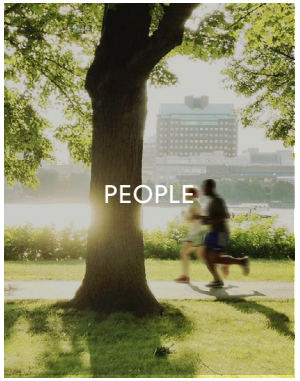
BREAK OUT SESSION

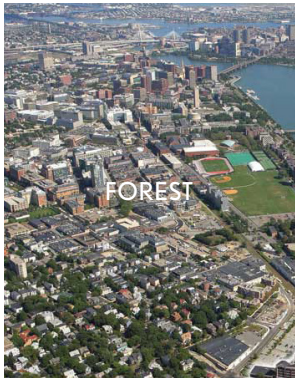
REPORT BACK

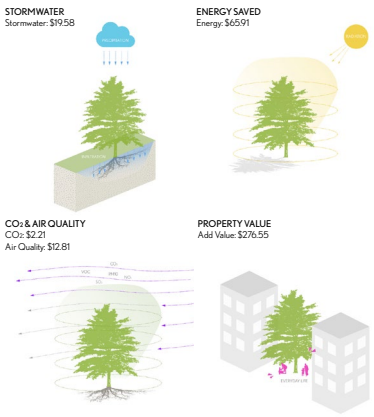
PUBLIC COMMENT

TASK FORCE SCHEDULE DISCUSSION

To maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.







Ecosystem services for an average Pin Oak in Cambridge
Source: i-Tree Streets - Annual Savings for Average Pin Oak in Cambridge

Cultural Value

We need to know
where to act

ANALYTICS

Research
Impact Analysis
Cost / Benefit Analysis
Scenario Planning

We need to know
how to do it

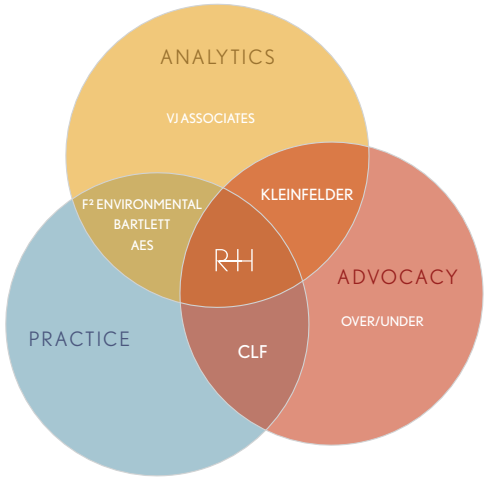
PRACTICE

Standards and Guidelines
Care and Maintenance

We need to know
how to make it happen

ADVOCACY

Education
Policy
Incentives
Commitments



Nathalie Beauvais, Kleinfelder

Deanna Moran, CLF

Chris Grimley, Over Under

Kim Chapman, AES

Steven Apfelbaum, AES

Nick Martin, Bartlett

Mike Sherwood, Bartlett

Eric T Fleisher, F2 Environmental

Clive Tysoe, VJ Associates

Barbara Murphy-Warrington, Resident

Louise Weed, Resident

Caitlin McDonough Mackenzie, Resident

Ahron Lerman, Resident

Kathleen Fitzgerald, Resident

Tessa Mae Buono, Resident

Elena Saporta, Resident

Randa Ghattas, Resident

Lena Jean Nahan, Resident

Conrad Crawford, Resident

Denise Jillson, Resident, Exec. Director of Harvard Square Business Assoc.

Maggie Booz, Resident, CPP Co-chair

Florrie Wescoat, Resident, CPP Co-chair

Caitlin Tamposi, Representative of the Chamber of Commerce

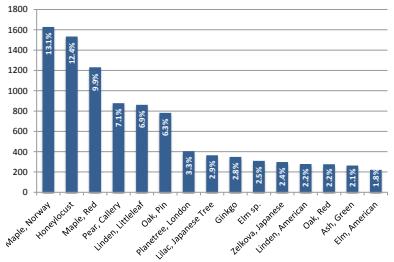
Laura Tenny, MIT Representative

Mark Verkennis, Harvard University Representative

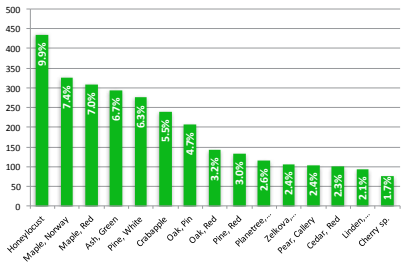
Tom Evans, Cambridge Redevelopment Authority Representative

Michael Johnston, Cambridge Housing Authority Representative

what is the state of the urban forest today?

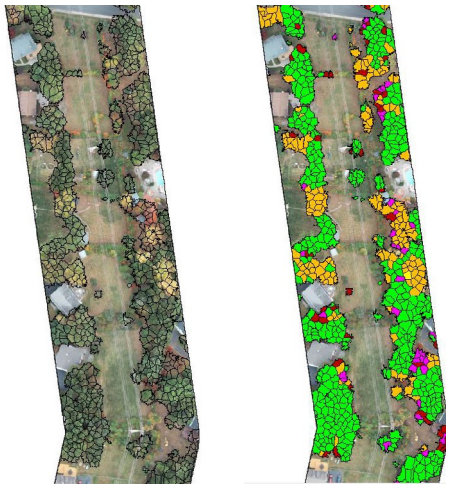


15 most abundant City-owned street trees in Cambridge
Source: Earthwatch Institute, Urban Forest Management Plan, 2016



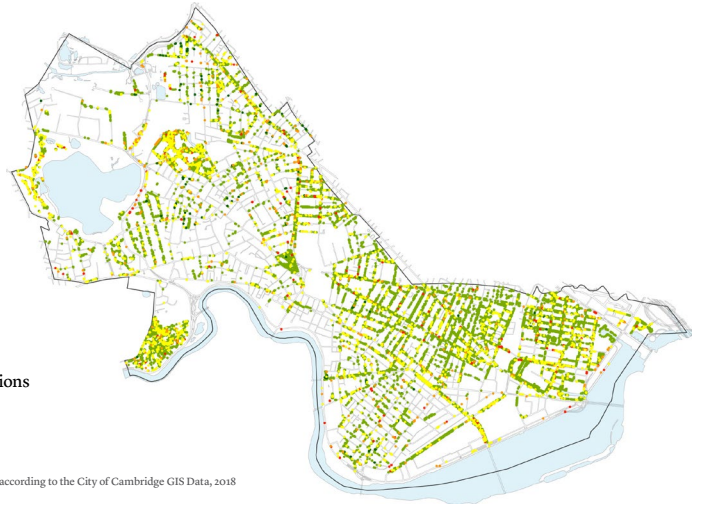
15 most abundant City-owned park trees in Cambridge
Source: Earthwatch Institute, Urban Forest Management Plan, 2016

Source: Google Earth, 2018



Hazard Tree Classification
Species Group: Ash
Height: >20 ft
Proximity:<25 ft

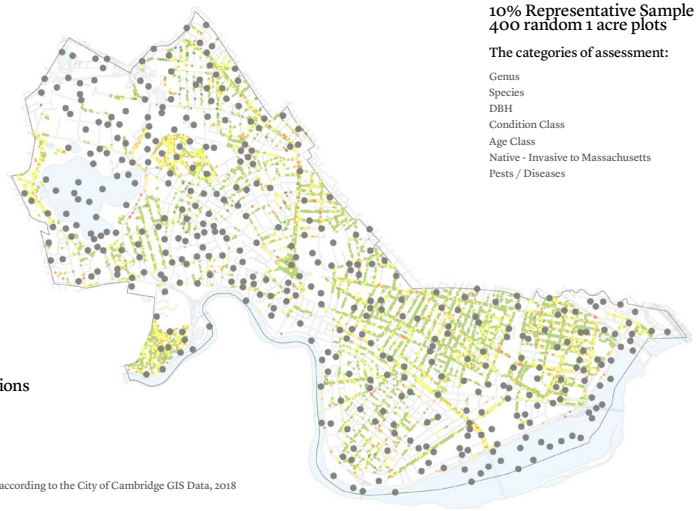
Tree Canopy Mapping
Source: AES



Tree Health Conditions
- Good
- Fair
- Poor
- Dead

Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

STATE OF THE URBAN FOREST | HEALTH OF ALL TREES



10% Representative Sample Plots
400 random 1 acre plots

The categories of assessment:

Genus
Species
DBH
Condition Class
Age Class
Native - Invasive to Massachusetts
Pests / Diseases

Tree Health Conditions

- Good
- Fair
- Poor
- Dead

Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

STUDY QUESTIONS | PRACTICE

how is the forest maintained and managed?

PRACTICE | ARBORICULTURE

Healthy and stressed trees

Tree assessment

PRACTICE | SOILS MANAGEMENT

Tree soils section / axonometric view

Soil sample analysis

STUDY QUESTIONS | ADVOCACY

how could we generate an impact through policy and engagement?

ADVOCACY | POLICY

Chapter 8.66 - TREE PROTECTION

Sections:

8.66.010 - Short Title

This Chapter may be cited as the Tree Protection Ordinance of the City of Cambridge.

(1277, Added, 08/02/2004)

8.66.020 - Statement of Purpose

The City Council hereby finds that the preservation of existing trees and the promotion of new tree planting is a public purpose that protects the public health, welfare, environment and aesthetics of the City of Cambridge and its citizens.

The urban forest serves a wide variety of functions, which promote the health, safety and welfare of residents. These functions include:

(a) conserving energy, by providing shade and evaporative cooling through transpiration;
(b) improving local and global air quality by absorbing carbon dioxide and ozone, absorbing particulate matter, and producing oxygen;
(c) reducing wind speed and directing air flow;
(d) reducing noise pollution;
(e) providing habitat for birds, small mammals, and other wildlife;
(f) reducing storm runoff and the potential for soil erosion;
(g) increasing real property values; and
(h) enhancing visual and aesthetic qualities that attract visitors and businesses.

Significant Trees. Any tree or trees larger that 8" DBH which is on a lot or which has been removed from the lot within one year prior to the submission of a Tree Study to the City Arborist.

Tree Protection Plan. This plan may be either a separate drawing or part of a landscape plan, and shall include the following information:

a) Drawings of tree protection measures and (i) their location on the lot, including Tree Save Areas, and the location, height and DBH of Significant Trees and an indication of which Significant Trees would remain on the site, or (ii) in the event that any Significant Trees are proposed to be removed, the location of those Significant Trees, and the location, height and DBH of Replacement Trees which are proposed to be planted on the lot if feasible, or (iii) in the event that Replacement Trees are not proposed to be planted on the lot, the total sum, as identified in the Mitigation Plan, to be paid to the City to be deposited into the Tree Replacement Fund, shall be required to be submitted together with the Tree Protection Plan;
b) A schedule for planting the proposed Replacement Trees and a representation that such trees will be inspected and, if necessary, treated by a Certified Arborist once a year for five years; and
c) Such other information as is required by the City Arborist pursuant to applicable regulations.

Tree Save Area. The area surrounding a tree which must remain undisturbed so as to prevent damage to the tree.

Tree Study. The information submitted to the City Arborist, which shall include a Tree Survey, a Tree Protection Plan, and, if applicable, a Mitigation Plan.

Tree Survey. A plan showing the location, type, height and DBH of all trees on a lot.

8.66.050 - Procedure for Large Projects

a. In any project which requires a special permit under §§ 4.26.I - 4.26.3, §19.20, §11.12.1, §11.12.2, or §11.12.3 of the Zoning Ordinance, the application for the special permit shall include a Tree Study, which shall first have been submitted to the City Arborist not less than twenty-one (21) days prior to the submission of the application for a special permit. The Tree Study shall be reviewed by the City Arborist, who shall certify that he has reviewed it, indicating whether it is complete and complies with the applicable provisions of this Chapter and regulations promulgated thereunder. The City Arborist shall refer the Tree Study with his certification and recommendations to the Planning Board, to assist the Planning Board in establishing any conditions that may be required as a result of the findings of the Tree Study in connection with the issuance of a special permit.
b. Regarding any project which includes a building of 25,000 square feet or more and which is subject to the provisions of § 19.50 of the Zoning Ordinance, the materials submitted to the Inspectional Services Department with the application for a building permit shall include a Tree Study, together with a certification from the City Arborist that the applicant has submitted the Tree Study for review to the City Arborist not less than twenty-one (21) days prior to the submission of the application for a building permit, and that the Tree Study is complete and complies with the applicable provisions of this Chapter and regulations promulgated thereunder. The owner of the lot shall be required to commit to comply with all provisions of the Tree Study and the applicable provisions of this Chapter and regulations promulgated hereunder in the application for a building permit.

(1277, Added, 08/02/2004)

8.66.060 - Tree Replacement

If Significant Trees are to be removed from a lot in connection with the development of a project subject to the provisions of this Chapter, upon approval of any project subject to the provisions of §8.66.050(a) of this Chapter by grant of a special permit from the Planning Board, or submission to the Inspectional Services Department of certification from the City Arborist under the provisions of §8.66.050(b) of this Chapter, the owner of the lot shall either plan Replacement Trees on the same lot in accordance with the schedule set forth in the Tree Study, or he shall pay the estimated cost of Replacement Trees and associated costs for the maintenance of said trees pursuant to the Mitigation Plan, if applicable, to the City to be deposited into the Tree Replacement Fund. In addition, the owner of the lot shall, prior to the issuance of a building permit, post and file a bond with the City Clerk in the amount of the total costs set forth in the Mitigation Plan, but in no event less than five thousand dollars ($5,000.00), with one or more sureties conditioned to the faithful observance of the conditions and specifications of the Tree Protection Plan and, if applicable, the Mitigation Plan.

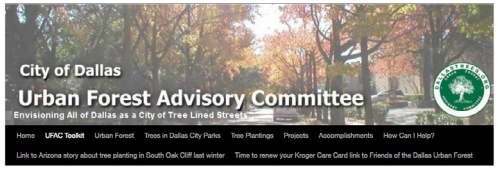
(1277, Added, 08/02/2004)

8.66.070 - Tree Replacement Fund

There is hereby established a Tree Replacement Fund which shall be held by the City Treasurer in an account and administered in accordance with applicable provisions of the General Laws. Any payments into the Tree Replacement Fund required by §8.66.060 shall be deposited in said Fund, and shall be used solely for the purpose of buying, planting and maintaining trees in the City.

Cambridge Tree Ordinance

ADVOCACY | POLICY



UFAC Toolkit

UFAC has prepared a Toolkit to assist neighborhood associations and groups interested in organizing tree planting events that qualify for free trees that may be provided through the City of Dallas MOWmentum and for the Reforestation Fund. Trees from these programs are targeted for planting in City of Dallas street medians and in the "parkway", which in most neighborhoods is the strip of grassy area between the sidewalk and the street.

TOOLKIT

In the Toolkit Table 3.1 List of Sample Forms, Letters, and Checklist consists of examples of Forms/Letters/Checklist to assist Neighborhoods to organize a tree planting project, identify volunteers and supporters, obtain and plant trees, and follow-up after the tree-planting event. These sample documents are go-by's and can to altered for your specific Neighborhood Tree Planting Project needs. Below are links to editable versions of the examples shown in the Toolkit that you can download and modify.

Coming Events

- June 19, 2018
  - UFAC Meeting at 6:00 pm

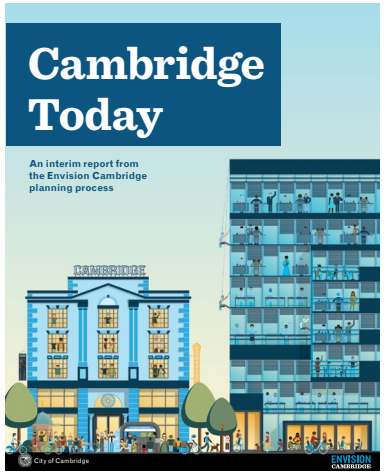
UFAC on Facebook

Helpful Links

1. Dallas City Arborist
2. TAMU Tree Guide
3. UFAC Tree Guide
4. MOWmentum Program
5. UFAC Bulletin
6. UFAC BOLETIN INFORMATIVO
7. Planting & caring for trees in your yard
8. Plantación y cuidado de los árboles de su jardín
9. Alliance for Community Trees
10. Turtle Creek Park Study
11. Texas Forest Service

City of Dallas Urban forest Policies

ADVOCACY | ENGAGEMENT



STUDY QUESTIONS | FUTURE RISK

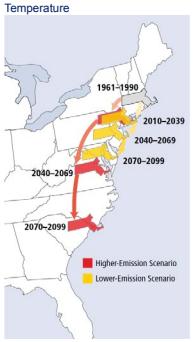
what are the risks to the urban forest?

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN

RISK | CLIMATE CHANGE

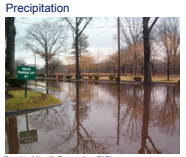
Climate Projections & Key Impacts

Temperature



Source: Army Corps of Engineers

Precipitation



Friends of Alewife Reservation (FAR)

More extreme events

Sea Level Rise (SLR)

Amelia Earhart Dam (Source: MAUSHarbors.com)

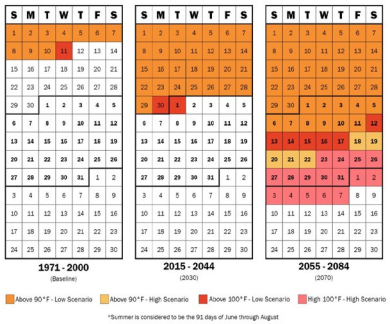
Charles River Dam (Source: New England District, US Army Corps of Engineers, 2015)

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 1 | JUNE 12, 2018 26

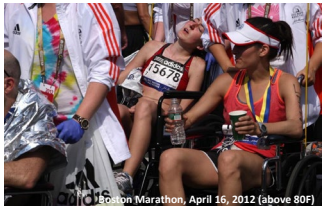
PREVIOUS STUDIES| CLIMATE PREPAREDNESS

Increasing Temperatures – Increasing Heat Vulnerability

By 2030, the number of days above 90 F could triple



*Summer is considered to be the 91 days of June through August

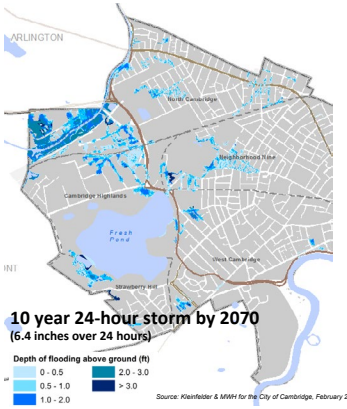


- More frequent & longer heat waves
- Temperatures exacerbated by urban heat island affect
- Extreme hot days will shift most areas from "cautious" for human health to "extreme caution"; Alewife Quad "dangerous"
- Average temps will be warmer

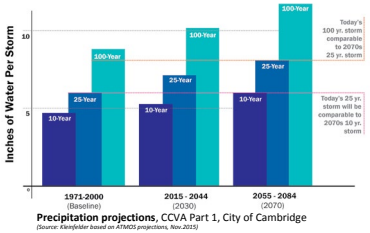
REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 1 | JUNE 12, 2018 27

RISK | CLIMATE CHANGE

Increasing Intensity of Precipitation - Flooding



Source: Kleinfelder & MWH for the City of Cambridge, February 2017

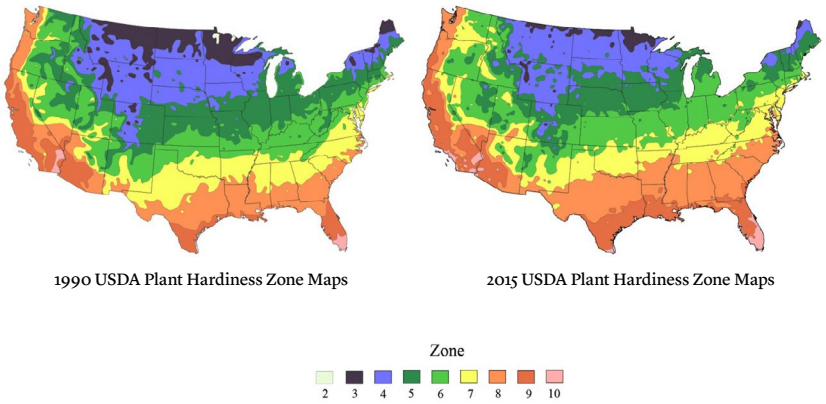


Precipitation projections, CCVA Part 1, City of Cambridge

(Source: Kleinfelder based on ATMOS projections, Nov.2015)

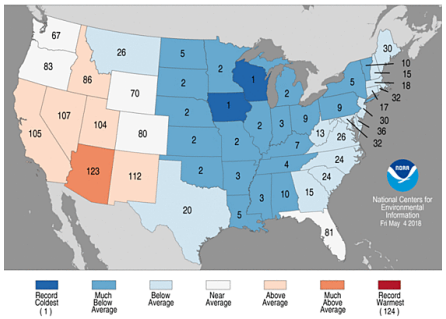
- **Rain and snow will fall harder**
- **More rain and snow in the winter and spring**
- **Overbank flooding from Alewife Brook will worsen**
- **Street flooding will worsen**

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 1 | JUNE 12, 2018 28

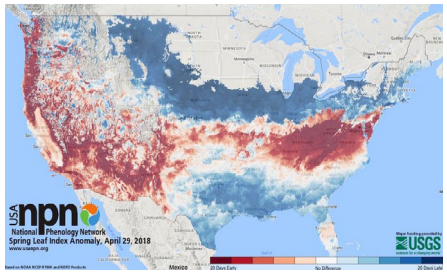


1990 USDA Plant Hardiness Zone Maps

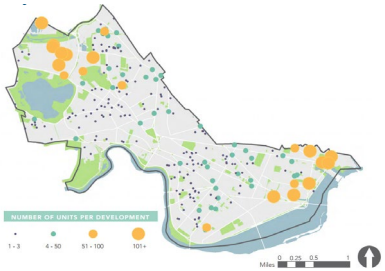
2015 USDA Plant Hardiness Zone Maps



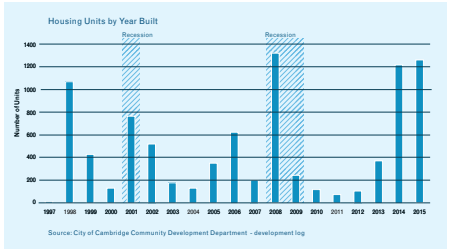
Statewide Average Temperature Ranks - April 2018
Period: 1895-2018
Source: National Center for Environmental Information



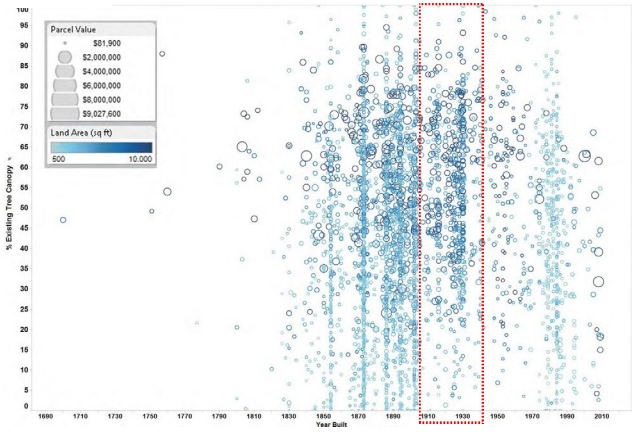
Spring Leaf Index Anomaly - April 29, 2018
Source: National Phenology Network



New Housing by Number of Units, 2010-2016
Source: Cambridge Housing Market Profile, 2016



More than 2000 new housing units were built in Cambridge between 2014-2015
Source: City of Cambridge Community Development Department; Envision Cambridge Analysis



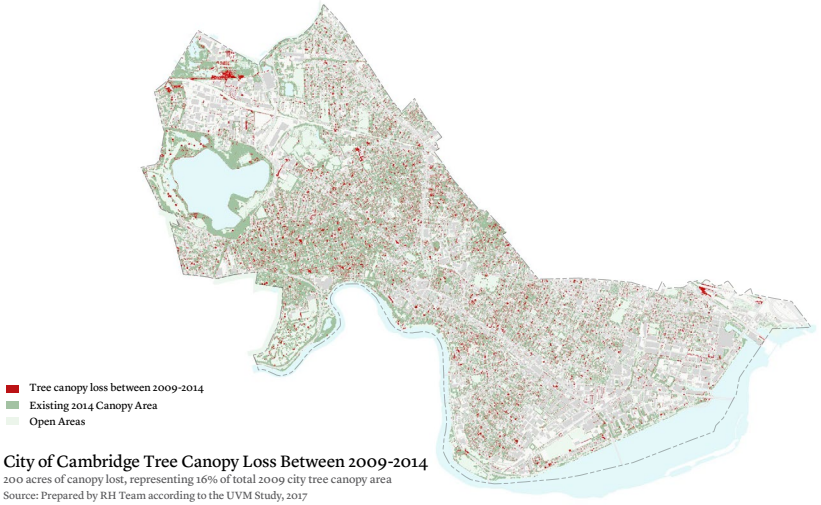
Percentage of existing tree canopy in relation to year built, parcel value and land area for single family residential parcels
Source: University of Vermont Tree Study, 2012

STUDY QUESTIONS

why act?

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN

WHY ACT | A TREND OF CANOPY LOSS

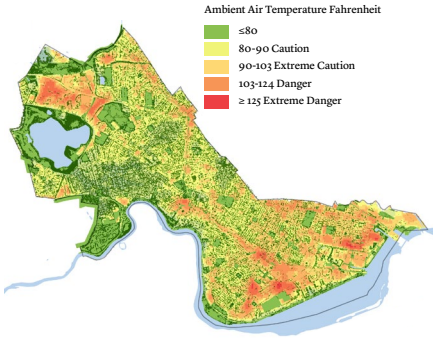


City of Cambridge Tree Canopy Loss Between 2009-2014

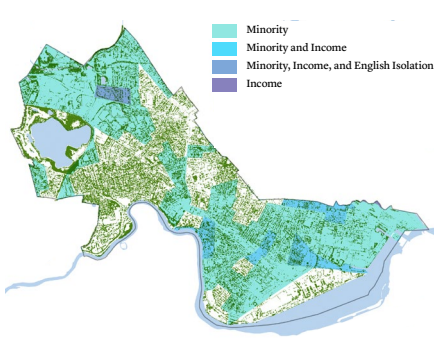
200 acres of canopy lost, representing 16% of total 2009 city tree canopy area

Source: Prepared by RH Team according to the UVM Study, 2017

WHY ACT | DISPROPORTIONATE IMPACTS

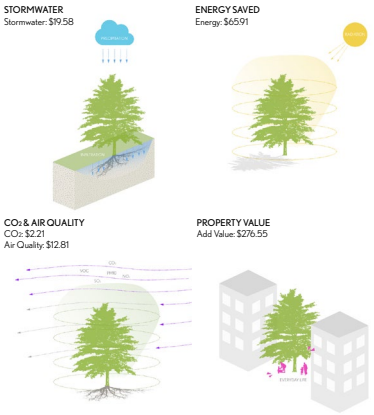


Urban heat island



Vulnerable populations

WORKING FROM DATA | QUANTIFYING THE BENEFITS OF THE URBAN FOREST



Ecosystem services for an average Pin Oak in Cambridge

Source: i-Tree Streets - Annual Savings for Average Pin Oak in Cambridge

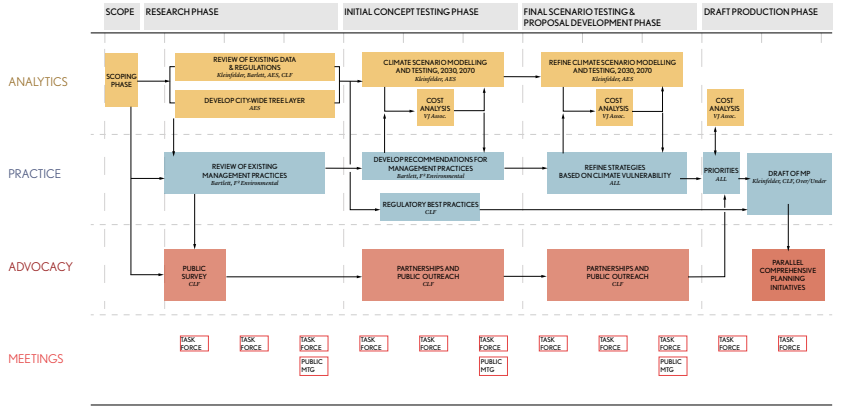
Cultural Value

STUDY QUESTIONS | MITIGATION AND EXPANSION

how do we adjust?

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN

PROCESS | OVERVIEW



REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 1 | JUNE 12, 2018 38

NEXT STEPS

Public Survey

Representative Tree Health Survey

Soils Testing

Satellite Imagery Analysis

Analysis of Best Practices

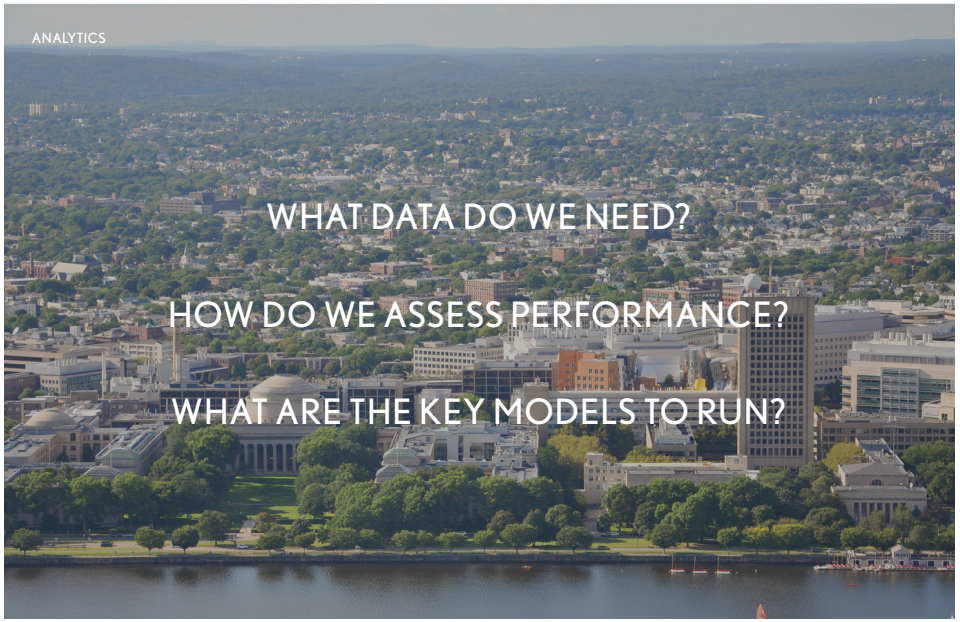
— Arboriculture

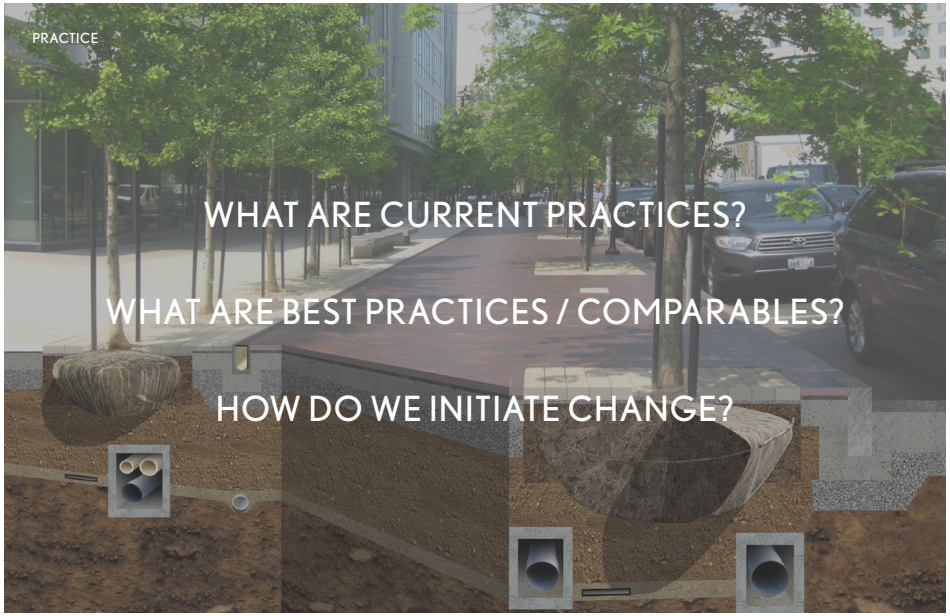
— Soils Management

— Regulation / Policy

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN

BREAK OUT GROUPS





BREAK OUT GROUPS

REPORT BACK

PUBLIC COMMENT

SCHEDULE

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulatory and Management Review
JULY 26	RESEARCH: Initial Findings
AUGUST 30	TESTING: Process and Key Questions
SEPTEMBER 27	TESTING: Baseline
OCTOBER 25	TESTING: Findings
NOVEMBER 29	PROPOSAL DEVELOPMENT:TBD
DECEMBER 20	PROPOSAL DEVELOPMENT:TBD
JANUARY 31	PROPOSAL DEVELOPMENT:TBD
FEBRUARY 28	DRAFT DOCUMENTATION: TBD
MARCH 28	DRAFT DOCUMENTATION: TBD

INTRODUCTION

PRACTICE / ARBORICULTURE

ADVOCACY / REGULATION

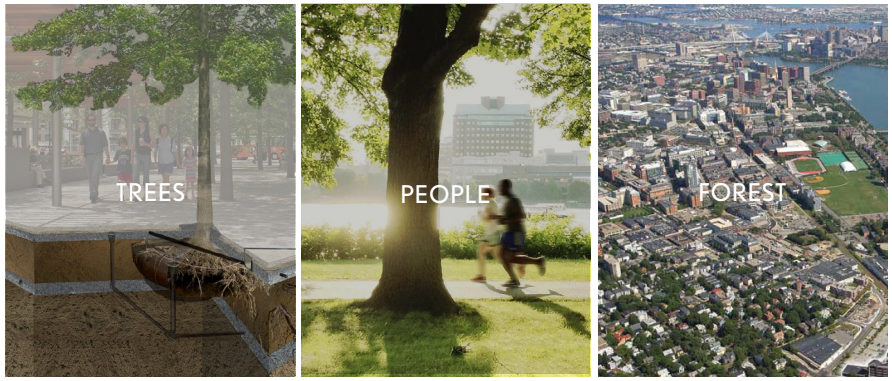
DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

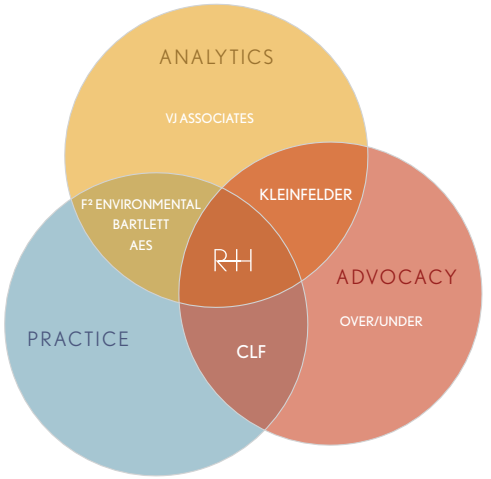
To maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.

How do we measure success?

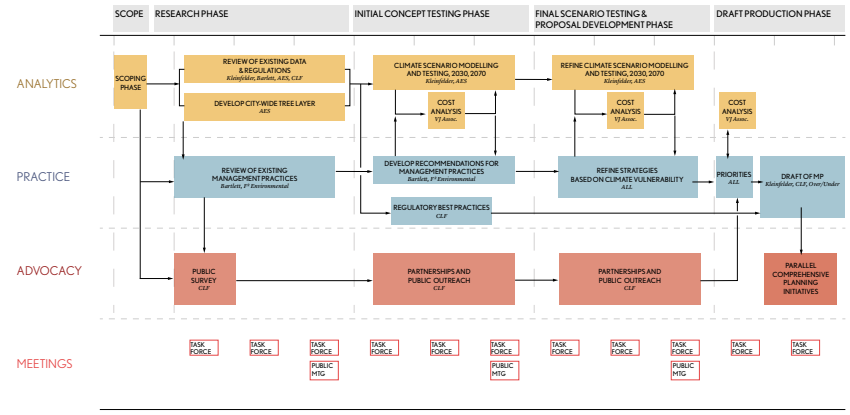
THINKING TELESCOPICALLY | MANAGING HEALTHY AND CONNECTED SYSTEMS



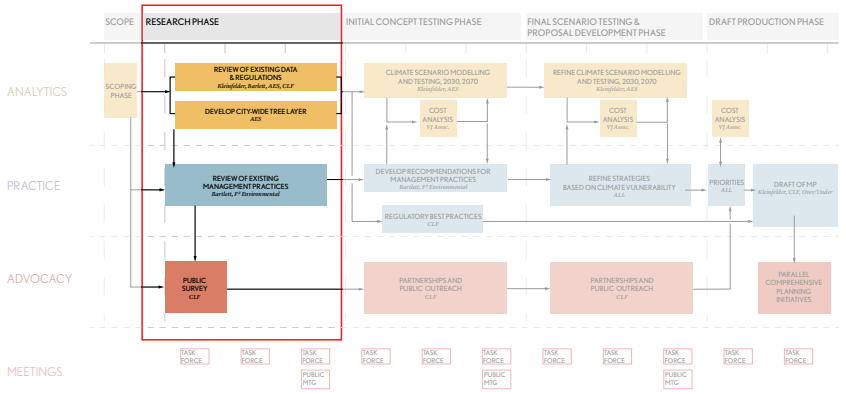
INTRODUCTION | TEAM MEMBERS



PROCESS | OVERVIEW



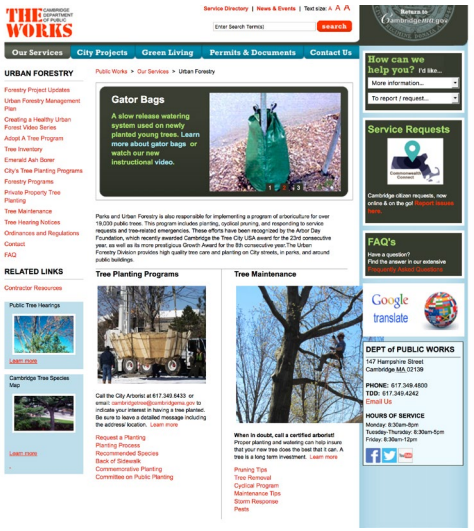
PROCESS | OVERVIEW



PRACTICE

ARBORICULTURE
ABOVE AND BELOW GROUND

PRACTICE | URBAN FORESTRY
Public Identity



PRACTICE | URBAN FORESTRY
Cambridge has a strong and growing department

— Forestry Budget: $18 per capita in 2016 and $19.75 per capita 2017. (Compare with $7.30 average per capita spending for other Tree Cities in MA)

— Today the average municipal expenditure on tree planting in U.S. is $5.83 per capita (Nature Conservancy report)

— 6 out of 8 forestry staff are certified arborists

— Forestry division growing

— Cartegraph, new Tree tracking system

TREE CITY USA®

PRACTICE | URBAN FORESTRY
Tree performance depends on management above grade and below

CURRENT PRACTICES
CHALLENGES
ADDITIONAL RESEARCH
BEST MANAGEMENT PRACTICES
OPEN QUESTIONS / NEXT STEPS

Above Ground

- Species Selection
- Pruning
- Pests & Diseases
- Tree Removal

ABOVE GROUND | SPECIES SELECTION

City of Cambridge recommends select species for new planting

Ornamental Tree (overhead wires present)	Height (feet)
Amur maackia (Maackia amurensis)	20-30
Accolade cherry (Prunus 'Accolade')	20
Akebono cherry (Prunus x yedoensis 'Akebono')	25
Autumn cherry (Prunus subhirtella 'Autumnalis')	25-40
Crabapple spp (Malus sp.)	15-25
Eastern redbud (Cercis canadensis)	20-30
Hedge Maple (Acer campestre)	25-30
Japanese tree lilac (Syringa reticulata)	20-30
Kwanzan cherry (Prunus serrulata 'Kwanzan')	25
Okame cherry (Prunus x incam 'Okame')	15-25
Paperbark maple (Acer griseum)	30
Sargent cherry (Prunus sargentii)	25-40
Serviceberry (Amelanchier sp.)	20-30
Snowgoose cherry (Prunus serrulata 'Snowgoose')	20

Shade Tree (no wires present)	Height (feet)
American elm (Ulmus americana)	50-70
Armstrong Red maple (Acer x freemanii)	50-70
Black oak (Quercus velutina)	50-60
Black tupelo (Nyssa sylvatica)	30-50
Dawn redwood (Metasequoia glyptostroboides)	75
Elm cultivars (Ulmus sp.)	40-60
Ginkgo (Gingko biloba)	40-80
Golden raintree (Koelreuteria paniculata)	30-40
Hackberry (Celtis occidentalis)	60
Honeylocust (Gleditsia triacanthos)	45-50
Hornbeam (Carpinus caroliniana)	35
Katsuratree (Cercidiphyllum japonicum)	50
Kentucky coffeetree (Gymnocladus dioicus)	75
Littleleaf linden (Tilia cordata)	45-60
London planetree (Platanus x acerifolia)	80
Pear spp (Pyrus sp.)	30-40
Pin oak (Quercus palustris)	75
Red maple (Acer rubrum)	40-70
Red oak (Quercus rubra)	75
River birch (Betula nigra)	50-70
Silver linden (Tilia tormentosa)	30-40
Sophora (Sophora (Styphnolobium) japonica)	50
Swamp White oak (Quercus bicolor)	45
Sweetgum (Liquidambar styraciflua)	65
Tuliptree (Liriodendron tulipifera)	70-90
Zelkova (Zelkova serrata)	50-70

ABOVE GROUND | PRUNING

Approach is proactive and reactive

Proactive
- 6 year street tree/8 year municipal tree rotation scheduled under contract
- Pruning contract follows American National Standard for Tree Care Operations
- Pruning around utilities - Eversource relationship

Reactive
- Hazard
- Storm damage
- Public notice

http://www.reddeer.ca/city-services/electric-light-and-power/electrical-safety-information/trees-and-power-lines/

ABOVE GROUND | PESTS + DISEASES
Existing threats are managed pro-actively

EMERALD ASH BORER

https://www.constructionspecifier.com/seeing-the-urban-forests-for-the-trees-secondary-benefits-of-our-cities-wood-2/

DUTCH ELM DISEASE

http://hvphc.com/wp/wp-content/uploads/2012/03/Dutch_Elm_Disease.jpg

ABOVE GROUND | PESTS + DISEASES
Existing threats are managed pro-actively

—Pest treatment at Fresh Pond

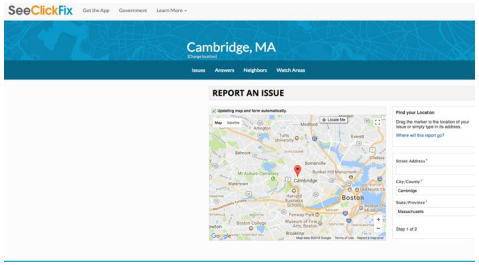
HEMLOCK WOOLY ADELGID

https://en.wikipedia.org/wiki/Adelgidae

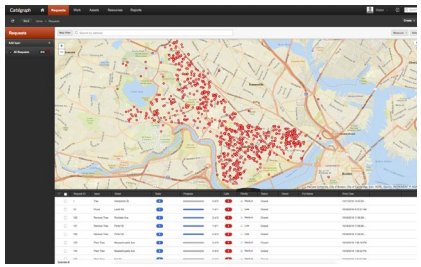
WINTER MOTH

https://www.cedarlawn.com/plant-health-care/winter-moth-control/

ABOVE GROUND | TREE REMOVALS
Removals are identified and tracked electronically



CLICK-FIX



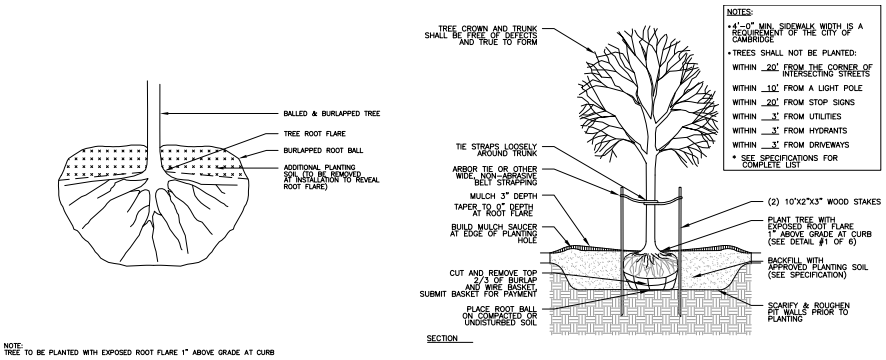
CARTEGRAPH

Below Ground

- Planting Details
- Irrigation
- Mulching
- Soil Details

PRACTICE | PLANTING DETAILS

Standard replanting: expose root flare



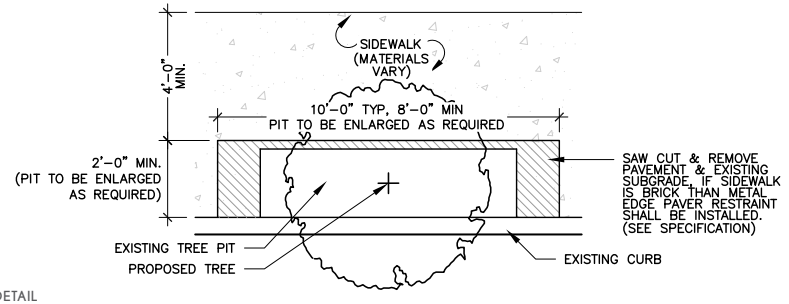
CITY PLANTING DETAIL

PRACTICE | PLANTING DETAILS

Standard replanting: mininum soil area, 48 cu ft

New standard for fall plantings

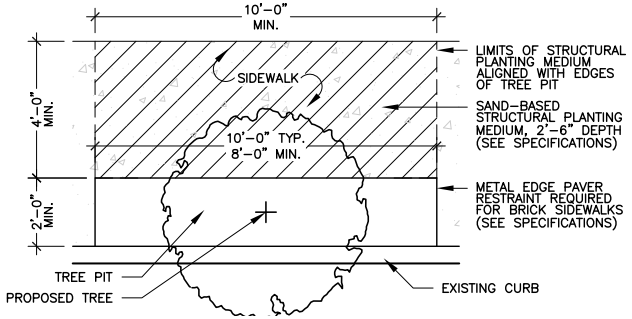
ADAAG R301.3.1 (recommended) min sidewalk pinch point of 4'



CITY PLANTING DETAIL

PRACTICE | PLANTING DETAILS

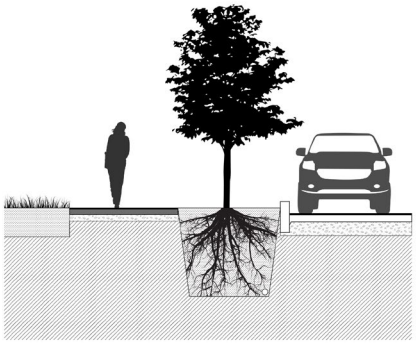
New Plantings with rebuilt sidewalk: mininum soil area 144 cu ft +



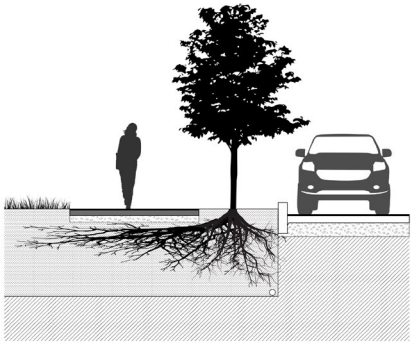
CITY PLANTING DETAIL

PRACTICE | PLANTING DETAILS

Strategies maximize soil volumes



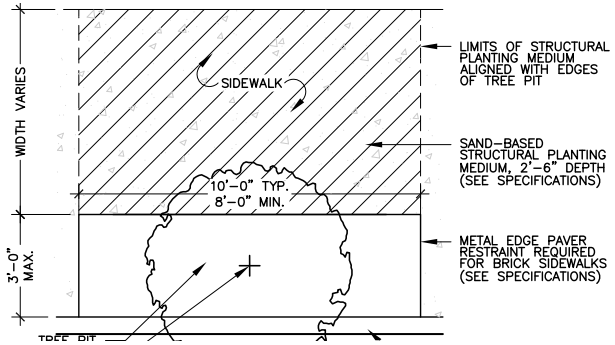
TREES CONFINED IN PITS



TREEWAYS WITH STRUCTURAL SOIL UNDER SIDEWALKS

PRACTICE | PLANTING DETAILS

New Plantings with rebuilt sidewalk: SBSS extent grows as sidewalk widens

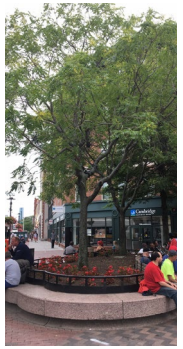


CITY PLANTING DETAIL

PRACTICE | PLANTING DETAILS – SURFACE TREATMENT

Strategies for managing access and limiting compaction

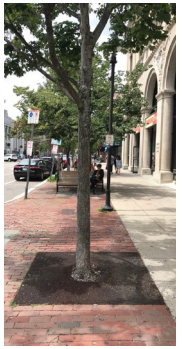
OPEN PIT



PLANTING BED

MULCH

TREE GRATE



FLEXIPAVE

PRACTICE | IRRIGATION

For establishment and maintenance

GATOR BAGS

http://www.homegardeningproducts.com/Treegator-Original-Slow-Release-Watering-Bag-98183-R_p_3.html

WATER BY BIKE PROGRAM

PRACTICE | MULCH

Performance Mulch with Organic Compost - Park trees

2.05 MULCH

A. Mulch shall be high quality, shredded or double-ground, premium bark mulch consisting of clean, organic plant material.

B. Shall be uniform in color, a good brown color. The composition of the shredded pine bark material shall not exhibit a noticeable degree of any color change characteristics when wet.

C. The mulch must be free of dirt, insects, disease and extraneous debris that would be harmful to all trees being installed.

D. The shredded pine bark mulch material shall not have an unpleasant odor.

E. Bark Mulch shall be a well-graded material conforming to the following:

1. pH between 4.0 – 8.0
2. Particle size 100% passing a 50mm (2 inch) screen
3. Soluble salt content < 4.0 mmhos/cm

F. Prior to the Contractor ordering shredded pine bark mulch material, the Contractor shall submit to the City Arborist, at the Contractor's expense, one cubic foot sample of the shredded pine bark mulch material. The Contractor shall not order any delivery of the shredded pine bark mulch material until the Contractor's sample has been inspected and approved by the City Arborist.

G. If the City Arborist disapproves of the sample submitted by the Contractor, then the Contractor shall continue at no expense to the City, to obtain other sources of pine bark mulch material as specified until the Contractor's sample of such material, meets with the City Arborist's approval.

2017 Delivered Prices

Products	Jan- March $ Per Yard	April – June $ Per Yard
Natural Hemlock Bark	$29.50	$30.00
Premium Hemlock Blend	$26.50	$27.00
Aged Hemlock	$27.00	$28.50
100% Spruce Bark (Aged)	$26.25	$26.75
Dark Pine	$24.25	$24.75
Natures Black (no dye)	$27.50	$28.50
Pitch Black (color enhanced)	$24.25	$24.75
Kidsafe Playground Chips	$22.00	$22.50
Performance Mulch (Bark/compost blend)	$25.00	$26.00
Organic Compost (certified)	$29.00	$30.00
Compost	$20.00	$21.00

Traditionally uses Compost/biosolids (sludge) 50/50

special w/ compost instead of biosolids 50/50

Call 207-232-3329

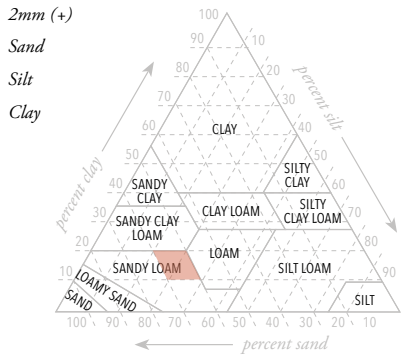
$30 CUYD DELIVERED

Loads must be delivered on or before March 31st to receive early season price.
Prices are based on full trailer loads.
COD or Terms based on credit approval. We accept Visa and MasterCard.
Past due balances over agreed terms are subject to a 1.5% per month late fee.
A fuel surcharge may apply if diesel prices reach $3.00 per gallon.

Performance Mulch w/ Organic Compost 50/50

PRACTICE | SOILS

Characterizing standard re-planting soils



2.01 PLANTING SOILS

A. Contractor shall provide all planting soil required to complete the planting operation. Planting soil shall be a natural, fertile, friable loam typical of cultivated planting soil of the locality, containing at least 10% and not more than 70% decayed organic matter (humus). Planting soil shall be free of sub-soil, stones greater than one and one-quarter inches, earth clods, sticks, stumps, clay lumps, roots, or other objectionable, extraneous matter or debris. Planting soil shall not be by test either excessively acid or alkaline nor contain toxic substances. Planting soil shall not be delivered or used for planting while in a frozen or muddy condition.

B. Soil for planting trees shall be one of the following sandy loams; "course sandy loam ", "sandy loam", and "fine sandy loam": determined by mechanical analysis (ASTM D 422) and based on the "USDA Classification System" and as defined in this Section. It shall be of uniform composition, without admixture of subsoil. Planting soil for trees shall have the following grain size distribution for material passing the #10 sieve:

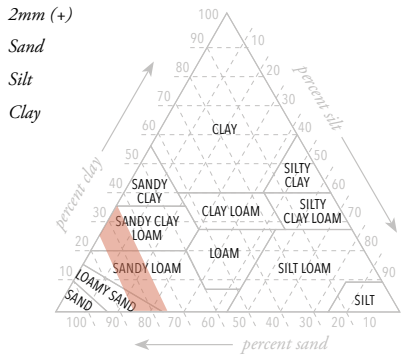
Millimeter	Percent Passing by Weight Maximum	Minimum
2	------	100
1	100	80
0.5	87	67
0.25	78	48
0.10	68	30
0.05	55	22
0.002	7	2

1. Maximum size shall be one and one quarter inches largest dimension. The maximum retained on the #10 sieve shall be 75% by weight of the total sample.
2. The ratio of the particle size for 80% passing (D_{80}) to the particle size for 30% passing (D_{30}) shall be 6.0 or less. ($D_{80}/D_{30} < 6.0$)

C. Name of planting soil supplier and sample to be approved by the City Arborist.

PRACTICE | SOILS

Characterizing sand-based structural soils



2.02 STRUCTURAL PLANTING MEDIUM ("SPM")

A. In specific areas designated in the Contract Documents the soil underlying the pavement cross section and the granular base material will be replaced with a material designed to structurally support the pavement slab and promote the root growth of street trees. This soil will be called Structural Planting Medium in this Section and shall be a mixture of Sand, Base Loam and Compost. Structural Planting Medium shall be the manufactured product of a commercial processing facility specializing in the production of manufactured soils and loam borrow. Structural Planting Medium shall be manufactured from sands, loams and compost, in accordance with the requirements of this Section. Structural Planting Medium shall be manufactured outside the Project limits and transported onto the Project for placement.

B. The Structural Planting Medium shall consist of a blend of four parts by volume of Sand, one part by volume of Planting Soil and one part by volume of Compost. Blending of the components shall be carried out with earth moving equipment prior to placement. The components shall be blended to create a uniform mixture as determined by the Owner's Representative.

C. Structural Planting Medium gradation shall be determined by the Soil and Plant Tissue Laboratory, University of Massachusetts, Amherst, using H_2O_2 to destroy organic matter. Structural Planting Medium shall conform to the following grain size distribution for material passing the #4 sieve:

U.S. Sieve No.	Percent Passing by Weight Maximum	Minimum
#4	----	100
#10	81	100
#20	57	88
#40	27	57
#100	11	24
#200	08	12
.002mm	01	02

D. Structural Planting Medium shall not contain less than 1.5 percent nor more than 3.0 percent organic matter as determined by the loss on ignition of oven-dried samples passing #10 sieve (Muffle furnace temperature: 450 +/- 10 degrees C for 8 hours).

E. The acidity range of the Structural Planting Medium shall be pH 5.5 to 6.5. Structural Planting Medium shall have a starting pH of no lower than 5.0 at the manufacturing site.

F. Structural planting medium shall be pH adjusted as required for planting of trees and shall be adjusted prior to delivery to the Project sites in accordance with recommendations by UMASS Soil & Plant Tissue Laboratory.

1. When pH of loam borrow is equal to or greater than 7 use aluminum sulfate to adjust pH downward to required levels.
2. When pH of loam borrow is less than 7 use either sulphur or ferrous sulfate to adjust pH downward to required levels.
3. When pH of loam borrow must be raised to the required levels use limestone.

CURRENT PRACTICES

CHALLENGES

ADDITIONAL RESEARCH

BEST MANAGEMENT PRACTICES

OPEN QUESTIONS / NEXT STEPS

PRACTICE | CHALLENGES

Conditions that limit health / increase mortality

Urban pressures
- Soil volume
- Utility conflicts
- Soil Compaction
- Fertility / nutrient cycling
- Gas Leaks
- Raised Fences
- Deicing Salts and Contaminants

Climate
- Moisture / drought
- Salt / pH
- Pests and Diseases

PRACTICE | BELOW GRADE – CHALLENGES
Conditions that limit health / increase mortality

MASS AVE BETWEEN HUDSON ST AND SHEPARD ST

MASS AVE BETWEEN MARTIN ST AND HUDSON ST

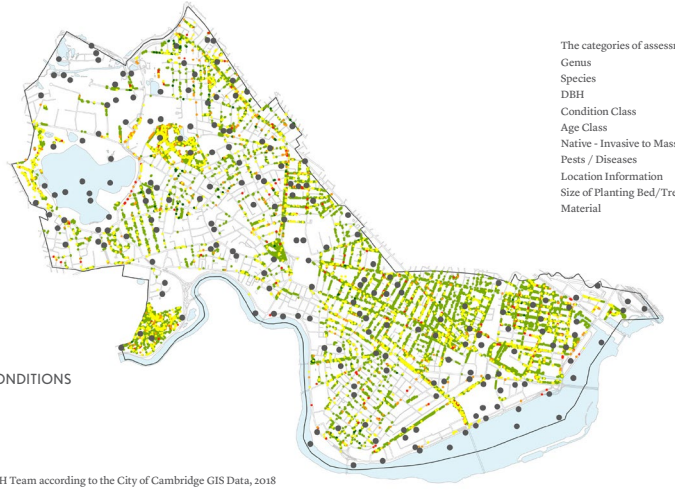
EXETER PARK TREE WELL

PRACTICE | BELOW GRADE – CHALLENGES
Conditions that limit health / increase mortality

MASS AVE BETWEEN EXETER PARK AND FOREST ST

CURRENT PRACTICES
CHALLENGES
ADDITIONAL RESEARCH
BEST MANAGEMENT PRACTICES
OPEN QUESTIONS / NEXT STEPS

RSEARCH ABOVE GROUND | SURVEY OF CURRENT CONDITIONS
200 random 1 acre plots equal a 5% representative sample



The categories of assessment:
Genus
Species
DBH
Condition Class
Age Class
Native - Invasive to Massachusetts
Pests / Diseases
Location Information
Size of Planting Bed/Tree Pit
Material

TREE HEALTH CONDITIONS
- Good
- Fair
- Poor
- Dead

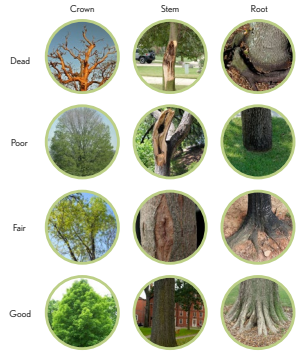
Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

RESEARCH ABOVE GROUND | SURVEY OF CURRENT CONDITIONS

Standard health metrics will be used

	Dead	Poor	Fair	Good
Tree Condition	tree is completely dead	Most of the canopy is affected with dieback undesirable leaf color, leaf size and new growth. Parts of the tree are in the process of failure.	Parts of the canopy undesirable leaf color, leaf size and new growth. Tree or parts of the tree are likely to fail.	Tree health and condition is acceptable

EXAMPLES OF TREE CONDITIONS:



BEST PRACTICES | DOCUMENTATION

CITY CURRENTLY COLLECTS

- Genus/ Species/Common Name
- Diameter (diameter at breast height, DBH)
- Tree Condition
- Neighborhood
- Created
- Creator

BARTLETT NEEDS AS REQUIRED

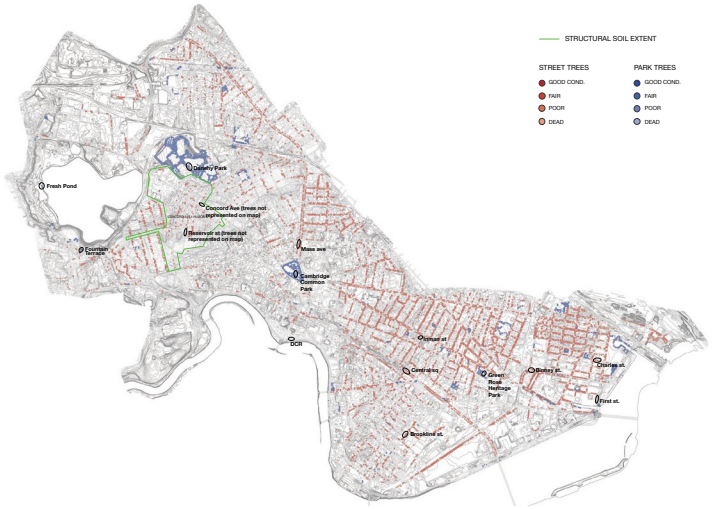
- Species Code
- Native to Massachusetts
- Invasive to Massachusetts
- Pests / Diseases

BARTLETT RECOMMENDS

- Location
- Street Name
- Street Number
- Diameter Measurement Height
- Trunks
- Age Class
- Canopy Radius
- Height Class
- Root Zone Infringement
- Tree Maintenance Activities and Priorities
- Tree Risk Assessment
- Tree Defects / Concerns
- Modified Date
- Planting Date
- Ecosystem Services Quantification

RESEACH PRACTICE | SOIL SURVEY

A representative sample to assess city soils



RESEACH PRACTICE | SOIL SURVEY

A representative sample to assess city soils

RESEARCH PRACTICE | SOIL SURVEY

A protocol that tests at three depths and for biology, chemistry and texture

0” - 12” biological analysis

textural and chemical analysis

12” - 24” textural and chemical analysis

24” - 36” textural and chemical analysis

CURRENT PRACTICES

CHALLENGES

ADDITIONAL RESEARCH

BEST MANAGEMENT PRACTICES

OPEN QUESTIONS / NEXT STEPS

BEST PRACTICES | TREE CARE

TREE SUPPORT SYSTEMS

—are used to help support defects or certain tree conditions that could lead to failure.

ROOT DEFECTS

— proactive response to potential long-term issues

LIGHTNING PROTECTION

—a preferred path to the ground for lightning (parks, cemeteries)

PROACTIVE PEST MANAGEMENT

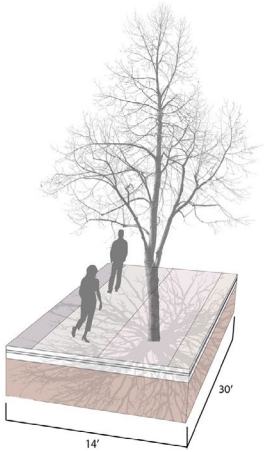
—regular monitoring including pest identification, pest population level, life stages, and techniques like regular visual inspections, using traps, phenology calendars to track life stages, monitoring key trees, etc.

RISK ASSESSMENT

—a windshield assessment for all trees once a year and after large storm events

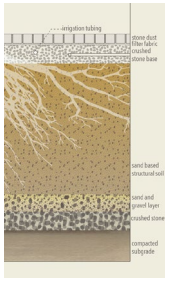
BEST PRACTICES | SOILS DETAILS

Recommended Soil Volume - 1250 cu ft per tree

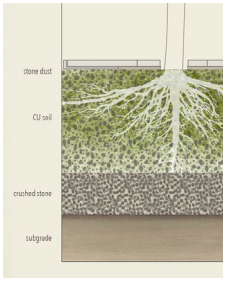


BEST PRACTICES | SOILS SPECIFICATIONS

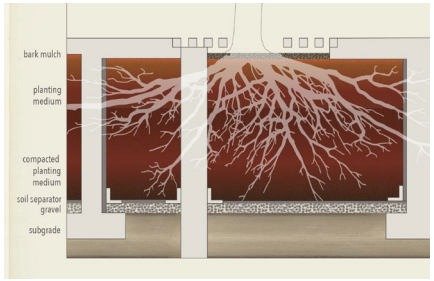
Engineered Soils — the right system in the right place



SBSS



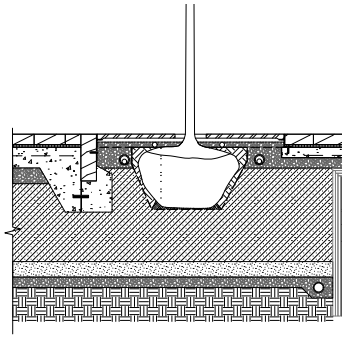
CU SOIL



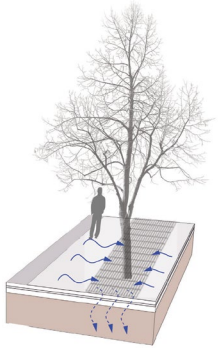
SUSPENDED PAVEMENT SYSTEMS

BEST PRACTICES | SOILS DETAILS

Absorptive ground plane



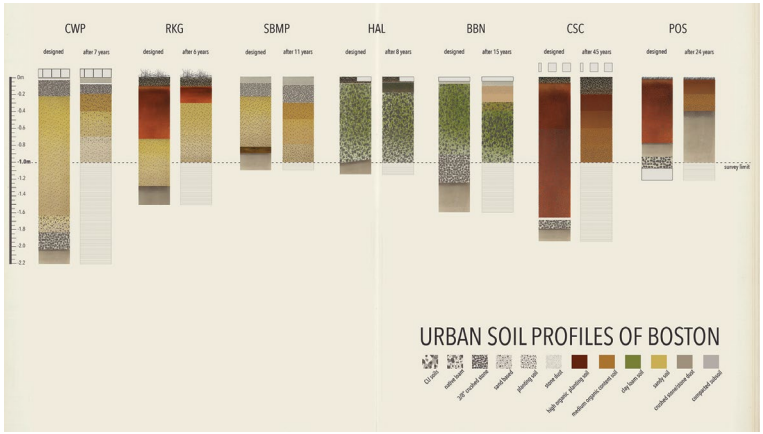
TREE GRATES



PERVIOUS PAVEMENT

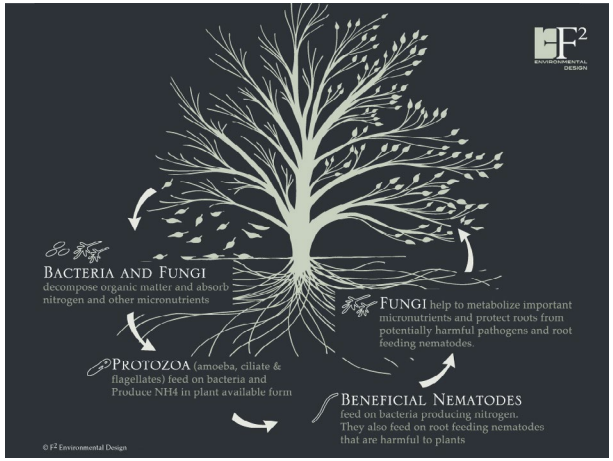
BEST PRACTICES | SOILS DETAILS

Managing moisture, compaction, and drainage



BEST PRACTICES | SOILS MANAGEMENT

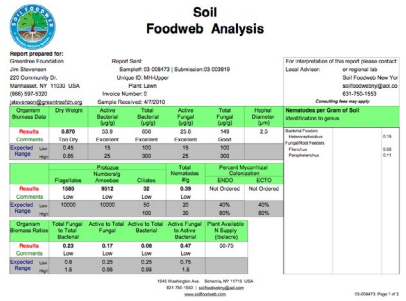
Nutrient cycling



Large scale compost systems

BATTERY PARK, NYC

Soil Testing



Soil
Foodweb Analysis

Report prepared for:
Greenhee Foundation
Jim Stevenson
220 Community Dr.
Manhasset, NY 11030 USA
(866) 597-5320
jstevenson@greenheafdn.org

Report Sent:
Sample#: 03 008473 | Submission 03 003819
Unique ID: MH-Upper
Plant: Lawn
Invoice Number: 0
Sample Received: 4/7/2010

For interpretation of this report please contact
Local Advisor:
or regional lab
Soil Foodweb New Yor
soilfoodwebny@aol.co
631-750-1553

Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacterial (ug/g)	Total Bacterial (ug/g)	Active Fungal (ug/g)	Total Fungal (ug/g)	Hyphal Diameter (um)
Results	0.870	33.9	606	23.6	149	2.5
Comments	Tree Dry	Inexistent	Inexistent	Inexistent	Good	
Expected Range Low	0.45	15	100	15	100	
Expected Range High	0.85	25	300	25	300	

Nematodes per Gram of Soil
identification to genus

Bacterial Feeders
Saprophytic Fungal/Root Feeders
Plant Parasites
Predators

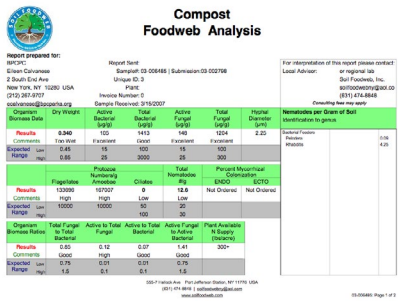
0.16
0.09
0.11

	Flagellates	Protozoa Numbers/g Amoebae	Ciliates	Total Nematodes #/g	Percent Mycorrhizal Colonization ENDO	ECTO
Results	1080	9512	32	0.39	Not Ordered	Not Ordered
Comments	Low	Low	Low	Low		
Expected Range Low	10000	10000	50	20	40%	40%
Expected Range High			100	30	80%	

Organism Biomass Ratios	Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply (Stalberg)
Results	0.23	0.17	0.08	0.47	30-70
Comments	Low	Low	Low	Low	
Expected Range Low	0.8	0.25	0.25	0.75	
Expected Range High	1.6	0.66	0.66	1.8	

1645 Washington Ave. Bohemia, NY 11716 USA
631-750-1553 | soilfoodwebny@aol.com
www.soilfoodweb.com

15-004473 Page 1 of 3



Compost
Foodweb Analysis

Report prepared for:
IBPCPC
Eileen Calvanese
2 South End Ave
New York, NY 10280 USA
(212) 267-0707
ecalvanese@bcpparks.org

Report Sent:
Sample#: 03 -006466 | Submission 03 003766
Unique ID: 3
Plant:
Invoice Number: 0
Sample Received: 3/15/2007

For interpretation of this report please contact
Local Advisor:
or regional lab
Soil Foodweb, Inc.
soilfoodwebny@aol.co
(631) 474-8648

Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacterial (ug/g)	Total Bacterial (ug/g)	Active Fungal (ug/g)	Total Fungal (ug/g)	Hyphal Diameter (um)
Results	0.240	103	1413	140	1204	2.20
Comments	Too Wet	Inexistent	Good	Inexistent	Inexistent	
Expected Range Low	0.45	15	100	15	100	
Expected Range High	0.85	25	3000	25	300	

Nematodes per Gram of Soil
identification to genus

Bacterial Feeders
Predators
Rhabditis

0.56
4.25

	Flagellates	Protozoa Numbers/g Amoebae	Ciliates	Total Nematodes #/g	Percent Mycorrhizal Colonization ENDO	ECTO
Results	130690	167007	0	12.6	Not Ordered	Not Ordered
Comments	High	High	Low	Low		
Expected Range Low	10000	10000	50	20		
Expected Range High			100	30		

Organism Biomass Ratios	Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply (Stalberg)
Results	0.85	0.12	0.07	1.41	300+
Comments	Good	High	Good	Good	
Expected Range Low	0.75	0.01	0.01	0.75	
Expected Range High	1.6	0.1	0.1	1.8	

555-7 Valley Ave Port Jefferson Station, NY 11776 USA
(631) 474-8648 | soilfoodwebny@aol.com
www.soilfoodweb.com

15-006466 Page 1 of 3

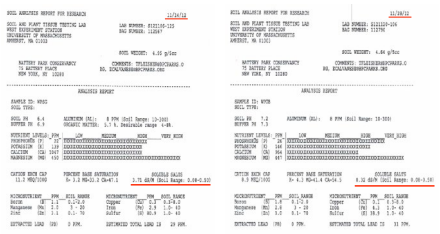
Soil Amendments - compost tea, biochar, humate, etc.

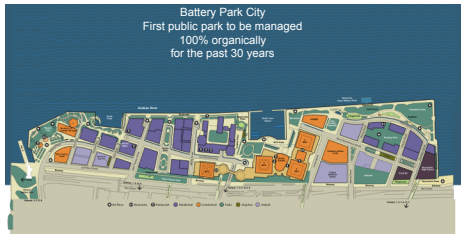
HARVARD YARD

BEST PRACTICES | SOILS MANAGEMENT
Management for inundation

BATTERY PARK, NYC

BEST PRACTICES | SOILS MANAGEMENT
Management for inundation





BEST PRACTICES | SOILS MANAGEMENT
Growth medium

BROOKLYN BRIDGE PARK

BEST PRACTICES | SOILS MANAGEMENT
Remediation for winter salt

CURRENT PRACTICES
CHALLENGES
ADDITIONAL RESEARCH
BEST MANAGEMENT PRACTICES
OPEN QUESTIONS

TREE DATABASE (Cartegraph)

— Analytics: evaluation of existing or best practices, performance over time, comparative analysis

— Feedback system for residents/ Proactive participation

FORMALIZE PRACTICES

— In house procedures

— Contracted work

BEFORE PLANTING

— Where should we plant trees? Are the conditions right? Are there alternative vegetative strategies?

— How can we manage barriers to planting? — conflict with solar access, views, etc.

— When should we be replanting, is it worth planting in tree pits or wait until sidewalk repair?

— How can we align tree selection and conditions?

DURING PLANTING

— What conditions, elements, and soil system (currently one SBSS spec) influence success?

AFTER PLANTING

— How are trees managed for establishment?

— How are trees and soils protected and nurtured over time?

— How can we respond to changing conditions (pest outbreak/drought)?

— How can we share responsibility for the urban forest?

— How can we use technology to monitor and respond pro-actively?

DISCUSSION / QUESTIONS

ADVOCACY / REGULATIONS

Deanna Moran
Conservation Law Foundation

M.G.L. Chapter 87: Shade Trees

— Applies to trees within the public right of way or within 20 feet of the public right of way with Tree Warden and Owner's consent

— Establishes powers for tree wardens

— Removal of healthy public shade trees requires advertised public hearing

— Trees that pose immediate hazards do not require a hearing to be removed

City Tree Removal Policy

City Tree Protection Ordinance
— Tree Replacement Fund
— Enforcement

City Zoning Articles 5 & 19
— Tree Study
— Tree Protection Plan

City Zoning Article 20 (Overlay Districts)
— Parkway Overlay
— Prospect Street Overlay

https://www.urbanforestprofessionals.com/wp-content/uploads/UrbanForestPro-68.jpg

Committee on Public Planting
— Advises City Council, City Manager, Public Works Commissioner, and other department heads on public planting issues

Tree Ambassador/Water by bike
— Paid summer position inspect, weed, and water young street trees via bicycle and cargo trailer

Planting Requests

— If a tree was removed from an existing well and you would like a replacement there is no expense to you

— If you'd like to have a tree planted where no tree well currently exists, the City will inspect the area and determine if it is suitable

Back of Sidewalk Program

— If a tree cannot be planted within the public right of way, the City will plant trees along the back of the sidewalk (up to 20 feet from the public way) on private property of interested, eligible owners

Adopt-a-Tree Program

— Residents commit to water and tending a tree near a specific address (home, school, business, etc.)

Commemorative Tree Program

— For cost of $200 you can receive purchase a tree in remembrance of a loved one or important event

— Evaluting barriers to buy-in/participation
  developers
  small property owners
  large private land-owners
  quasi-public and state property owners

— Assessing formal vs. informal policies

— Relationship with the state

— Cross-departmental city coordination

Feasibility Survey/Study

— Why are things working or not working

— Insights about what will be well-suited for Cambridge

— Narrowing the world of possibilities – not supporting a particular policy or proposal

https://nexusofchange.wordpress.com/2012/04/08/occupy-atlanta-surveys-public-opinion-for-better-society/

BEST PRACTICES

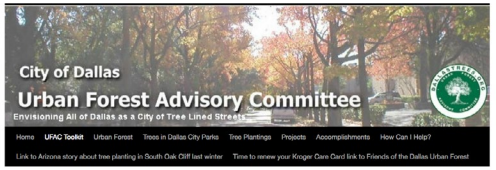
Seattle, WA
— Tree protection code
— Green Factor

Atlanta, GA
— Robust tree ordinance

Nashville, TN
— Protected trees and tree removal permits

Arlington, VA
— Subsidized plantings on private property

Dallas, TX
— Flexibility of Tree Fund



UFAC Toolkit

UFAC has prepared a Toolkit to assist neighborhood associations and groups interested in organizing tree planting events that qualify for free trees that may be provided through the City of Dallas MOWmentum and for the Reforestation Fund. Trees from these programs are targeted for planting in City of Dallas street medians and in the "parkway", which in most neighborhoods is the strip of grassy area between the sidewalk and the street.

TOOLKIT

In the Toolkit Table 3.1 List of Sample Forms, Letters, and Checklist consists of examples of Forms/Letters/Checklist to assist Neighborhoods to organize a tree planting project, identify volunteers and supporters, obtain and plant trees, and follow-up after the tree-planting event. These sample documents are go-by's and can to altered for your specific Neighborhood Tree Planting Project needs. Below are links to editable versions of the examples shown in the Toolkit that you can download and modify.

Coming Events
- June 19, 2018
  - UFAC Meeting at 6:00 pm

UFAC on Facebook

Helpful Links
1. Dallas City Arborist
2. TAMU Tree Guide
3. UFAC Tree Guide
4. MOWmentum Program
5. UFAC Bulletin
6. UFAC BOLETIN INFORMATIVO
7. Planting & caring for trees in your yard
8. Plantación y cuidado de los árboles de su jardín
9. Alliance for Community Trees
10. Turtle Creek Park Study
11. Texas Forest Service

DISCUSSION / QUESTIONS

PUBLIC COMMENT

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulatory and Management Review
JULY 26	RESEARCH: Initial Data Analysis
AUGUST 30	TESTING: Process and Key Questions
SEPTEMBER 27	TESTING: Baseline
OCTOBER 25	TESTING: Findings
NOVEMBER 29	PROPOSAL DEVELOPMENT:TBD
DECEMBER 20	PROPOSAL DEVELOPMENT:TBD
JANUARY 31	PROPOSAL DEVELOPMENT:TBD
FEBRUARY 28	DRAFT DOCUMENTATION: TBD
MARCH 28	DRAFT DOCUMENTATION: TBD
APRIL 25	DRAFT DOCUMENTATION: TBD

PROGRESS UPDATE

INITIAL SPATIAL ANALYSIS

PROJECT GOALS

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

PROGRESS UPDATE

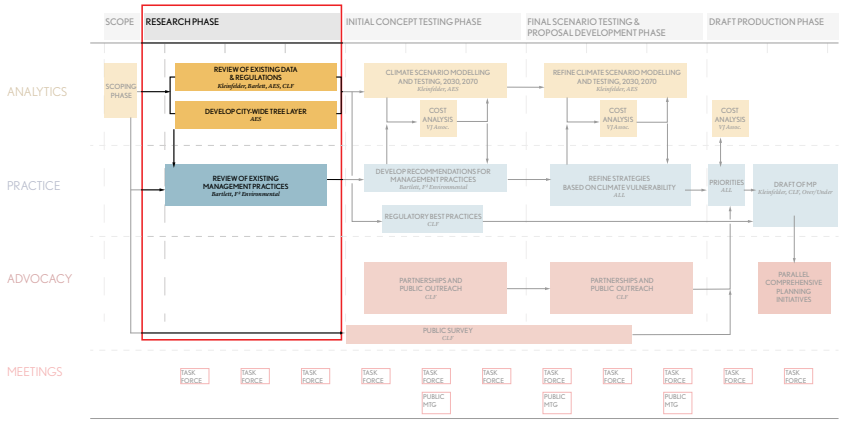
INITIAL SPATIAL ANALYSIS

PROJECT GOALS

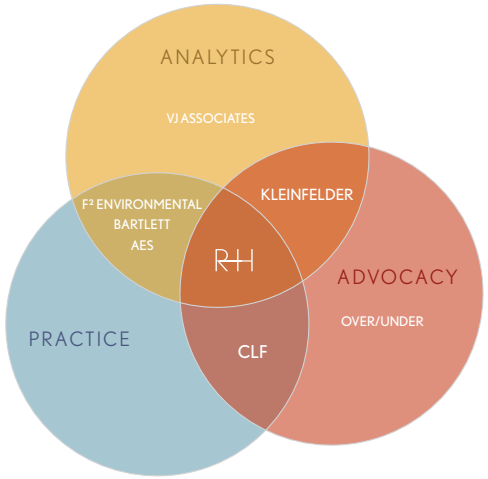
DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

SCHEDULE

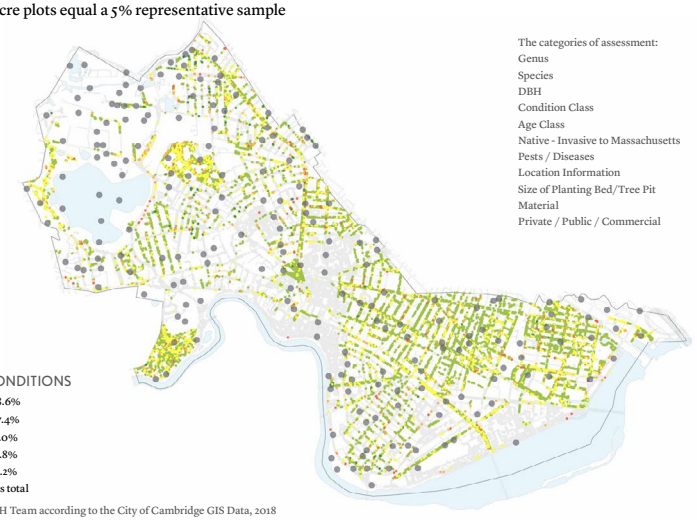


RESEARCH
Preliminary team summit — July 2018



RESEARCH
Preliminary team summit — July 2018

SURVEY OF CURRENT CANOPY
200 random 1 acre plots equal a 5% representative sample



The categories of assessment:
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Species
DBH
Condition Class
Age Class
Native - Invasive to Massachusetts
Pests / Diseases
Location Information
Size of Planting Bed/Tree Pit
Material
Private / Public / Commercial

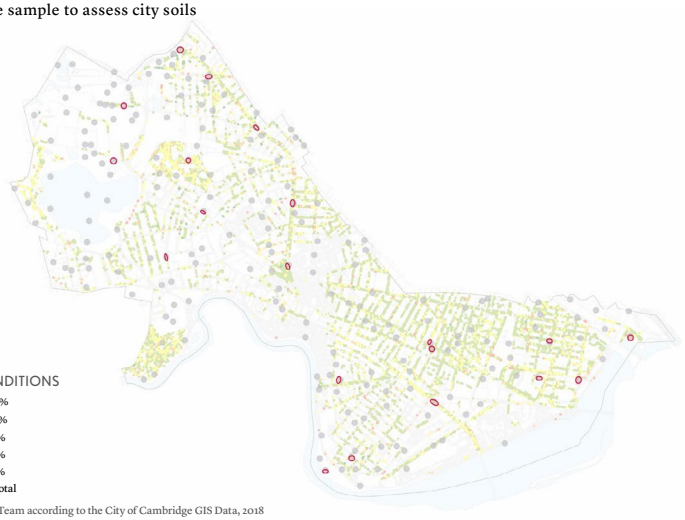
TREE HEALTH CONDITIONS

Good	28.6%
Fair	7.4%
Poor	2.0%
Dead	0.8%
No Information	61.2%

31,800 tree data points total

Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

SOIL SURVEY
A representative sample to assess city soils



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No Information	61.2%

31,800 tree data points total

Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

PROGRESS UPDATE

INITIAL SPATIAL ANALYSIS

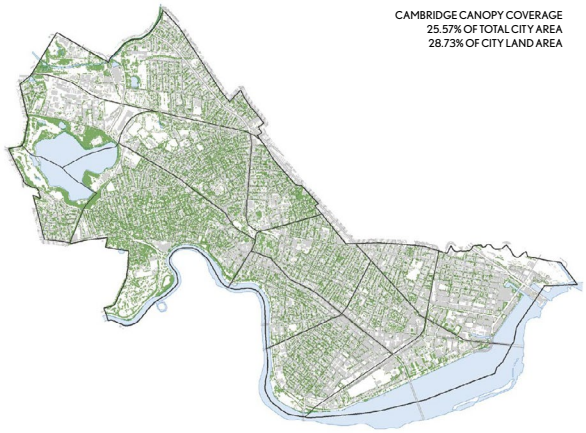
PROJECT GOALS

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

TREE CANOPY COVER

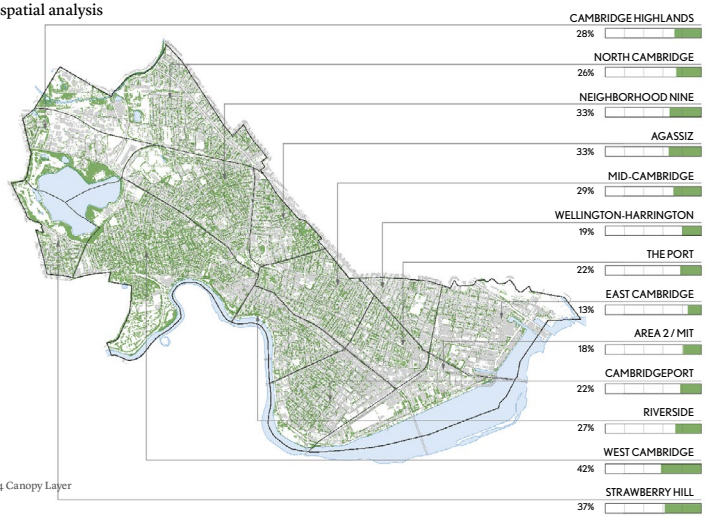
Preliminary spatial analysis



Source: UVM 2014 Canopy Layer

TREE CANOPY COVER

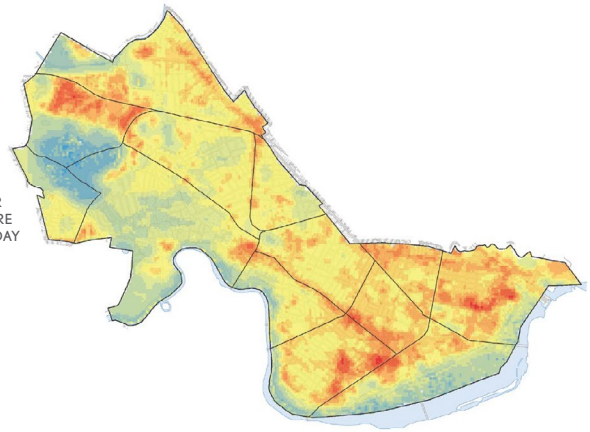
Preliminary spatial analysis



Source: UVM 2014 Canopy Layer

URBAN HEAT ISLAND

Predicted heat impacts 2070

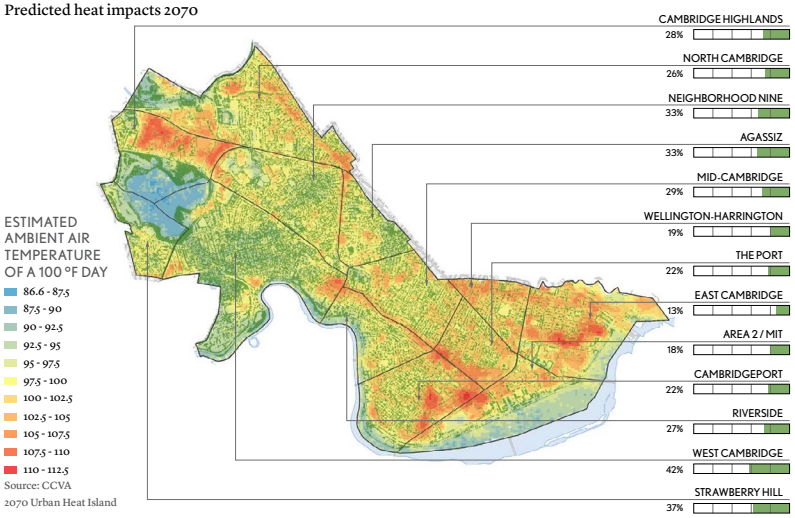


Source: CCVA

2070 Urban Heat Island

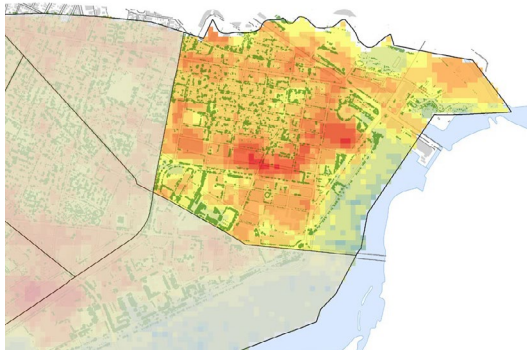
URBAN HEAT ISLAND AND CANOPY COVER

Predicted heat impacts 2070



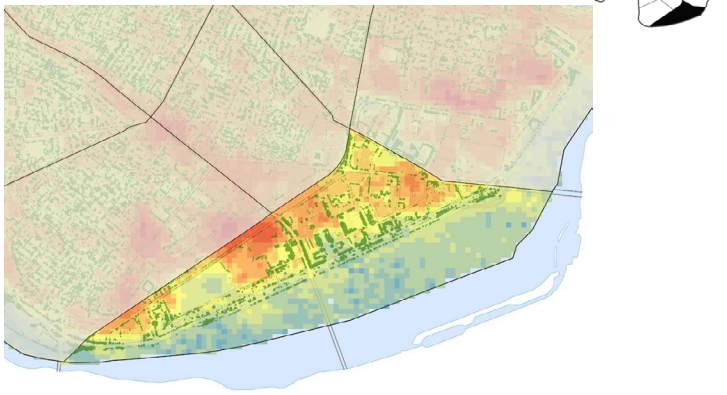
CANOPY COVER

East Cambridge — 13% Coverage



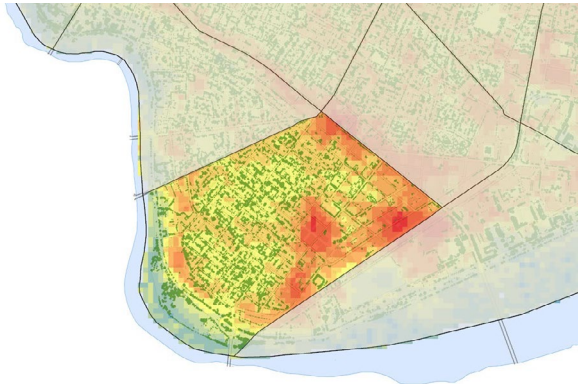
CANOPY COVER

Area 2 / MIT — 18% Coverage



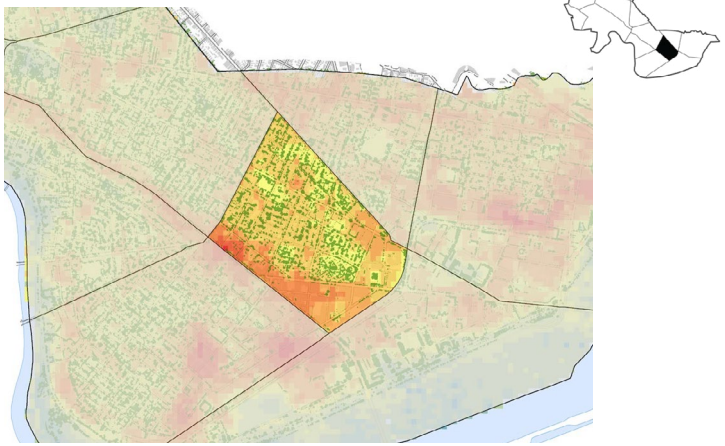
CANOPY COVER

Cambridgeport — 22% Coverage



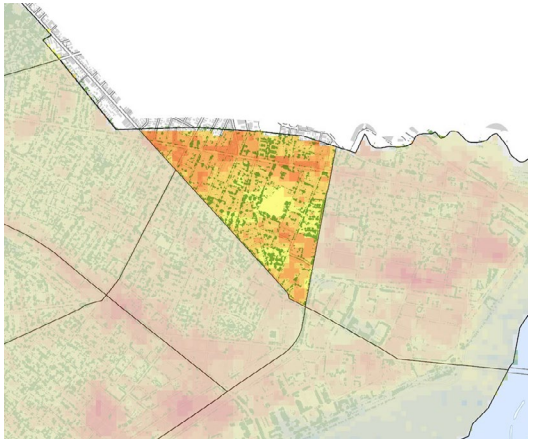
CANOPY COVER

The Port — 22% Coverage



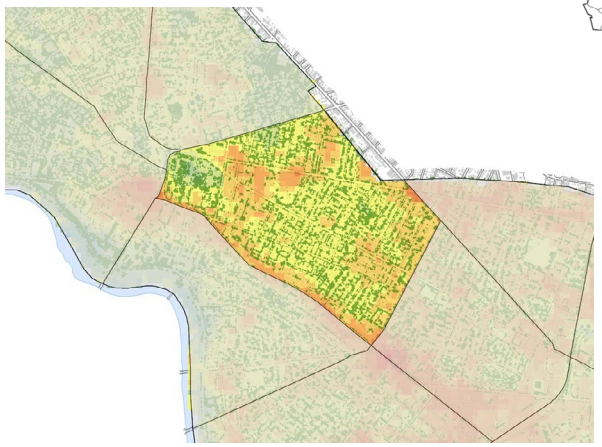
CANOPY COVER

Wellington-Harrington — 19% Coverage



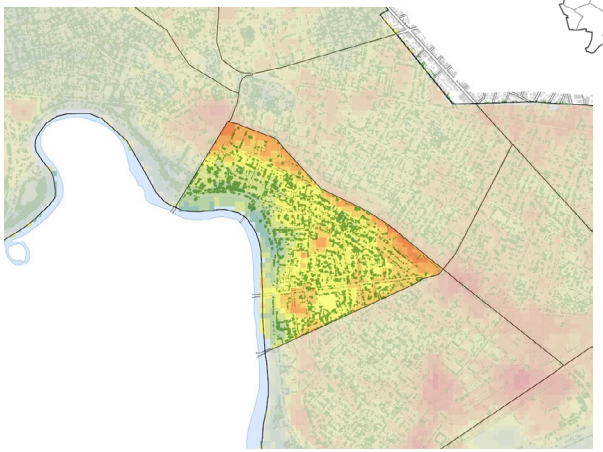
CANOPY COVER

Mid-Cambridge — 29% Coverage



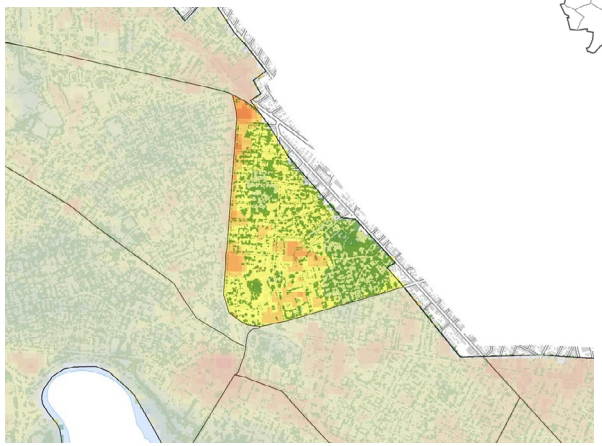
CANOPY COVER

Riverside — 27% Coverage



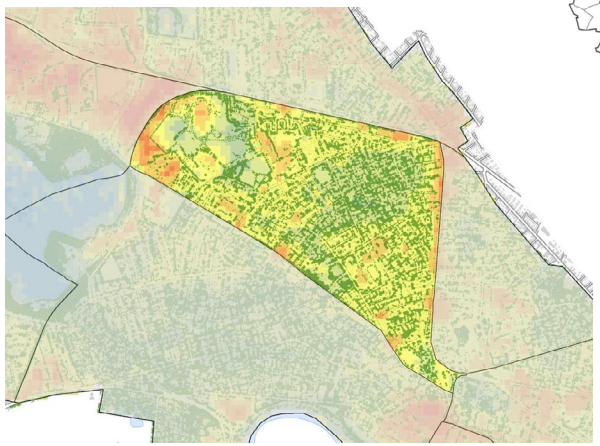
CANOPY COVER

Agassiz — 33% Coverage



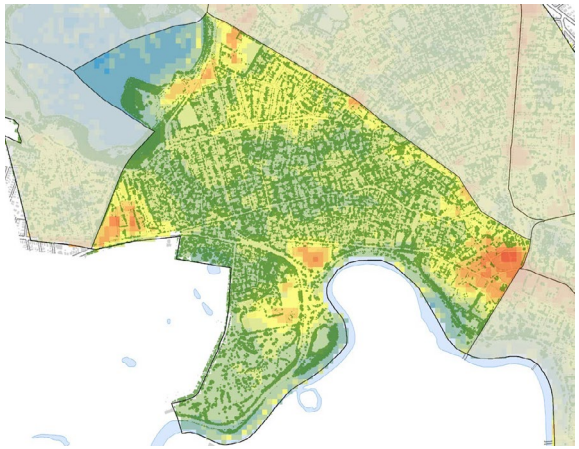
CANOPY COVER

Neighborhood Nine — 33% Coverage



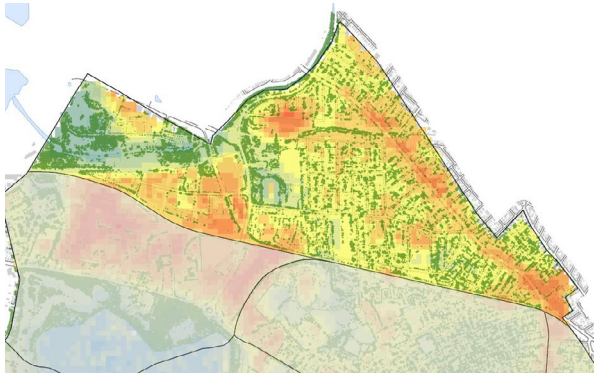
CANOPY COVER

West Cambridge — 42% Coverage



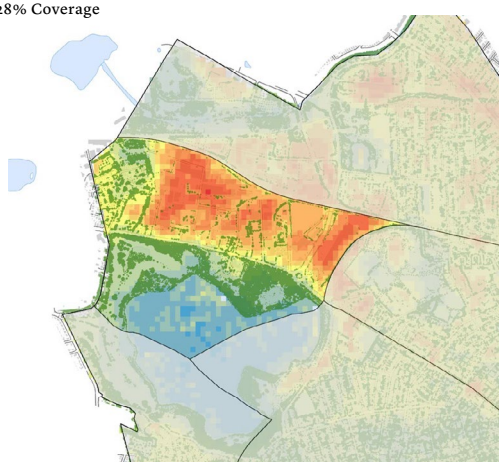
CANOPY COVER

North Cambridge — 26% Coverage



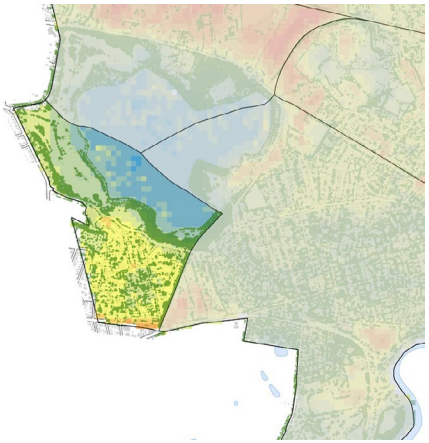
CANOPY COVER

Cambridge Highlands — 28% Coverage



CANOPY COVER

Strawberry Hill — 37% Coverage



LAND USE

Generalized land use

COMMERCIAL
MIXED USE COMMERCIAL
OFFICE
OFFICE/R&D
VACANT COMMERCIAL

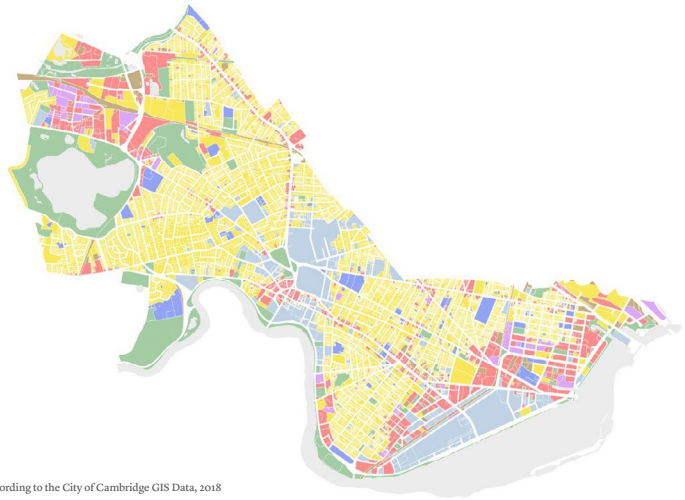
OPEN SPACE
CEMETERY
PRIVATELY-OWNED OPEN SPACE
PUBLIC OPEN SPACE

INDUSTRIAL
MIXED USE INDUSTRIAL
UTILITY
VACANT INDUSTRIAL

INSTITUTIONAL
CHARITABLE/RELIGIOUS
EDUCATION RESIDENTIAL
HEALTH
HIGHER EDUCATION
MIXED-USE EDUCATION

PUBLIC
EDUCATION
GOVERNMENT OPERATIONS

RESIDENTIAL
ASSISTED LIVING/BOARDING
MIXED USE RESIDENTIAL
VACANT RESIDENTIAL



Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

LAND USE

Generalized land use relationship to canopy cover

COMMERCIAL
MIXED USE COMMERCIAL
OFFICE
OFFICE/R&D
VACANT COMMERCIAL

OPEN SPACE
CEMETERY
PRIVATELY-OWNED OPEN SPACE
PUBLIC OPEN SPACE

INDUSTRIAL
MIXED USE INDUSTRIAL
UTILITY
VACANT INDUSTRIAL

INSTITUTIONAL
CHARITABLE/RELIGIOUS
EDUCATION RESIDENTIAL
HEALTH
HIGHER EDUCATION
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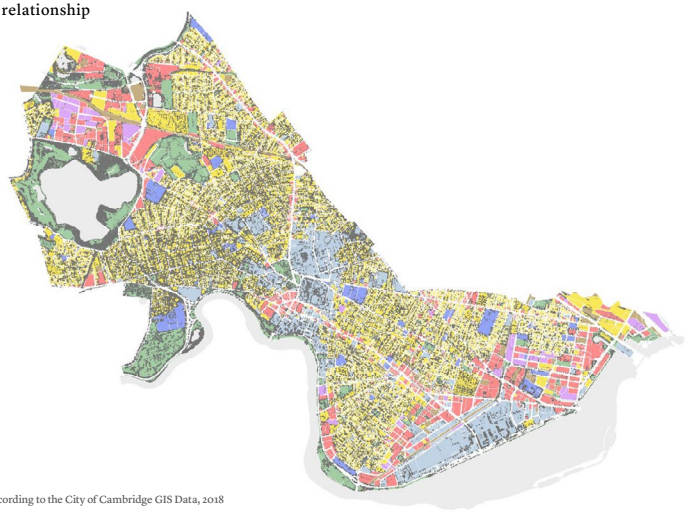
PUBLIC
EDUCATION
GOVERNMENT OPERATIONS

RESIDENTIAL
ASSISTED LIVING/BOARDING
MIXED USE RESIDENTIAL
VACANT RESIDENTIAL



Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

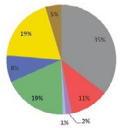
LAND USE

Generalized relationship to canopy cover - East Cambridge

13% canopy cover

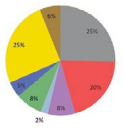
CANOPY COVER BY LAND USE

COMMERCIAL	11%
OPEN SPACE	19%
INDUSTRIAL	2%
INSTITUTIONAL	1%
PUBLIC	8%
RESIDENTIAL	19%
TRANSPORTATION	5%
R.O.W.	35%



LAND USE AS % OF NEIGHBORHOOD LAND AREA

COMMERCIAL	20%
OPEN SPACE	8%
INDUSTRIAL	28%
INSTITUTIONAL	2%
PUBLIC	5%
RESIDENTIAL	25%
TRANSPORTATION	6%
R.O.W.	25%

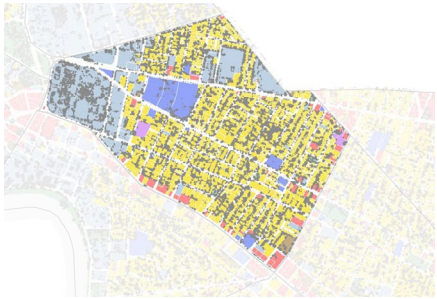


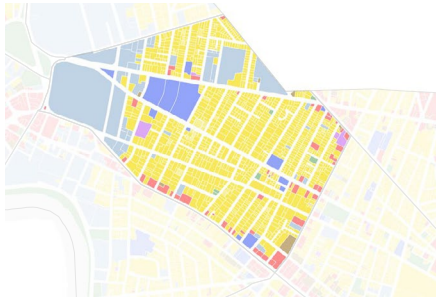
Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

LAND USE

Generalized relationship to canopy cover - Mid Cambridge

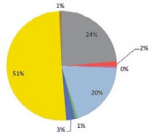
29% canopy cover





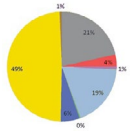
CANOPY COVER BY LAND USE

COMMERCIAL	2%
OPEN SPACE	1%
INDUSTRIAL	0%
INSTITUTIONAL	20%
PUBLIC	3%
RESIDENTIAL	51%
TRANSPORTATION	1%
R.O.W.	24%



LAND USE AS % OF NEIGHBORHOOD LAND AREA

COMMERCIAL	4%
OPEN SPACE	0%
INDUSTRIAL	1%
INSTITUTIONAL	19%
PUBLIC	6%
RESIDENTIAL	49%
TRANSPORTATION	1%
R.O.W.	21%

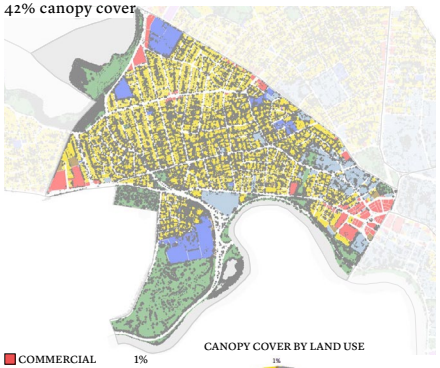


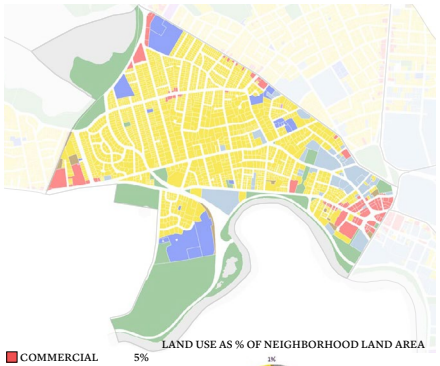
Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

LAND USE

Generalized relationship to canopy cover - West Cambridge

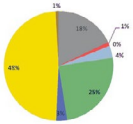
42% canopy cover





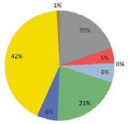
CANOPY COVER BY LAND USE

COMMERCIAL	1%
OPEN SPACE	25%
INDUSTRIAL	0%
INSTITUTIONAL	4%
PUBLIC	3%
RESIDENTIAL	48%
TRANSPORTATION	1%
R.O.W.	18%



LAND USE AS % OF NEIGHBORHOOD LAND AREA

COMMERCIAL	5%
OPEN SPACE	21%
INDUSTRIAL	0%
INSTITUTIONAL	6%
PUBLIC	6%
RESIDENTIAL	42%
TRANSPORTATION	1%
R.O.W.	20%



Source: Prepared by RH Team according to the City of Cambridge GIS Data, 2018

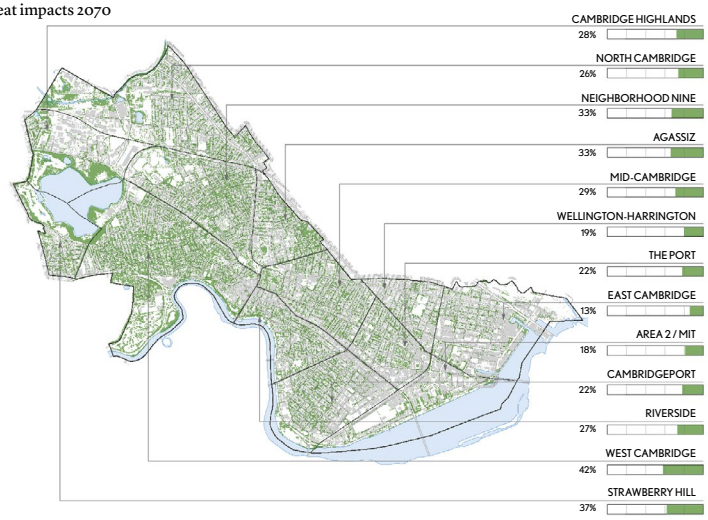
TREE CANOPY COVER

Relative change per census block between 2009 and 2014

Source: 2014 UVM Study

URBAN HEAT ISLAND AND CANOPY COVER

Predicted heat impacts 2070



PROGRESS UPDATE

INITIAL SPATIAL ANALYSIS

PROJECT GOALS

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

What is the vision?

How do we set measurable goals?

PROJECT GOALS

Initial mission statement

To maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.

PROJECT GOALS
What is the most effective metric of success?

PROJECT GOALS
Canopy cover goals for northeastern cities

CITY	% COVER FOR THE YEAR CITY'S CANOPY GOAL SET	RECENT CANOPY COVER MEASUREMENT	TARGET
CAMBRIDGE	N/A	29%	?
BOSTON	29% (2006)	27% (2017)	49% (2016)
BALTIMORE	20% (2007)	28.5% (2013)	40% (2036)
HARTFORD	25% (2013)	-	35% (ONGOING)
NEW YORK CITY	24% (2006)	20.9% (2013)	36% (2036)
PHILADELPHIA	20% (2011)	20.8% (2013)	30% (2025)

Source: D.J. Nowak et al., Environmental Pollution 178 (2013), 229-236
Leff, Michael, The Sustainable Urban Forest Guide (2016). Davey Institute.

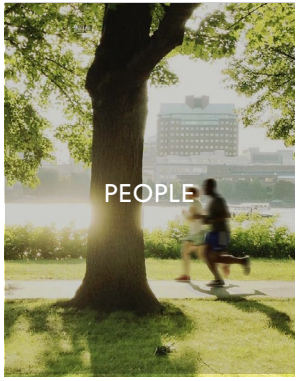
PROJECT GOALS
Relevant goals from draft of Envision Cambridge

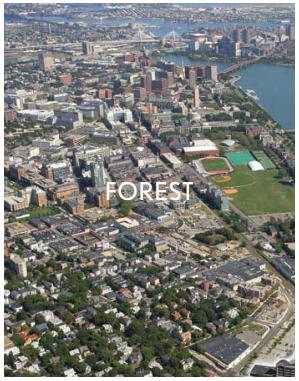
CLIMATE & ENVIRONMENT	• Protect lives and livelihoods of Cambridge community members, particularly those who are at greater risk of climate change and environmental impacts. • Maintain sustainable water resources by taking action to reduce water usage, manage stormwater runoff, and improve the quality of surface water and groundwater.
URBAN FORM	• Create a connected network of high-quality open spaces that link all residents to local and regional natural assets, that are inclusive of all people.
COMMUNITY WELLBEING	• Ensure access to resources that support health and well-being.
HOUSING	• Support high-quality housing that is healthy, climate-resilient, and energy-efficient without increasing costs for low and moderate income indicidual and families.
ECONOMY	• Support efforts to erase racial and gender disparities in economic opportunity.
MOBILITY	• Ensure that the city transportation system supports shared community spaces and enhances neighborhood streets. • Create an easy-to-understand, integrated, continuous, and comfortable transportation network

PROJECT GOALS
Relevant strategies from Draft CCPR Alewife

RESILIENT URBAN FOREST	• Reduce the urban heat island effect by increasing the urban forest canopy, developing a comprehensive urban forest management plan, and continuing urban forest maintenance efforts.
ENHANCED OUTDOOR THERMAL COMFORT	• Develop "cool corridors" aligned with bike and pedestrian routes and MBTA bus stops to enhance outdoor thermal comfot for transit users.
REDUCE IMPERVIOUS AREA	• Reduce impervious area of upstream parcels to limit flooding at downstream parcels. Evaluate the implementation of a combination of grey and green infrastructure in parcels upstreamof flood-prone areas to reduce runoff from impervious areas.
GREEN INFRASTRUCTURE OPPORTUNITIES	• Implement Green Infrastructure to improve water quality and reduce flooding impacts from smaller rainfall events and mitigate urban heat islands.

PROJECT GOALS
A layered approach to success





PROJECT GOALS
DRAFT Decision support framework

Vision	Goals		Evaluative Criteria	Baseline	2030 Target	2070 Target
To build, maintain, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.	PEOPLE: A forest that contributes to residents' well-being	Reduce urban heat island effects	Degrees above city avg			
		Enhance citywide stormwater management	Runoff volume			
		Increase equity in distribution of canopy cover	Canopy cover by vulnerable population			
		Improve air quality	Air pollutants			
		Create aesthetically pleasing streetscapes	Property value			
		Enhance pedestrian outdoor thermal comfort	Sidewalk temperatures re: city avg			
		Increase carbon sequestration	Carbon sequestration			
	TREES: A healthy forest whose trees live longer and thrive during predicted changing climate conditions	Improve soils health	Soil metric			
		Improve tree health	% trees in good health			
		Improve street tree lifespan	Avg life of street tree			
	FOREST: A forest that supports a resilient, connected ecosystem	Enhance habitat	Canopy connectivity			
		Diversify forest composition	Shannon Index			
		Plan for disaster response (noreaster, drought)	Increased disaster resiliency			

PROGRESS UPDATE
INITIAL SPATIAL ANALYSIS
PROJECT GOALS
DISCUSSION AND QUESTIONS
PUBLIC COMMENTS

PROGRESS UPDATE
INITIAL SPATIAL ANALYSIS
PROJECT GOALS
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TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Analysis and Findings
SEPTEMBER 27	TESTING: Baseline Change Model
OCTOBER 25	TESTING: Impact Analysis
NOVEMBER 29	TESTING: Impact Analysis (2)
DECEMBER 20	PROPOSAL DEVELOPMENT
JANUARY 31	PROPOSAL DEVELOPMENT
FEBRUARY 28	DRAFT DOCUMENTATION
MARCH 28	DRAFT DOCUMENTATION
APRIL 25	DRAFT DOCUMENTATION

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DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

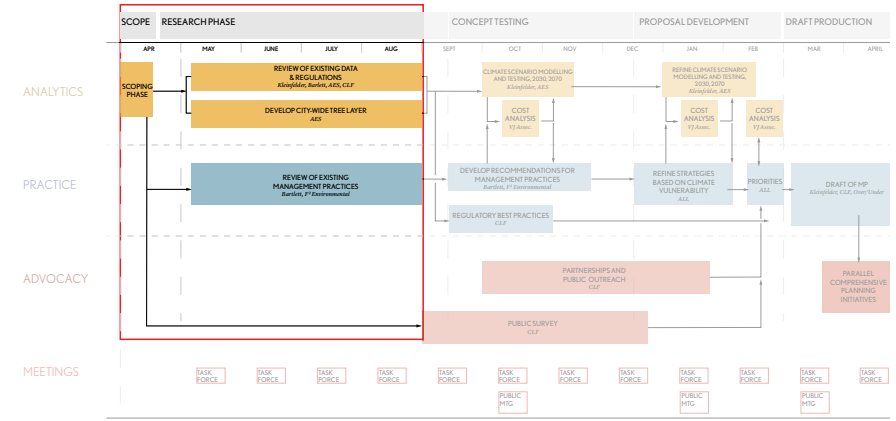
CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

SCHEDULE



REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 4 | AUGUST 30, 2018 3

DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

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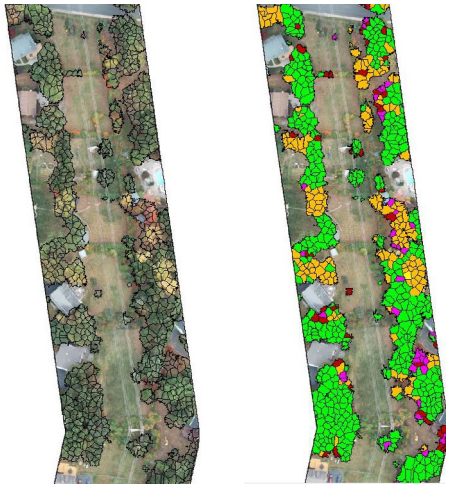
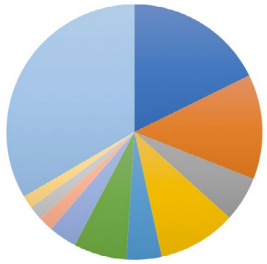
DRAFT CITY-WIDE TREE CLASSIFICATION
LIDAR analysis



Hazard Tree Classification
Species Group: Ash
Height: >20 ft
Proximity:<25 ft

Tree Canopy Mapping
Source: AES

DRAFT CITY-WIDE TREE CLASSIFICATION
Percentage of Tree Species within the Urban Forest



Norway Maple	17.70%
Honey Locust	13.28%
Red Maple	5.70%
Pin Oak	9.87%
Littleleaf Linden	4.43%
Red Oak	6.70%
Green Ash	3.56%
Elm	1.88%
London Planetree	1.79%
Sycamore	1.63%
Other	33.43

DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

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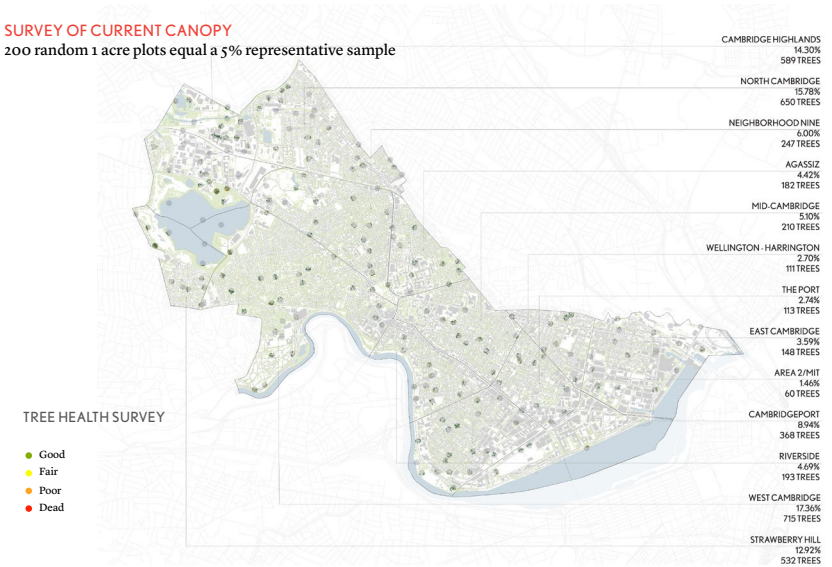
SURVEY OF CURRENT CANOPY
200 random 1 acre plots equal a 5% representative sample



TREE HEALTH SURVEY

- Good
- Fair
- Poor
- Dead

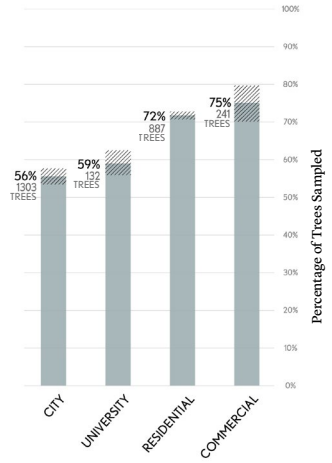
SURVEY OF CURRENT CANOPY

Summary

	Total	Percent of Total
Total Trees Inventoried:	4,118	
Number of Species:	139	
Number of Trees with Pests	80	1.94%
Location:		
Lawn	1,541	37.42%
Median	38	0.92%
Park	230	5.59%
Private	1,730	42.01%
Tree pit	579	14.06%
Material		
Compacted Soil	1,230	29.87%
Flexipave	10	0.24%
Grate	37	0.90%
Planting Bed	555	13.48%
Porous Pavement	18	0.44%
Turf	2,268	55.08%
Condition:		
Good	2,563	62.24%
Fair	1,050	25.50%
Poor	329	7.99%
Dead	176	4.27%
Age Class:		
New Planting	50	1.21%
Young	1,302	31.62%
Semi-mature	1,375	33.39%
Mature	1,358	32.98%
Over-mature	33	0.80%

TREE CONDITION

Trees on commercial and private properties have the highest percentage in good condition.
Trees on the city property have the lowest percentage in good condition.

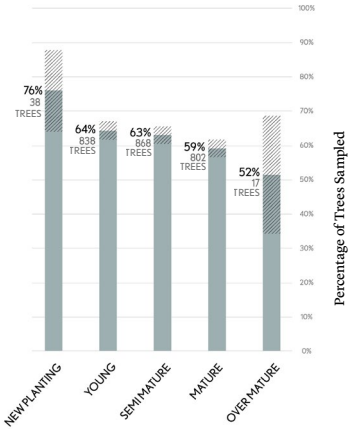


Percentage of Trees in Good Condition by General Land Use Type
95% Confidence Intervals

Source: Bartlett 2018 Tree Inventory

TREE CONDITION

The percentage of new plantings and young trees in good condition are the highest.
Only half of over-mature plantings are in good condition.

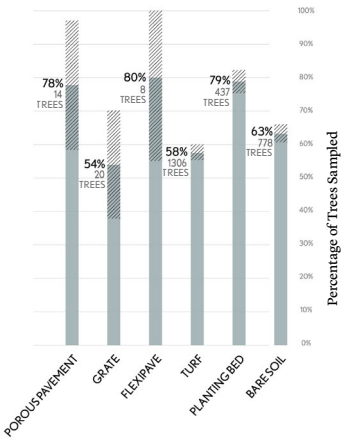


Percentage of Trees in Good Condition by Age Class
95% Confidence Intervals

Source: Bartlett 2018 Tree Inventory

TREE CONDITION

Flexipave and porous pavement had the highest percentages of good trees, but sample size is not large enought to draw conclusions. Grates had the highest percentage of dead/poor trees.

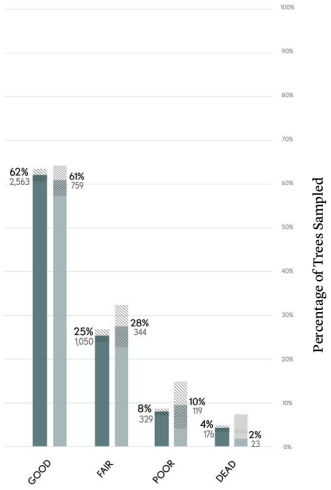


Turf = 62% Lawn (Fresh Pond Reservation)
1% Median
7% Park
28% Residential
2% Tree Pit

Percentage of Successful Trees in Different Material Conditions
95% Confidence Intervals

Source: Bartlett 2018 Tree Inventory

TREE CONDITION
Condition of Mature Trees



Condition of Trees in All Age Classes

Condition of Mature Trees

95% Confidence Intervals

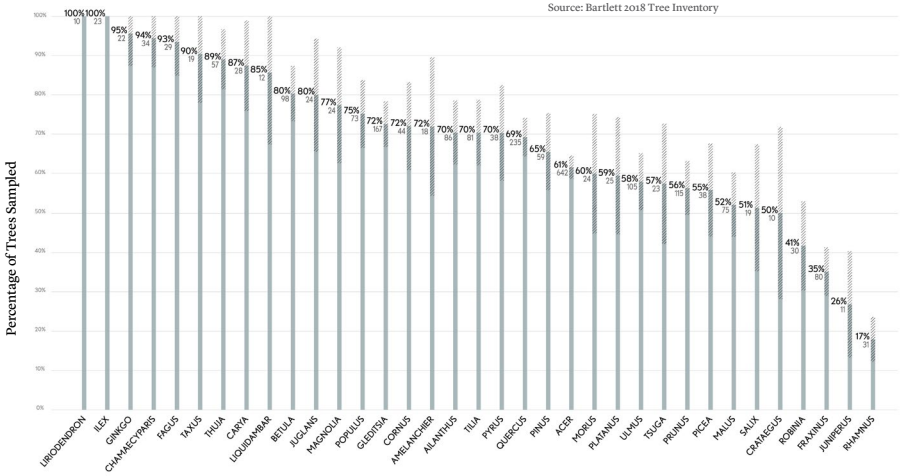
Source: Bartlett 2018 Tree Inventory

TREE CONDITION
Genus with 20 or more occurrences are shown

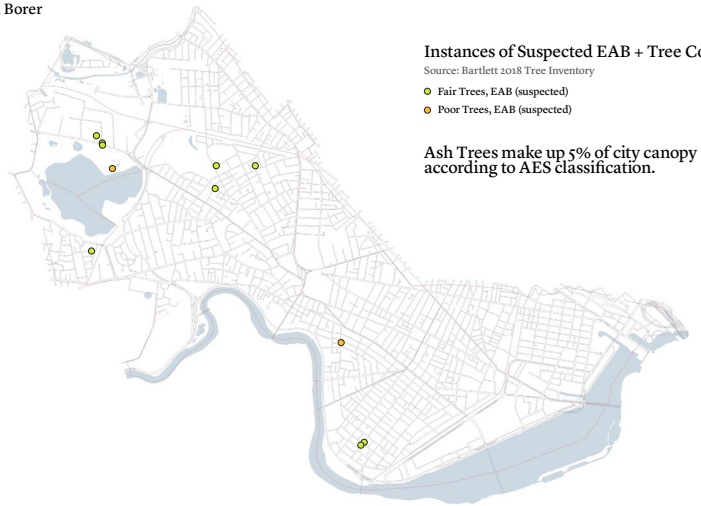
Percentage of Trees in Good Condition by Genus

95% Confidence Intervals

Source: Bartlett 2018 Tree Inventory



TREE CONDITION
Emerald Ash Borer



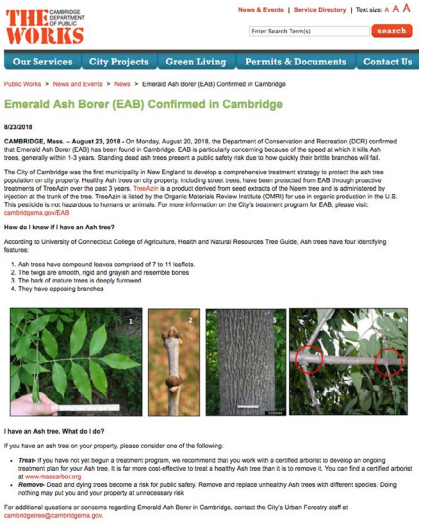
Instances of Suspected EAB + Tree Condition

Source: Bartlett 2018 Tree Inventory

- Fair Trees, EAB (suspected)
- Poor Trees, EAB (suspected)

Ash Trees make up 5% of city canopy according to AES classification.

TREE CONDITION
City of Cambridge Press Release on Emerald Ash Borer



THE WORKS — CAMBRIDGE DEPARTMENT OF PUBLIC WORKS

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Public Works > News and Events > News > Emerald Ash borer (EAB) Confirmed in Cambridge

Emerald Ash Borer (EAB) Confirmed in Cambridge

8/23/2018

CAMBRIDGE, Mass. – August 23, 2018 – On Monday, August 20, 2018, the Department of Conservation and Recreation (DCR) confirmed that Emerald Ash Borer (EAB) has been found in Cambridge. EAB is particularly concerning because of the speed at which it kills Ash trees, generally within 1-3 years. Standing dead ash trees present a public safety risk due to how quickly their brittle branches will fall.

The City of Cambridge was the first municipality in New England to develop a comprehensive treatment strategy to protect the ash tree population on city property. Healthy Ash trees on city property, including street trees, have been protected from EAB through proactive treatments of TreeAzin over the past 3 years. TreeAzin is a product derived from seed extracts of the Neem tree and is administered by injection at the trunk of the tree. TreeAzin is listed by the Organic Materials Review Institute (OMRI) for use in organic production in the U.S. This pesticide is not hazardous to humans or animals. For more information on the City's treatment program for EAB, please visit: cambridgema.gov/EAB

How do I know if I have an Ash tree?

According to University of Connecticut College of Agriculture, Health and Natural Resources Tree Guide, Ash trees have four identifying features:

1. Ash trees have compound leaves comprised of 7 to 11 leaflets.
2. The twigs are smooth, rigid and grayish and resemble bones
3. The bark of mature trees is deeply furrowed
4. They have opposing branches

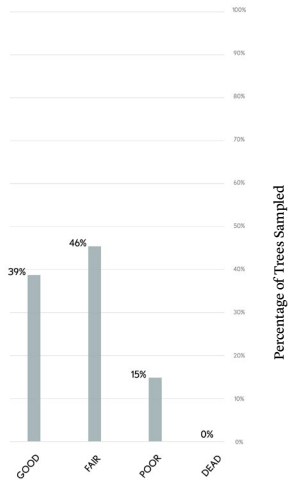
I have an Ash tree. What do I do?

If you have an ash tree on your property, please consider one of the following:

- ***Treat***- If you have not yet begun a treatment program, we recommend that you work with a certified arborist to develop an ongoing treatment plan for your Ash tree. It is far more cost-effective to treat a healthy Ash tree than it is to remove it. You can find a certified arborist at www.masarbor.org
- ***Remove***- Dead and dying trees become a risk for public safety. Remove and replace unhealthy Ash trees with different species. Doing nothing may put you and your property at unnecessary risk

For additional questions or concerns regarding Emerald Ash Borer in Cambridge, contact the City's Urban Forestry staff at cambridgetree@cambridgema.gov.

TREE CONDITION
Pests & Disease



Condition of Trees with Pests
Source: Bartlett 2018 Tree Inventory

TREE CONDITION
Pests & Disease

80 Trees (1.94% of all trees surveyed) with pests & diseases observed
Source: Bartlett 2018 Tree Inventory

Pests & Diseases
- Anthracnose
- Aphids
- Bark beetles
- Borers
- Emerald ash borer (suspected)
- Gall insects
- Leaf beetle
- Leaf scorch
- Leaf spot
- Powdery mildew
- Rust
- Scab
- Scale
- Slime flux
- Tip blight

DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

What will Cambridge's urban forest look like in 2030 and 2070 when impacted with climate change?

CLIMATE MODELING
Methodology - What data do we need?

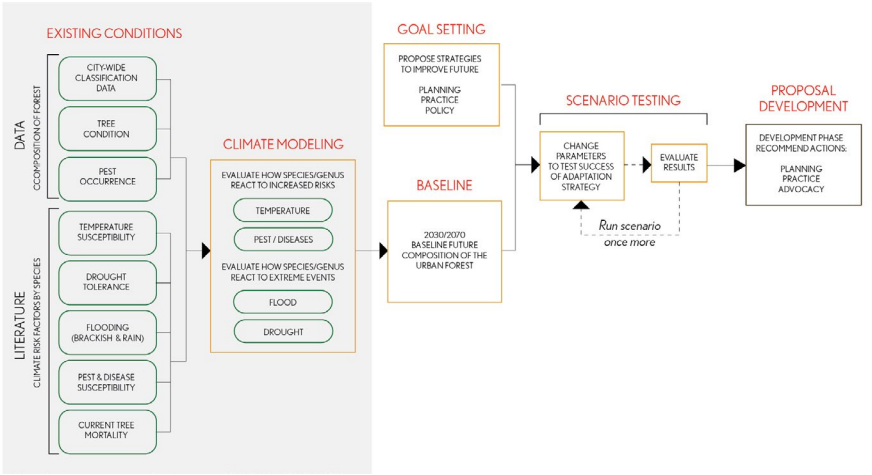
DATA

Existing urban canopy composition and condition → Baseline mortality rate

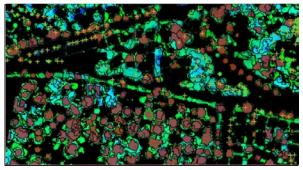
Climate assumptions/risks (CCVA/CCPR)

Species parameters → Additional mortality
-Gradual
-Extreme event

CLIMATE MODELING
Data- how does it work together?



CLIMATE MODELING
Model Inputs: Urban Forest Composition and Condition



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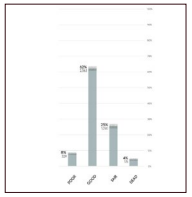


= 2018 SNAPSHOT OF CAMBRIDGE URBAN FOREST

2018 TREE CANOPY CLASSIFICATION (AERIAL IMAGERY, LIDAR, FIELDWORK): COMPOSITION

2018 5% TREE ASSESSMENT: CONDITION

CLIMATE MODELING
Baseline Mortality Rate

Urban Pressures
- Soil Volume
- Utility Conflicts
- Soil Compaction
- Fertility / nutrient cycling
- Gas Leaks
- Raised Fences
- Deicing Salts and Contaminants

Climate
- Soil Moisture / drought
- Heat Stress
- Salt / pH
- Pests and Diseases

CLIMATE MODELING
Baseline Mortality Rate

Earthwatch report survival rates:

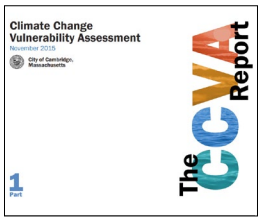
- Young trees: 96.7±1.2% (range 92.3% to 100%)
- Old trees (>10 yrs): 90.8±5.2% (range 73.0% to 99.9%)
- Best overall young trees: Callery pear, hedge maple, american elm, pin oak, leaf linden (above 98.6% survival rate)
- Best overall old trees: Honey locust, pin oak, london planetree, red maple (above 96.3% survival rate)

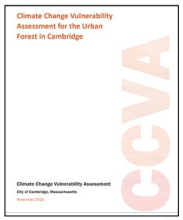
Roman and Scatena, 2011: Street tree annual survival rates ranged from 94.9 to 96.5%
Estimated mean life expectancy ranged from 19 to 28 years.

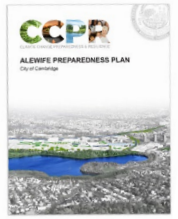
Finding Mortality Rate for Cambridge:

- Differentiate with tree condition and age?
- Differentiate between street and residential trees?

CLIMATE MODELING
Previous Climate Reports



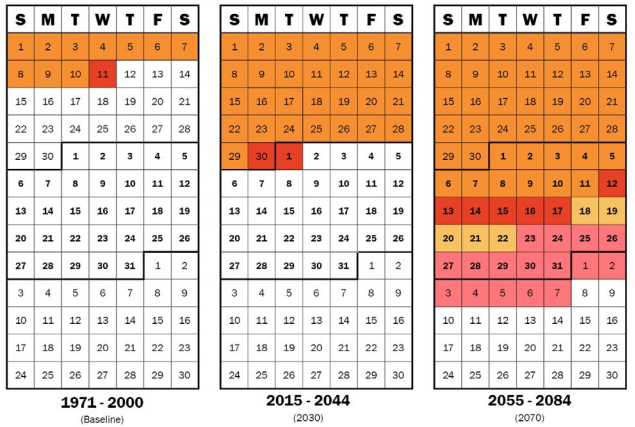




CLIMATE MODELING
Climate assumptions

Temperature Changes	Baseline 1971-2000	2030s (2015-2044) Lower	2030s (2015-2044) Higher	2070s (2055-2084) Lower	2070s (2055-2084) Higher
Annual Temperature (°F)	50	53.3	53.5	55.8	58.7
Summer Temperature (°F)	70.6	74.5	74.8	77.4	80.6
Winter Temperature (°F)	29.8	32.2	33	34.6	38
Days > 90°F (days/year)	11	29	31	47	68
Days > 100°F (days/year)	<1	2	2	6	16
Heat Index (°F)	85	94.75	96	101	115.5

CLIMATE MODELING
Climate assumptions



1. Pests and Diseases

Risk: increasing severity of existing pests & diseases

Effect on Urban Forest: species specific

PEST/DISEASE	IMPACTED SPECIES	ANNUAL LOSS RATE
WOOLLY ADELGID	HEMLOCK	X%
BLISTER RUST	WHITE PINE	X%
EAB	ASH	X%
ETC	ETC	X%

Source of Parameters: Barlett, iTree, etc.

2. Temperature Increase

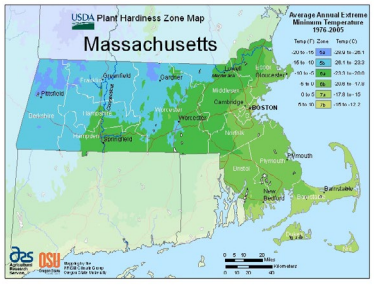
Risk: gradual increase in mean annual temperature

Effect on Urban Forest:

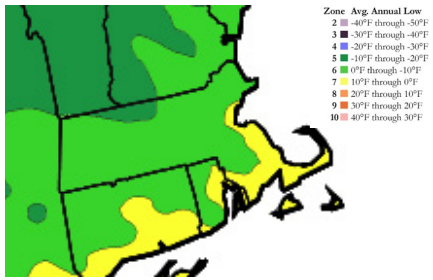
- species specific
- steady, gradual die-off of trees at south edge of range (aspen, birch, spruce, fir)
- increase in growth rate of species at center or northern edge of range (red maple, red oak, black cherry, basswood)

SPECIES	HARDINESS ZONES	ANNUAL LOSS RATE
Gleditsia triacanthos	3-8a	X%
Populus tremuloides	2-6	X%
ETC	ETC	X%

Sources of Parameters: Arbor Day Foundation, Morton Arboretum



2012 USDA ZONES



2015 ARBOR DAY FOUNDATION ZONES

1. Flooding

Risk: Greater frequency of large precipitation events

Flood Event: 10 yr 24 hr (6") storm event and/or 100 yr 24 hr (12") storm event

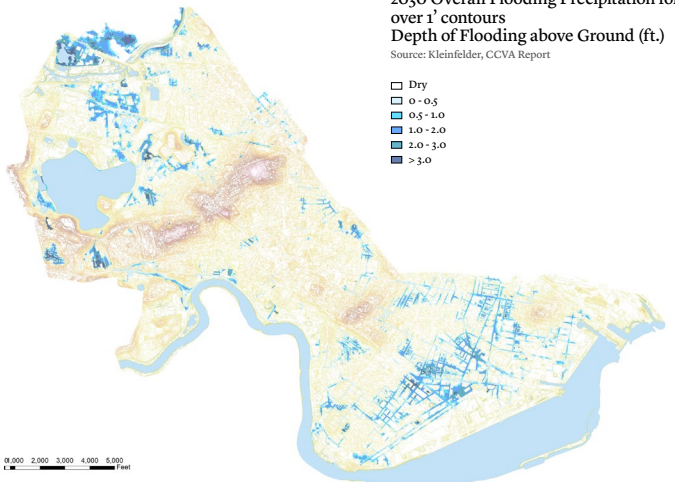
Effect on Urban Forest: in low-lying areas, intolerant trees and intermediate tolerant trees will be impacted

SPECIES	FLOOD TOLERANCE	EVENT LOSS RATE
Gleditsia triacanthos	intermediate	X%
Acer rubrum	tolerant	X%
ETC	ETC	X%

Sources of Parameters: UT Extension, USDA Field Guide, Iowa State Extension, Cornell, MSU Extension

CLIMATE MODELING

Climatic Risks - Additional Mortality - Extreme Events



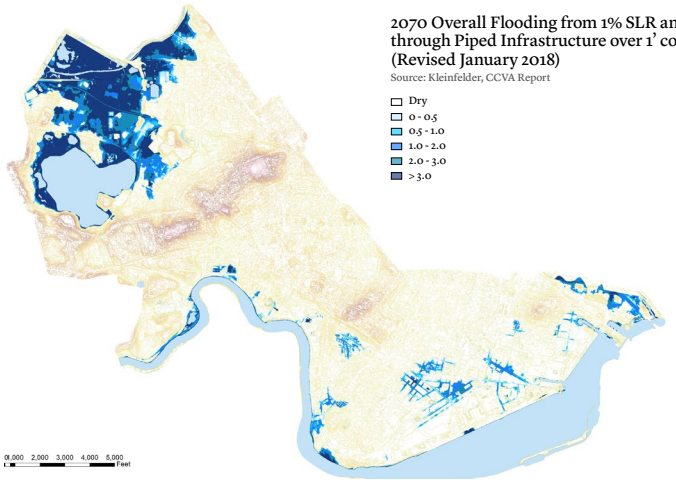
2030 Overall Flooding Precipitation for 100 year storm event over 1' contours
Depth of Flooding above Ground (ft.)

Source: Kleinfelder, CCVA Report

- Dry
- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

CLIMATE MODELING

Climatic Risks - Additional Mortality - Extreme Events



2070 Overall Flooding from 1% SLR and Storm Surge + Propagation through Piped Infrastructure over 1' contours
(Revised January 2018)

Source: Kleinfelder, CCVA Report

- Dry
- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

CLIMATE MODELING

Climatic Risks - Additional Mortality - Extreme Events

2. Heat/Drought Combination

Extreme heat event: 3+ days of > 90 degree days with moderate drought

Effect on Urban Forest:

- Winter stress to conifers at south edge of range
- Summer stress to moist-site species

SPECIES	EXTREME HEAT TOLERANCE	DROUGHT TOLERANCE	EVENT LOSS RATE
Gleditsia triacanthos	xxxxx	high	X%
Quercus palustris	xxxxx	low	X%
Etc	Etc	Etc	X%

Sources of Parameters: USDA plant profiles, Environmental Horiculture

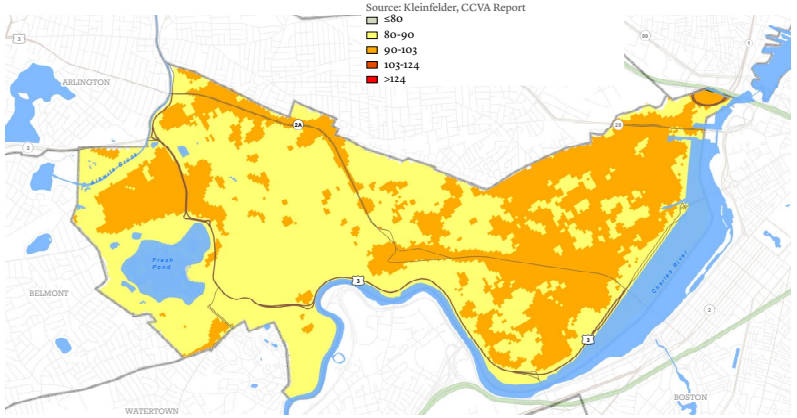
CLIMATE MODELING

Climatic Risks - Additional Mortality - Extreme Events

2030 Scenario, Ambient Air (90 °F)

Source: Kleinfelder, CCVA Report

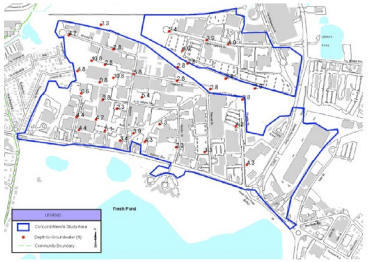
- ≤80
- 80-90
- 90-103
- 103-124
- >124



CLIMATE MODELING
Climatic Risks - Other Climate Effects

Spatial Evaluation
- wind (shallow groundwater, shallow utilities)
- salt water intrusion (flood prone)

Species Specific Evaluation
- ice storm
- extreme cold event



Shallow groundwater in Alewife/Concord area

CLIMATE MODELLING
What's Next?

How can we manage change to enable and advance larger social, spatial and performative goals?

Develop future urban canopy scenarios:
- What does the urban forest look like?
- What policies/planning efforts will be required to support these goals?
- What are the costs and benefits of these efforts?

DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

URBAN FOREST SURVEY

What are residents' perceptions about the number and health of trees in their community and the City writ-large?

What benefits do residents' believe trees in Cambridge provide?

What is the level of awareness residents' have of existing city programs (voluntary) for tree planting and maintenance?

What are residents' attitudes toward regulations, policies, and incentives for tree planting, removal, and replacement?

How do resident awareness and attitudes differ based on neighborhood and housing tenure (whether they rent or own their home)?

DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

PUBLIC MEETING COMING UP ON OCT 3

PRESENTATION OF RESEARCH: SUMMARY OF FINDINGS

DRAFT CITY-WIDE TREE CLASSIFICATION

TREE CONDITION INVENTORY

CLIMATE MODELING

URBAN FOREST SURVEY

DISCUSSION AND QUESTIONS

PUBLIC COMMENTS

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction	NOVEMBER 29	TESTING: Impact Analysis
JUNE 28	RESEARCH: Regulation and Management	DECEMBER 20	PROPOSAL DEVELOPMENT
JULY 26	RESEARCH: Goal Setting	JANUARY 31	PROPOSAL DEVELOPMENT
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling	FEBRUARY 28	DRAFT DOCUMENTATION
SEPTEMBER 27	RESEARCH: Summary of Findings	MARCH 28	DRAFT DOCUMENTATION
OCTOBER 25	TESTING: Baseline Change Model	APRIL 25	DRAFT DOCUMENTATION

www.cambridgema.gov/ufmp

OBSERVATIONS & DISCUSSION

- CANOPY COVER
- SPECIES DIVERSITY
- CANOPY EQUITY
- HUMAN EXPERIENCE

PUBLIC COMMENT

PARKING DAY

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 5 | SEPTEMBER 27, 2018 3

OBSERVATIONS & DISCUSSION

- CANOPY COVER
- SPECIES DIVERSITY
- CANOPY EQUITY
- HUMAN EXPERIENCE

PUBLIC COMMENT

OBSERVATION | CANOPY COVER

Today, Cambridge has **25.3%** of its land area covered by canopy.

Cambridge has had an average net loss of **31 acres** of canopy cover every year.

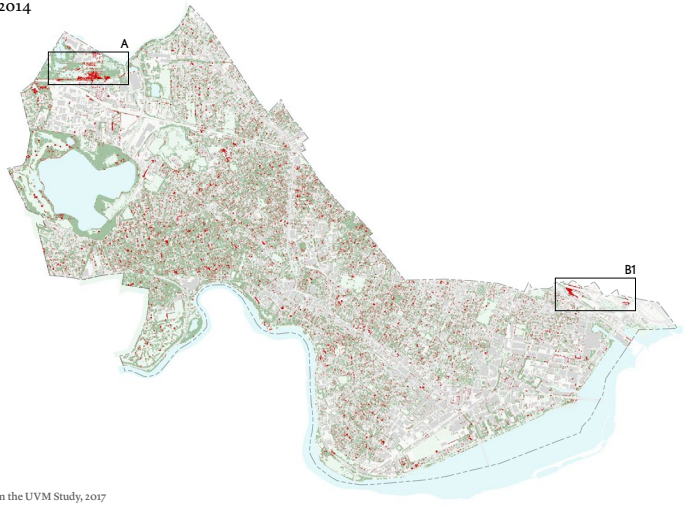
At this rate, canopy cover will be **16.2% in 2030**.

OBSERVATION | CANOPY COVER

Change Between 2009-2014

2009	30.8% COVER
2014	28.3% COVER
GAIN	2.5% (101 ACRES)
LOSS	4.9% (200 ACRES)
NET	– 99 ACRES

0.48% AVERAGE LOSS OF PERCENT CANOPY COVER PER YEAR



DRAFT

- Area of Canopy Loss
- 2014 Canopy Cover
- Open Areas

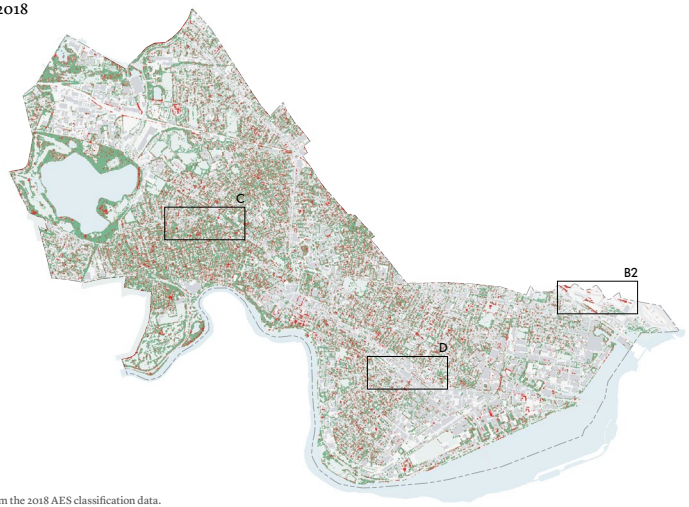
Source: Prepared by RH Team from the UVM Study, 2017

OBSERVATION | CANOPY COVER

Change Between 2014-2018

2014	28.3% COVER
2018	25.3% COVER (1,027 ACRES)
GAIN	5% (206 ACRES)
LOSS	8.1% (330 ACRES)
NET	– 124 ACRES

0.76% AVERAGE LOSS OF PERCENT CANOPY COVER PER YEAR



DRAFT

- Area of Canopy Loss
- 2018 Canopy Cover
- Open Areas

Source: Prepared by RH Team from the 2018 AES classification data.

DISCUSSION

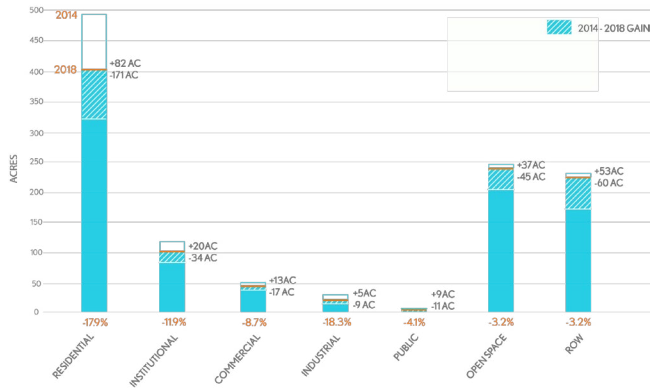
What are the primary causes of canopy loss?

What will it take to reverse the trend?

Where are the most opportune places to act?

DISCUSSION | CANOPY COVER

Canopy change by land use



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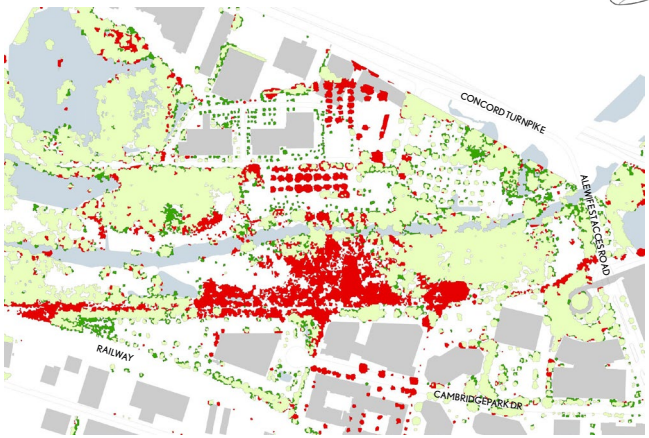
Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

DISCUSSION | CANOPY COVER

What were the causes of canopy change?

ALEWIFE 2009-2014



DRAFT

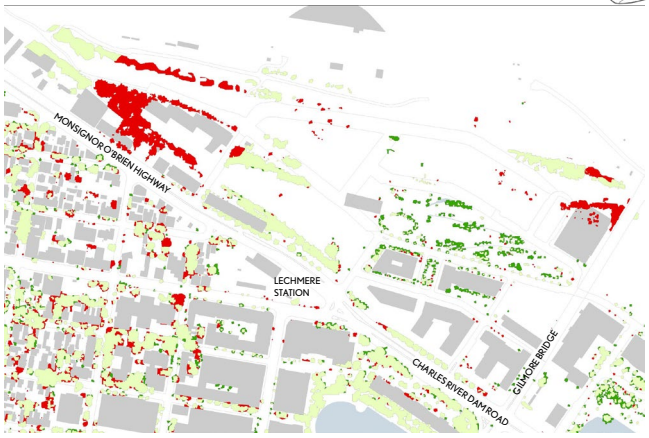
Area of Canopy Loss
Area of Canopy Gain
Area with No Change

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

DISCUSSION | CANOPY COVER

What were the causes of canopy change?

NORTH POINT 2009-2014



DRAFT

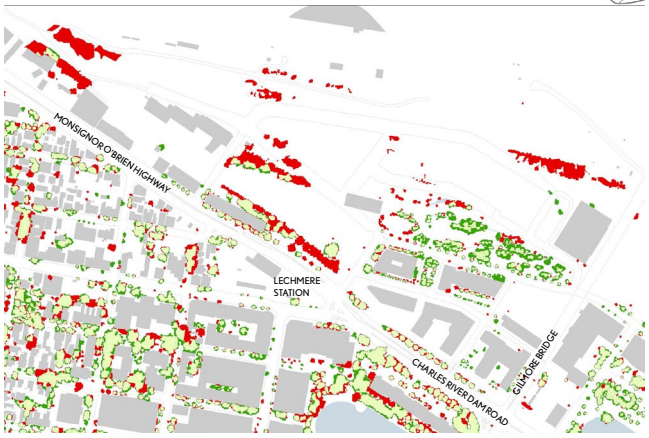
Area of Canopy Loss
Area of Canopy Gain
Area with No Change

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

DISCUSSION | CANOPY COVER

What were the causes of canopy change?

NORTH POINT 2014-2018



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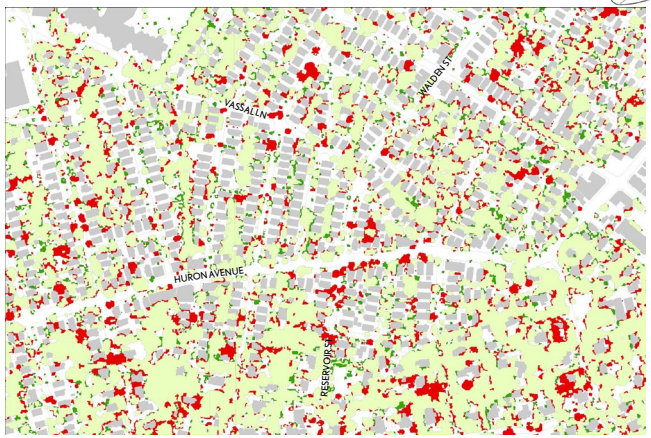
Area of Canopy Loss
Area of Canopy Gain
Area with No Change

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

DISCUSSION | CANOPY COVER

What were the causes of canopy change?

HURON AVE 2014-2018



DRAFT

- Area of Canopy Loss
- Area of Canopy Gain
- Area with No Change

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

DISCUSSION | CANOPY COVER

What were the causes of canopy change?

CENTRAL SQ 2014-2018

DRAFT

- Area of Canopy Loss
- Area of Canopy Gain
- Area with No Change

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

DISCUSSION | CANOPY COVER

What were the causes of canopy loss?

AGE CLASS	
NEW PLANTING	1.12%
YOUNG	31.6%
SEMI-MATURE	33.3%
MATURE	32.9%
OVERMATURE	0.8%

CONDITION	
GOOD	62.2%
FAIR	25.5%
POOR	7.9%
DEAD	4.2%

TOTAL TREES SURVEYED: 4,118

Source: Bartlett 5% Representative Survey

DISCUSSION | CANOPY COVER GOALS

What should Cambridge set as its goal?

CITY	% COVER FOR THE YEAR CITY'S CANOPY GOAL SET	RECENT CANOPY COVER	GOAL
CAMBRIDGE	N/A	25.3%	TBD
BOSTON	29% (2006)	27% (2017)	49% (2016)
BALTIMORE	20% (2007)	28.5% (2013)	40% (2036)
HARTFORD	25% (2013)	-	35% (ONGOING)
NEW YORK CITY	24% (2006)	20.9% (2013)	36% (2036)
PHILADELPHIA	20% (2011)	20.8% (2013)	30% (2025)

Source: D.J. Nowak et al., Environmental Pollution 178 (2013), 229-236

Leff, Michael, The Sustainable Urban Forest Guide (2016). Davey Institute.

HOW MANY INDIVIDUAL TREES DO WE NEED TO PLANT ?

To offset canopy loss (replace **31 acres** per year) we need to plant **4,300 3" caliper trees** each year, and wait 20 years.

— A shade tree that is 3" caliper at planting will have approximately 20 ft spread in 20 years.
— This is not a recommendation and is presented only as a thought experiment.

HOW MANY INDIVIDUAL TREES DO WE NEED TO PLANT ?

For a **1% increase** in citywide canopy cover over land area after 20 years (e.g. 25% to 26%), we need to plant **5,633 trees**.

— The total land area of the city is 4,061 acres.
— A shade tree that is 3" caliper at planting will have approximately 20 ft spread in 20 years.
— This is not a recommendation and is presented only as a thought experiment.

Where are the most opportune places to act?

CAMBRIDGE CANOPY COVERAGE
25.3% OF CITY LAND AREA

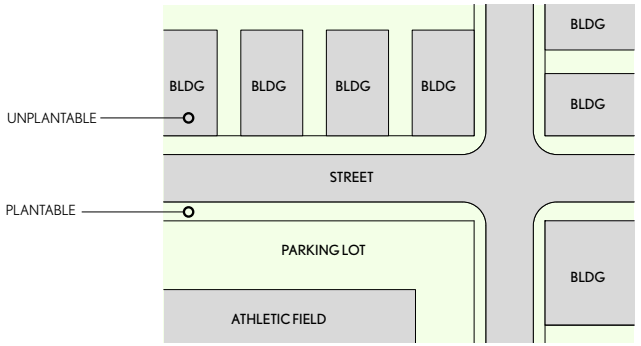
DRAFT

Source: Prepared by RH Team from the 2018 AES classification data.

Where are the most opportune places to act?

HOW MUCH PLANTABLE AREA IS IN THE CITY?

PLANTABLE AREA = TOTAL AREA OF CITY -
(STREETS + BUILDINGS + WATER + ATHLETIC FIELDS)



DISCUSSION | CANOPY COVER

Grouping of Land Use Categories

COMMERCIAL
MIXED USE COMMERCIAL
OFFICE
OFFICE/R&D
PRIVATELY-OWNED OPEN SPACE
VACANT COMMERCIAL

OPEN SPACE
CEMETERY
PUBLIC OPEN SPACE

INDUSTRIAL
MIXED USE INDUSTRIAL
UTILITY
VACANT INDUSTRIAL

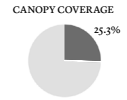
INSTITUTIONAL
CHARITABLE/RELIGIOUS
EDUCATION RESIDENTIAL
HEALTH
HIGHER EDUCATION
MIXED-USE EDUCATION

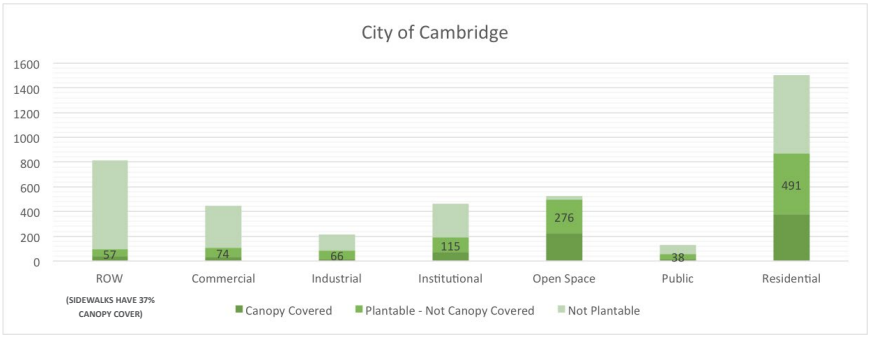
PUBLIC
EDUCATION
GOVERNMENT OPERATIONS

RESIDENTIAL
ASSISTED LIVING/BOARDING
MIXED USE RESIDENTIAL
VACANT RESIDENTIAL

DISCUSSION | CANOPY COVER

Where are the most opportune places to act?



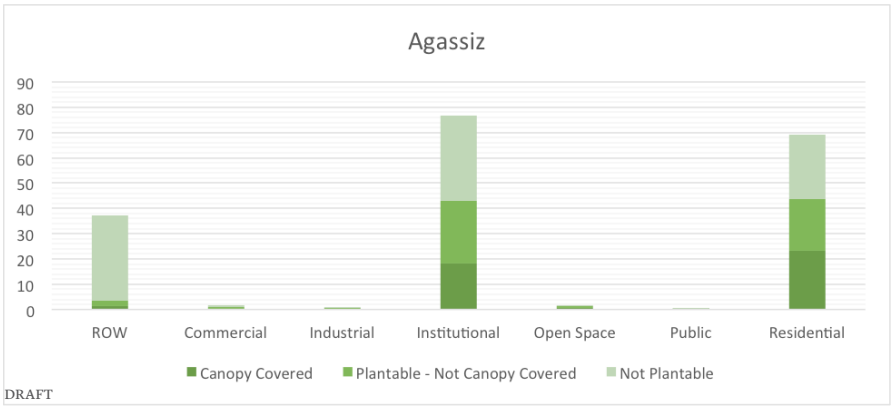


DRAFT

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

OBSERVATION | CANOPY COVER

Plantable area by neighborhood



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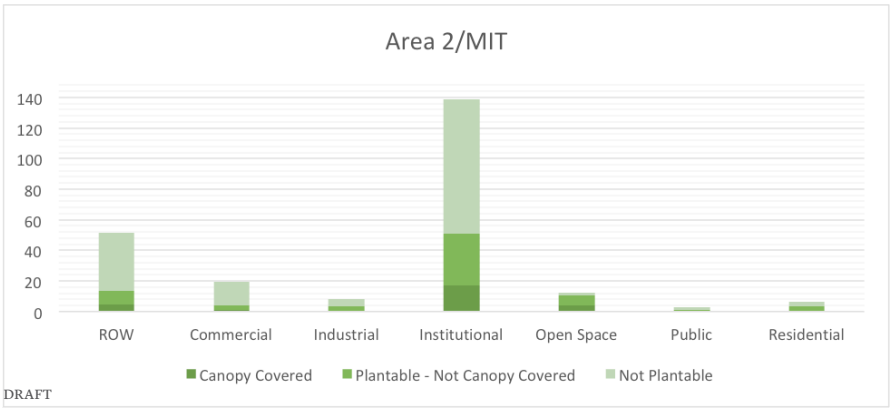
OBSERVATION | CANOPY COVER

Plantable area by neighborhood



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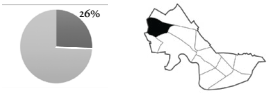
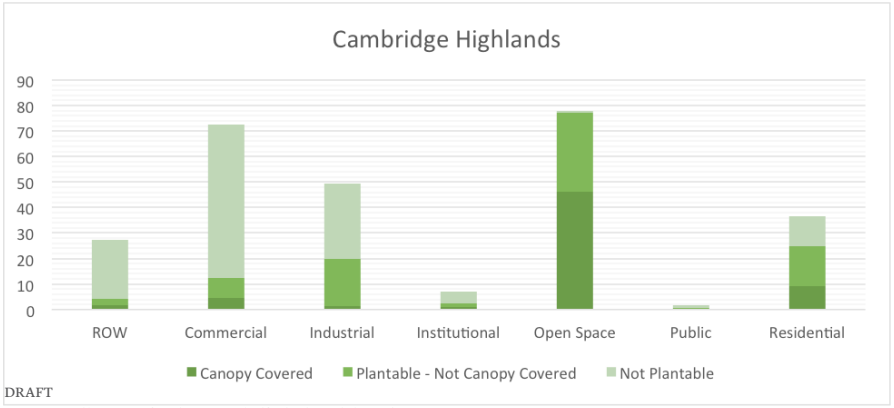
Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

OBSERVATION | CANOPY COVER
Plantable area by neighborhood





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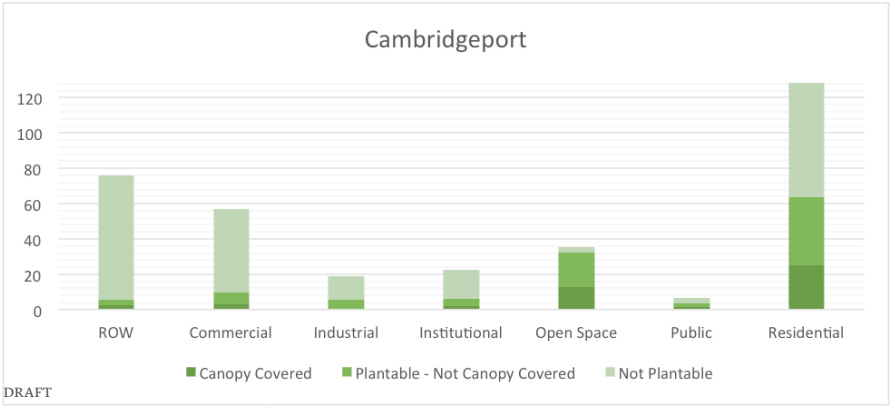
OBSERVATION | CANOPY COVER
Plantable area by neighborhood



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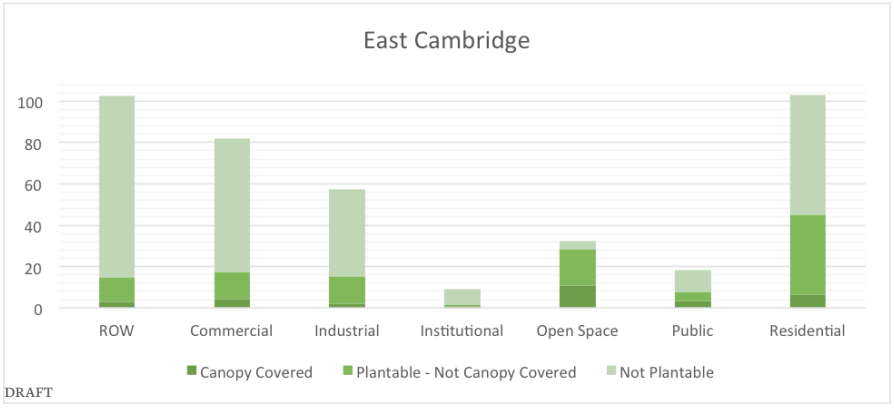
OBSERVATION | CANOPY COVER
Plantable area by neighborhood



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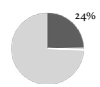
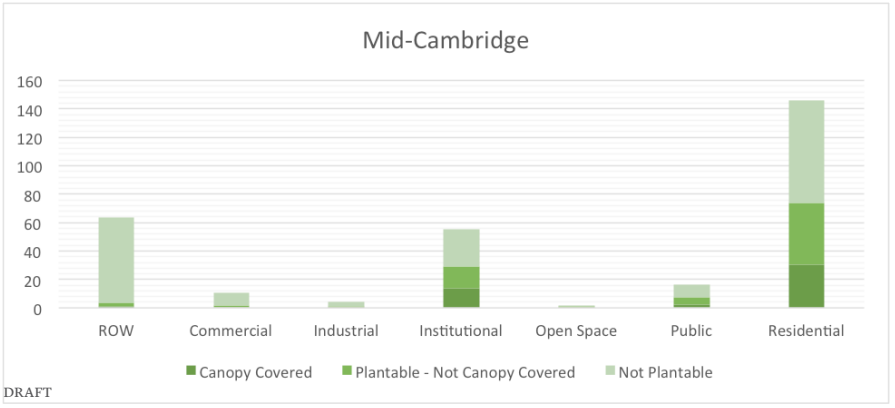
OBSERVATION | CANOPY COVER
Plantable area by neighborhood





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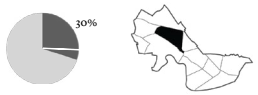
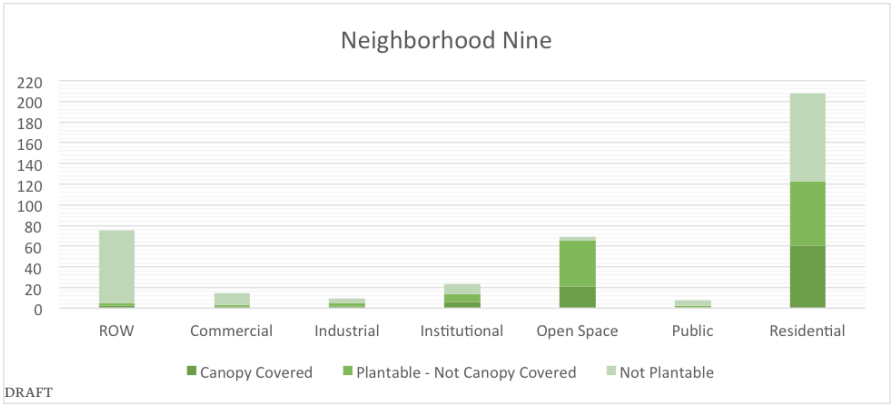
OBSERVATION | CANOPY COVER
Plantable area by neighborhood





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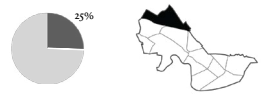
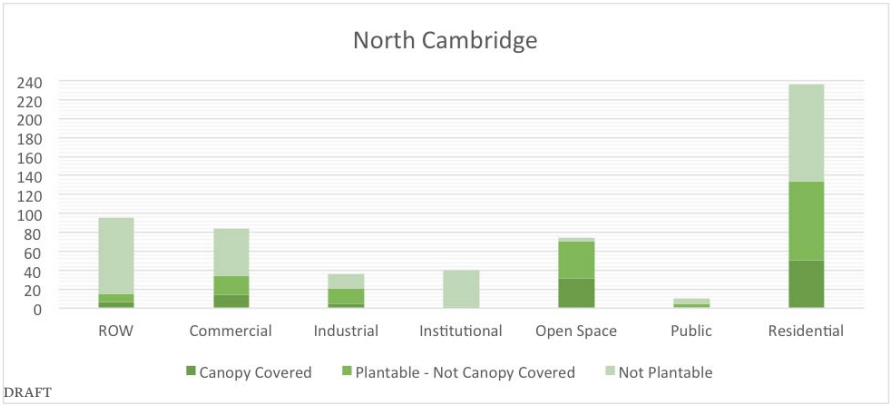
OBSERVATION | CANOPY COVER
Plantable area by neighborhood





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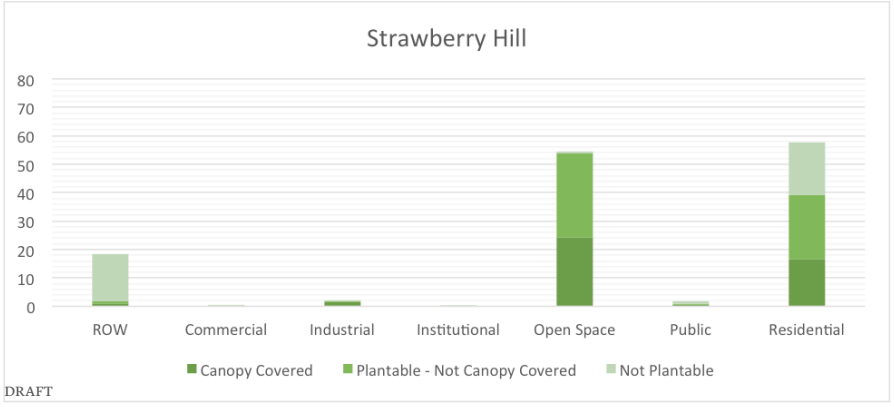
OBSERVATION | CANOPY COVER
Plantable area by neighborhood



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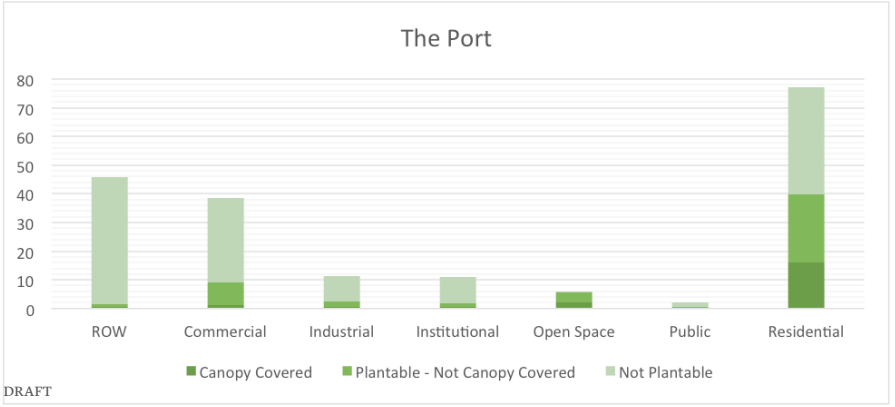
OBSERVATION | CANOPY COVER
Plantable area by neighborhood



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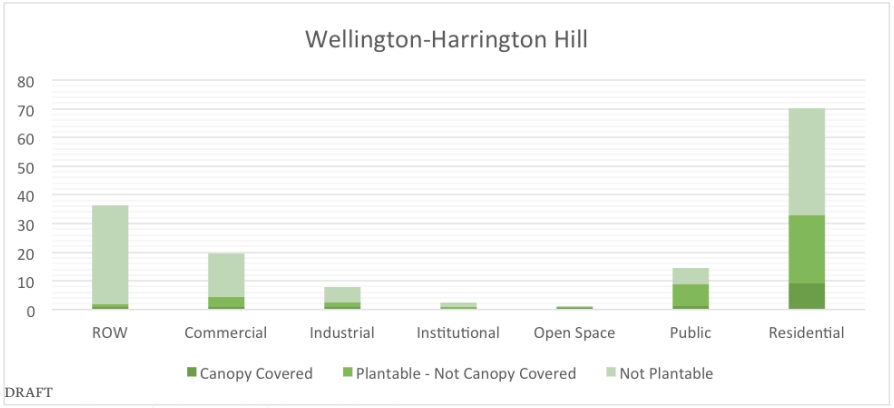
OBSERVATION | CANOPY COVER
Plantable area by neighborhood



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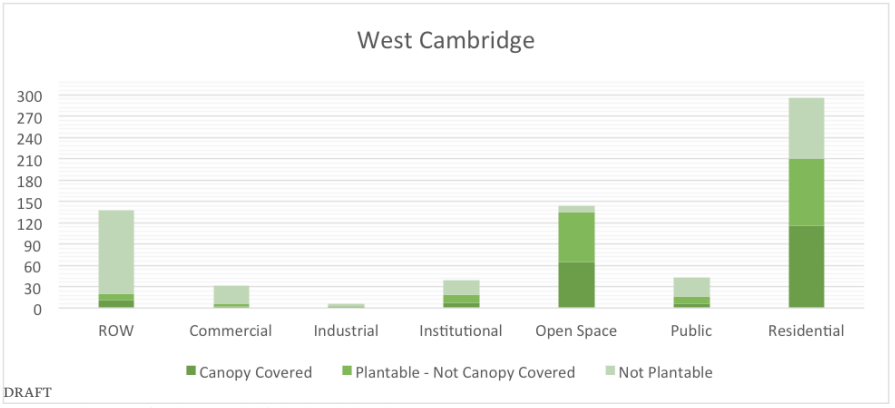
OBSERVATION | CANOPY COVER
Plantable area by neighborhood



DRAFT

Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

OBSERVATIONS & DISCUSSION

– CANOPY COVER
– SPECIES DIVERSITY
– CANOPY EQUITY
– HUMAN EXPERIENCE

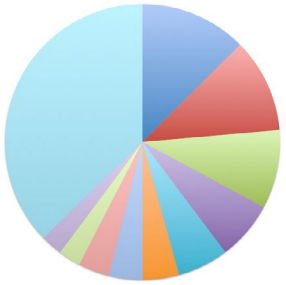
PUBLIC COMMENT

OBSERVATION | CITY-WIDE SPECIES DIVERSITY

Today, **3 species** make up over **30%** of the Cambridge forest.

Catastrophic loss of those 3 species would result in **17% remaining** total canopy cover.

OBSERVATION | CITY-WIDE SPECIES DIVERSITY



Other	36.4%
Norway Maple	12.5%
Pin Oak	11 %
Honey locust	9.2%
Red Maple	6.8%
Red Oak	6%
Littleaf Linden	4.2%
Callery Pear	3.9%
London Planetree	3.6%
Ash	3.4%
Crabapple	2.5%

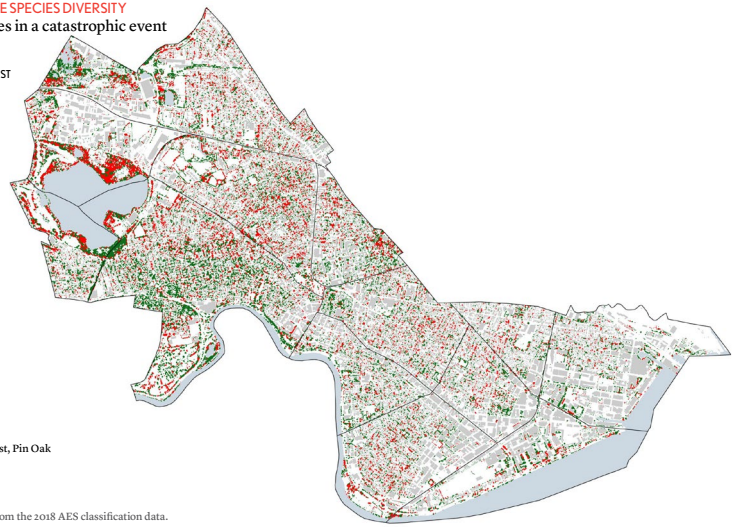
DRAFT

Source: Prepared by RH Team according to the 2018 AES classification data.

OBSERVATION | CITY WIDE SPECIES DIVERSITY

Loss of top three species in a catastrophic event

NORWAY MAPLE, HONEY LOCUST AND PIN OAK COMPOSE 32.7% OF THE URBAN FOREST



Norway Maple, Honey Locust, Pin Oak

Remaining Canopy

DRAFT

Source: Prepared by RH Team from the 2018 AES classification data.

DISCUSSION

What diversity targets should Cambridge set?

And how can the city best achieve that goal?

DISCUSSION | SPECIES DIVERSITY

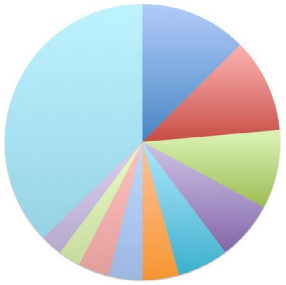
Suggested diversity target

5%	10%	20%
SPECIES	GENUS	FAMILY

Santamour, 1990: Urban foresters and municipal arborists should use the following guidelines for tree diversity within their areas of jurisdiction:
(1) plant no more than 10% of any species,
(2) no more than 20 % of any genus,
(3) no more than 30 % of any family.

Melbourne Urban Forest Diversity Guidelines, 2011: The urban Forest Diversity Guidelines recommend that by 2040
(1) no more than 5 percent of the forest is to be of any single species,
(2) no more than 10 percent is to be of any one genus,
(3) no more than 20 percent is to be of any one Family.

DISCUSSION | SPECIES DIVERSITY



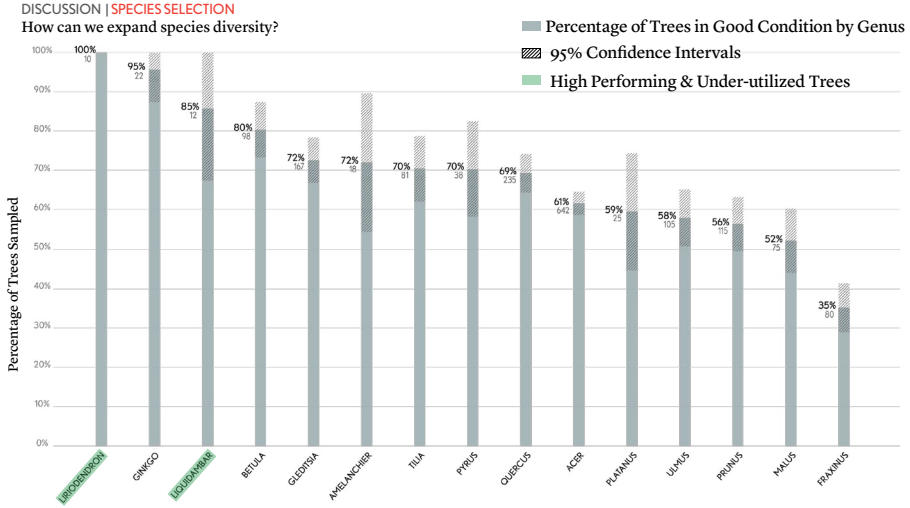
Other	36.4%	
Norway Maple	12.5%	Above 5% per species
Pin Oak	11 %	
Honey locust	9.2%	
Red Maple	6.8%	
Red Oak	6%	Above 10% per genus
Littleaf Linden	4.2%	
Callery Pear	3.9%	
London Planetree	3.6%	
Ash	3.4%	
Crabapple	2.5%	

DRAFT

Source: Prepared by RH Team according to the 2018 AES classification data.

DISCUSSION | SPECIES SELECTION

How can we expand species diversity?



Source: Prepared by RH Team according to Bartlett 5% Representative Tree Inventory .

DISCUSSION | SPECIES SELECTION

How should the city's recommendations change?

Ornamental Tree (overhead wires present)	Height (feet)
Amur maackia (Maackia amurensis)	20-30
Accolade cherry (Prunus 'Accolade')	20
Akebono cherry (Prunus x yedoensis 'Akebono')	25
Autumn cherry (Prunus subhirtella 'Autumnalis')	25-40
Crabapple spp (Malus sp.)	15-25
Eastern redbud (Cercis canadensis)	20-30
Hedge Maple (Acer campestre)	25-30
Japanese tree lilac (Syringa reticulata)	20-30
Kwanzan cherry (Prunus serrulata 'Kwanzan')	25
Okame cherry (Prunus x incam 'Okame')	15-25
Paperbark maple (Acer griseum)	30
Sargent cherry (Prunus sargentii)	25-40
Serviceberry (Amelanchier sp.)	20-30
Snowgoose cherry (Prunus serrulata 'Snowgoose')	20

Trees with low condition ratings
Trees that exceed diversity target

Shade Tree (no wires present)	Height (feet)
American elm (Ulmus americana)	50-70
Armstrong Red maple (Acer x freemanii)	50-70
Black oak (Quercus velutina)	50-60
Black tupelo (Nyssa sylvatica)	30-50
Dawn redwood (Metasequoia glyptostroboides)	75
Elm cultivars (Ulmus sp.)	40-60
Ginkgo (Gingko biloba)	40-80
Golden raintree (Koelreuteria paniculata)	30-40
Hackberry (Celtis occidentalis)	60
Honeylocust (Gleditsia triacanthos)	45-50
Hornbeam (Carpinus caroliniana)	35
Katsuratree (Cercidiphyllum japonicum)	50
Kentucky coffeetree (Gymnocladus dioicus)	75
Littleleaf linden (Tilia cordata)	45-60
London planetree (Platanus x acerifolia)	80
Pear spp (Pyrus sp.)	30-40
Pin oak (Quercus palustris)	75
Red maple (Acer rubrum)	40-70
Red oak (Quercus rubra)	75
River birch (Betula nigra)	50-70
Silver linden (Tilia tormentosa)	30-40
Sophora (Sophora (Styphnolobium) japonica)	50
Swamp White oak (Quercus bicolor)	45
Sweetgum (Liquidambar styraciflua)	65
Tuliptree (Liriodendron tulipifera)	70-90
Zelkova (Zelkova serrata)	50-70

OBSERVATIONS & DISCUSSION

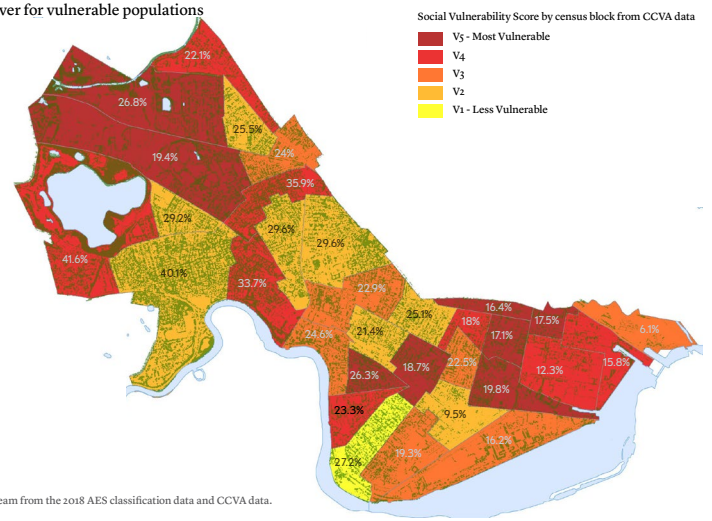
– CANOPY COVER
– SPECIES DIVERSITY
– CANOPY EQUITY
– HUMAN EXPERIENCE

PUBLIC COMMENT

More vulnerable populations tend to live in areas of Cambridge with **less canopy** cover.

Density, urban form, and land use tend to limit opportunities for tree planting in these neighborhoods.

Percent canopy cover for vulnerable populations



DRAFT

Source: Prepared by RH Team from the 2018 AES classification data and CCVA data.

What can Cambridge do to reverse the canopy deficit in vulnerable communities?

Plantable area and vulnerable populations

DRAFT

Source: Prepared by RH Team from the 2018 AES classification data and CCVA data.

OBSERVATIONS & DISCUSSION

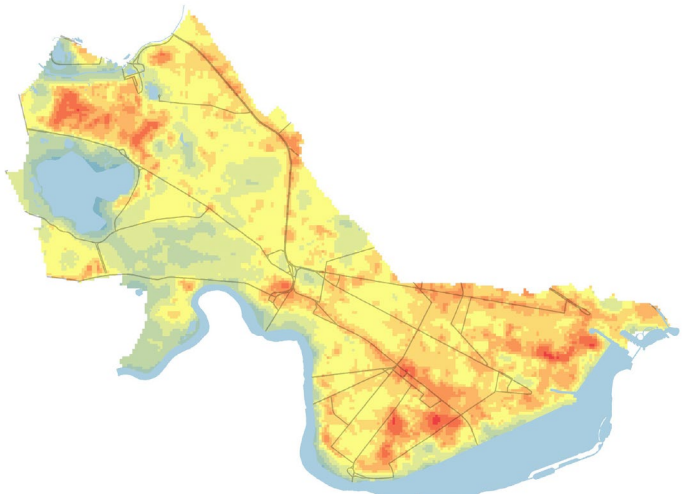
– CANOPY COVER
– SPECIES DIVERSITY
– CANOPY EQUITY
– HUMAN EXPERIENCE

PUBLIC COMMENT

Lack of shade, resulting in **heat island** effect, is often aligned with primary pedestrian corridors and commercial centers (squares).

As summer temperatures rise, developing connective corridors of shade (**cool corridors**) will be increasingly important.

Heat island + bus routes (cool corridors)

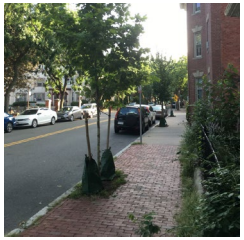


Where should the city focus resources in order to most effectively enhance human comfort?

Where street trees can't be planted in ideal conditions, are there alternative strategies?

OBSERVATION | HUMAN EXPERIENCE

Heat island + cool corridors



PROJECT GOALS

DRAFT Decision support framework

Vision	Goals		Evaluative Criteria	Baseline	2030 Target	2070 Target
To build, maintain, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.	PEOPLE: A forest that contributes to residents' well-being and residents who contribute to the forest well-being	Enhance shading and cooling				
		Improve pedestrian thermal comfort	Ambient sidewalk temperatures, Connectivity			
		Reduce urban heat island effects	Degrees relative to city avg			
		Increase equity in distribution of canopy cover	Canopy cover by vulnerable population			
		Create pleasing environments	Well-being / stress levels (survey)			
		Increase residents' awareness of value of trees	Engagement, program adoption (survey)			
		Enhance citywide stormwater management	Rainfall interception			
		Increase carbon sequestration	Carbon capture rates			
	TREES: A healthy forest whose trees live longer and thrive during predicted changing climate conditions	Improve soils health	Soil quality index			
		Improve tree health	% trees in good health			
		Improve street tree lifespan	Avg life of street tree			
	FOREST: A forest that supports a resilient, connected ecosystem	Enhance habitat	Canopy connectivity, species census			
		Diversify forest composition	City diversity index			
		Improve disaster response (noreaster, drought)	Projected impact and recovery rates			

OBSERVATIONS & DISCUSSION

– CANOPY COVER
– SPECIES DIVERSITY
– CANOPY EQUITY
– HUMAN EXPERIENCE

PUBLIC COMMENT

PUBLIC MEETING COMING UP ON OCT 3

PRESENTATION OF RESEARCH: SUMMARY OF FINDINGS

TASK FORCE MEETING SCHEDULE

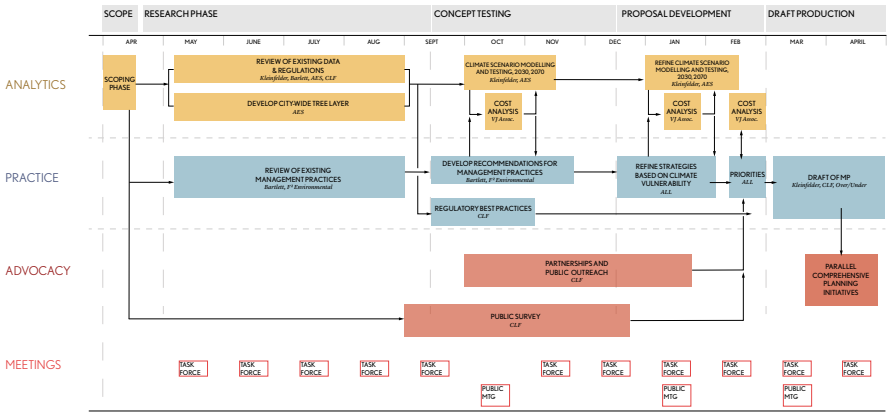
JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling
SEPTEMBER 27	RESEARCH: Summary of Findings
OCTOBER 25	TESTING: Baseline Change Model
NOVEMBER 29	TESTING: Impact Analysis
DECEMBER 20	PROPOSAL DEVELOPMENT
JANUARY 31	PROPOSAL DEVELOPMENT
FEBRUARY 28	DRAFT DOCUMENTATION
MARCH 28	DRAFT DOCUMENTATION
APRIL 25	DRAFT DOCUMENTATION

www.cambridgema.gov/ufmp

PROJECT STATUS UPDATE

An independent quality control analysis of the LiDAR data that is the foundation of this analysis does not materially change the previously reported findings.

To ensure comparable data in the future UVM will prepare an independent analysis of canopy change which will be appended to this study.



FROM RESEARCH TO TESTING

SOILS ANALYSIS

CLIMATE MODEL

RESPONSE STRATEGIES

PLANNING SYNERGIES

SOILS ANALYSIS

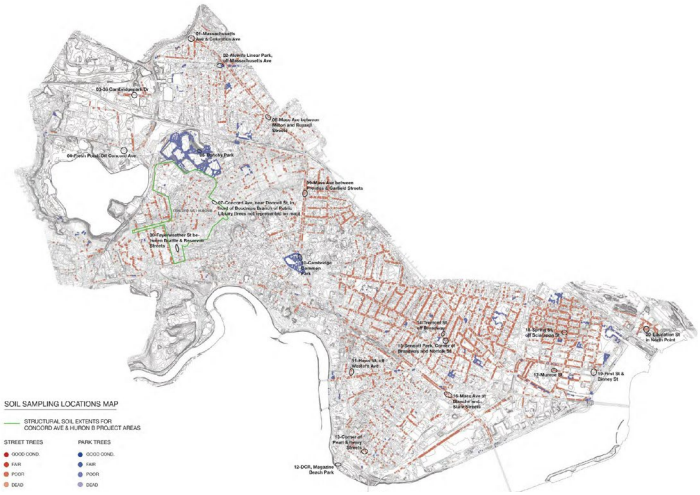
Overall soil condition for street trees is fair to poor, showing high compaction, low nutrient cycling, and poor drainage characteristics.

Soil condition can limit tree vitality.

Some limiting factors can be remediated through management practices.

INITIAL ANALYSIS RESULTS

20 sample sites



INITIAL ANALYSIS RESULTS

The following limiting factors to tree health were found:

Compaction — 16 of 20 sites had severe compaction

Low nutrient levels — 12 sites had little to no available nitrogen

Poor drainage — 7 sites showed poor drainage 2'-3' below surface

Texture — General inconsistency of soils materials, presence of construction debris

INITIAL ANALYSIS RESULTS

Possible remediation measures:

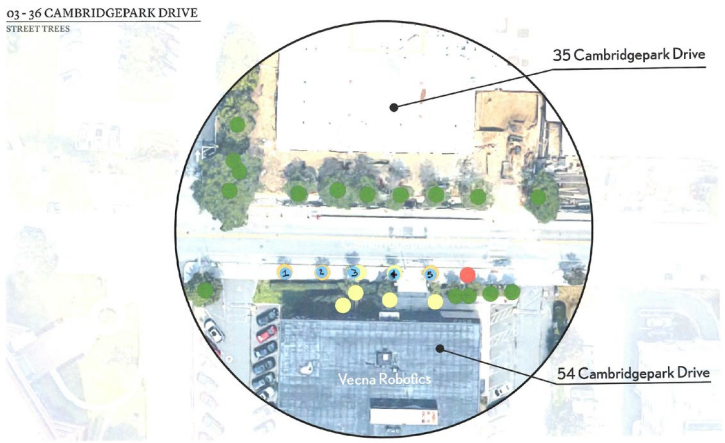
Compaction — Aeration can loosen soils

Low nutrient levels — Compost can be added

Poor drainage — Can't be addressed post-planting

Texture — Compost can have some effect but difficult to address post-planting

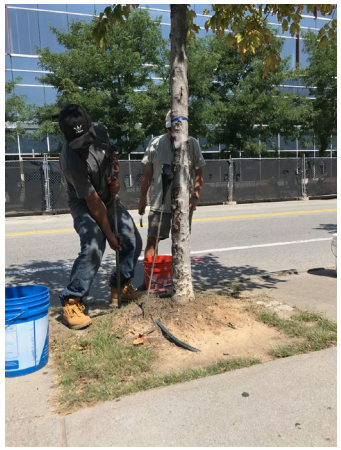
ANALYSIS SITES



1 Soil sample location

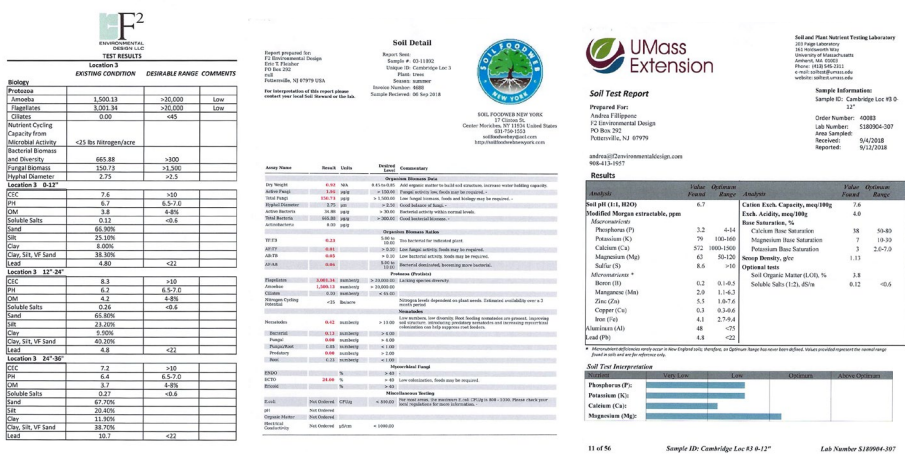
ANALYSIS SITES

Site 3 photos - compaction example



ANALYSIS SITES

Site 3 Datasheets



TEST RESULTS

Location 3 EXISTING CONDITION		DESIRABLE RANGE	COMMENTS
Biology			
Protozoa			
Amoeba	1,500.13	>20,000	Low
Flagellates	3,001.34	>20,000	Low
Ciliates	0.00	<45	
Nutrient Cycling Capacity from Microbial Activity	<25 lbs Nitrogen/acre		
Bacterial Biomass and Diversity	665.88	>300	
Fungal Biomass	150.73	>1,500	
Hyphal Diameter	2.75	>2.5	
Location 3 0-12"			
CEC	7.6	>10	
PH	6.7	6.5-7.0	
OM	3.8	4-8%	
Soluble Salts	0.12	<0.6	
Sand	65.30%		
Silt	25.10%		
Clay	8.00%		
Clay, Silt, VF Sand	33.10%		
Lead	4.80	<22	
Location 3 12"-24"			
CEC	8.3	>10	
PH	6.2	6.5-7.0	
OM	4.2	4-8%	
Soluble Salts	0.26	<0.6	
Sand	65.80%		
Silt	23.20%		
Clay	9.90%		
Clay, Silt, VF Sand	43.20%		
Lead	4.8	<22	
Location 3 24"-36"			
CEC	7.2	>10	
PH	6.4	6.5-7.0	
OM	3.7	4-8%	
Soluble Salts	0.27	<0.6	
Sand	67.70%		
Silt	20.40%		
Clay	11.90%		
Clay, Silt, VF Sand	38.70%		
Lead	10.7	<22	

Soil Detail

SOIL FOODWEB NEW YORK

UMass Extension

Soil Test Report

Prepared For:
Andrea Filippone
F2 Environmental Design
PO Box 292
Pottersville, NJ 07979

andrea@f2environmentaldesign.com
908-413-1057

Sample Information:
Sample ID: Cambridge Loc #3 0-12"
Order Number: 40083
Lab Number: S180904-307
Area Sampled:
Received: 9/4/2018
Reported: 9/12/2018

Results

Analysis	Value Found	Optimum Range
Soil pH (1:1, H2O)	6.7	
Modified Morgan extractable, ppm		
Macronutrients		
Phosphorus (P)	3.2	4-14
Potassium (K)	79	100-160
Calcium (Ca)	572	1000-1500
Magnesium (Mg)	63	50-120
Sulfur (S)	8.6	>10
Micronutrients *		
Boron (B)	0.2	0.1-0.5
Manganese (Mn)	2.0	1.1-6.3
Zinc (Zn)	5.5	1.0-7.6
Copper (Cu)	0.3	0.3-0.6
Iron (Fe)	4.1	2.7-9.4
Aluminum (Al)	48	<75
Lead (Pb)	4.8	<22

Analysis	Value Found	Optimum Range
Cation Exch. Capacity, meq/100g	7.6	
Exch. Acidity, meq/100g	4.0	
Base Saturation, %		
Calcium Base Saturation	38	50-83
Magnesium Base Saturation	7	10-39
Potassium Base Saturation	3	2.6-7.0
Scoop Density, g/cc	1.13	
Optional tests		
Soil Organic Matter (LOI), %	3.8	
Soluble Salts (1:2), dS/m	0.12	<0.6

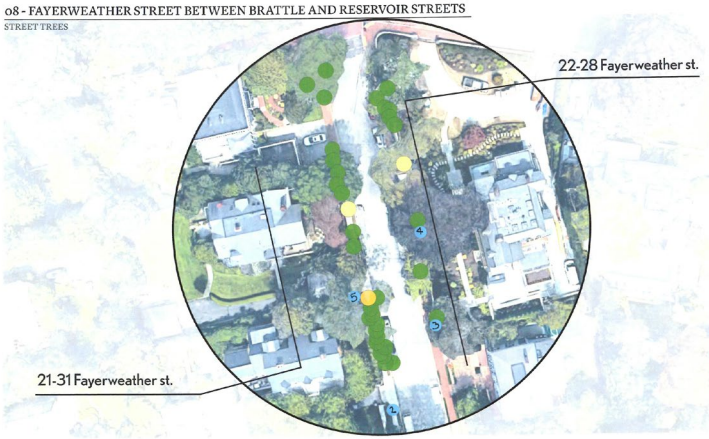
* Micronutrient deficiencies rarely occur in New England soils; therefore, an Optimum Range has never been defined. Values provided represent the normal range found in soils and are for reference only.

Soil Test Interpretation

Analysis	Very Low	Low	Optimum	Above Optimum
Phosphorus (P):				
Potassium (K):				
Calcium (Ca):				
Magnesium (Mg):				

11 of 56 *Sample ID: Cambridge Loc #3 0-12"* *Lab Number S180904-307*

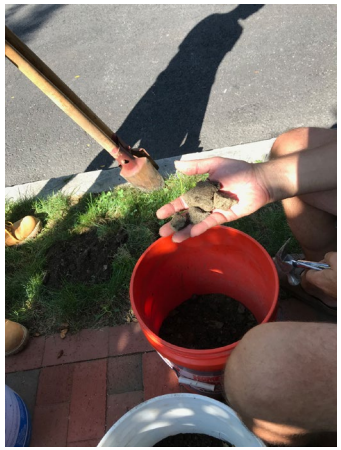
ANALYSIS SITES



1 Soil sample location

ANALYSIS SITES

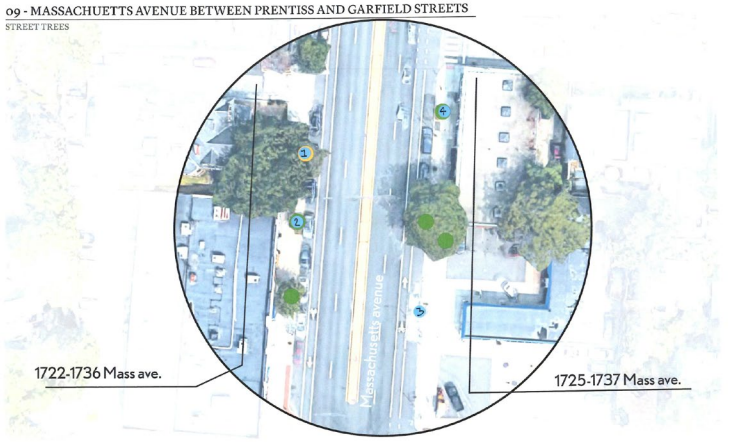
Site 8 photos - poor drainage example



ANALYSIS SITES

09 - MASSACHUETTS AVENUE BETWEEN PRENTISS AND GARFIELD STREETS

STREET TREES



1 Soil sample location

ANALYSIS SITES

Site 9 photos - poor soils: sandy, dry

FROM RESEARCH TO TESTING

SOILS ANALYSIS

CLIMATE MODEL

RESPONSE STRATEGIES

PLANNING SYNERGIES

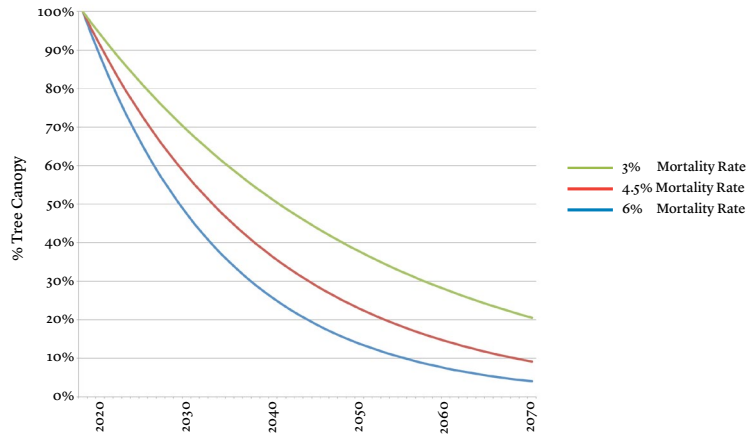
The increased threat of **pests and diseases** associated with a warming environment was found to have a **significant impact on tree mortality**.

Drought was found to have a potentially moderate impact on the existing tree canopy.

The findings from this simulation will inform city-wide tree **species recommendations** and include location-specific selection criteria, for example, planting only **flood tolerant species** in flood-prone areas.

BASELINE SCENARIOS LOSS RATE

With a 4.5% annual mortality rate, 56% of the canopy remains in 2030, and 9% remains in 2070



BASELINE SCENARIO PARAMETERS

Drivers of tree mortality

1. **Pests and Diseases**
   Increasing severity of existing pests & diseases
   Species were assigned low, average or high pest & disease loading

2. **Temperature Increase**
   Cambridge will move from hardiness zone 6b to 7a by 2070 *
   - 2030: 5 species will be removed:
     Black Ash, Bigtooth Aspen, Pin Cherry, Balsam Fir, Red Pine, and Tamarack. Only Red Pine has significant numbers in Cambridge (4.2 acres)
   - 2070: 11 species will be removed

*Melillo, J. M., T.C. Richmond, and G.W. Yohe (eds). 2014.

BASELINE SCENARIO PARAMETERS

Each tree species was evaluated for pests/disease loading, flood and drought tolerance average lifespan, hardiness zone,

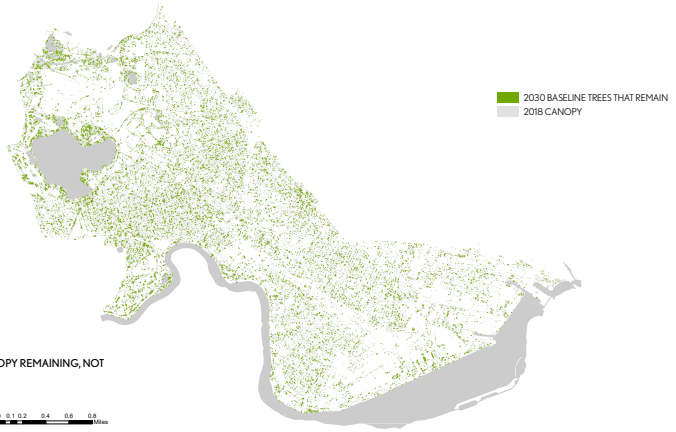
	Total Count in 5% Sample	% of Sample Population	% Dead Condition in Sample	% Fair Condition in Sample	% Good Condition in Sample	% Poor Condition in Sample	Average Lifespan	Hardiness Zones (Cambridge in Zone 6b)	Outside Hardiness Zone 6b in 2018?	Outside Hardiness Zone 7a (assume in 2070)?	Flood Tolerance Summary	Drought Final	Summary Pest/Disease Annual Mortality Level by 2030 (change up or down from 4.5% based on pest/disease load, based on red and orange columns)
Alder-Common	11	0.3%	0.00%	0.00%	100.00%	0.00%	100.00	3-7			Intermediate	Moderate	4.50%

Beech Bark Disease	Chestnut Blight	Anthracnose	Dutch Elm Disease	Emerald Ash Borer	Gypsy Moth	Hemlock Woolly Adelgid	Large Aspen Tortrix	Pine Shoot Beetle	Winter Moth	White Pine Blister Rust	Elongate Hemlock Scale	Needlecast	Butternut Canker	Asian Longhorned Beetle	Balsam Woolly Adelgid	Beech Leaf Disease	Oak Wilt	Spruce Beetle	Southern Pine Beetle
					Y		Y												

EXAMPLE PORTION OF THE SPECIES PARAMETER TABLE

BASELINE SCENARIO IMPACT

41.4% of the 2018 canopy remains (gross loss assuming no replanting) — resulting in **10.5% total canopy cover** — in 2030. When compared to the baselineof 56% remaining canopy, this is an additional decrease of 26.1%.



REPRESENTATIVE MAP OF THE CANOPY REMAINING, NOT MEANT TO BE SPATIALLY EXPLICIT

BASELINE SCENARIO IMPACT

Which species thrive and which do not? (Percent that survive)

Common thornless honeylocust	51%
Norway maple	39%
Red Maple	38%
Pin Oak	39%
Northern Red Oak	40%
London Planetree	38%
Littleleaf Linden	38%
Callery pear	37%
Zelkova	65%

Most Common Species
Cambridge 2030

Amur maackia	68%
Ginkgo	66%
Magnolia	66%
Buckthorn	66%
Japanese tree lilac	64%
Zelkova	64%
Black locust	63%
Kentucky coffeetree	60%
Amur cork tree	59%

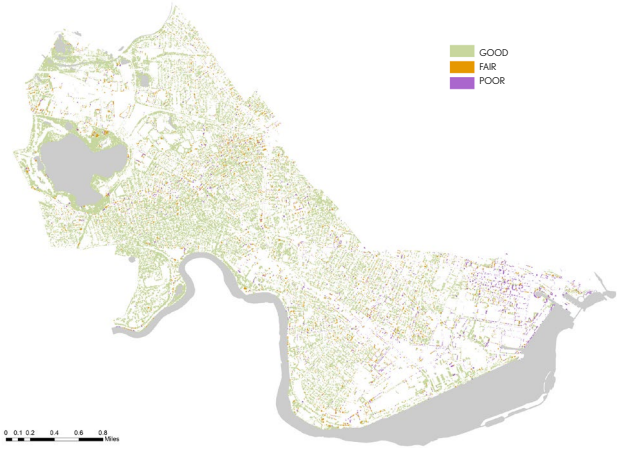
Best Performers
Cambridge 2030

Paperbark maple	9%
Amur maple	9%
Grey birch	11%
Poplar	11%
Slippery elm	14%
Eastern cottonwood	14%
Tartarian Maple	15%
Siberian Elm	16%
Eastern Hemlock	19%

Worst Performers
Cambridge 2030

EXTREME EVENTS PARAMETERS: TREE CONDITION

Tree condition was extrapolated from the 2018 LIDAR data and was used to evaluate how trees would fare in extreme events.



EXTREME EVENT PARAMETERS: MODERATE DROUGHT

Event:

Moderate drought event to occur once every 30 yrs within the 2035-2064 timeframe (Hayhoe et al 2006)

Droughts are defined as deficits of 10% or more in monthly soil moisture relative to the climatological mean. Moderate drought durataion is approximately 3-6 months.

Lower Bound:

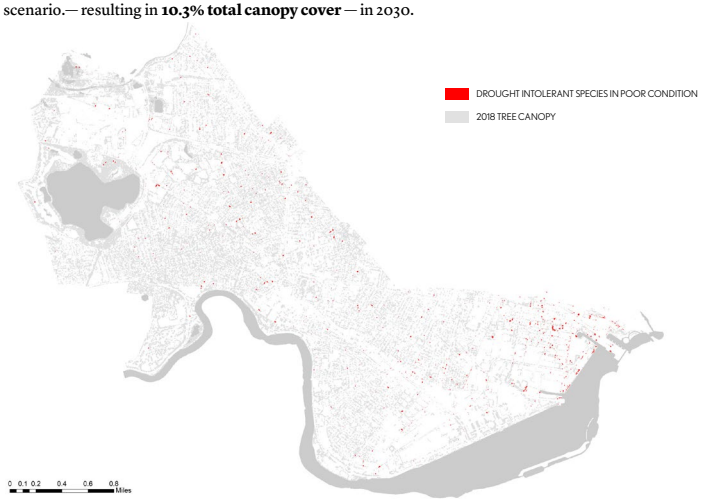
Drought- intolerant trees in poor condition will experience mortality.

Upper Bound:

Drought- intolerant trees in poor and fair condition and moderate drought tolerant trees in poor condition will experience mortality.

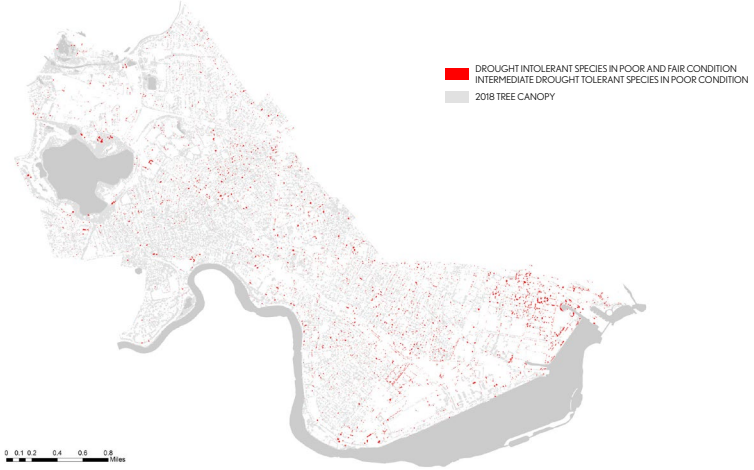
EXTREME EVENT PARAMETERS : MODERATE DROUGHT

The lower bound of the moderate drought event resulted in 1.9% additional mortality from the 2030 baseline scenario.— resulting in **10.3% total canopy cover** — in 2030.



EXTREME EVENT PARAMETERS : MODERATE DROUGHT

The upper bound of the moderate drought event resulted in 9.0% additional mortality from the 2030 baseline scenario— resulting in **9.5% total canopy cover** — in 2030.



EXTREME EVENTS IMPACTS : MODERATE DROUGHT

Best and Worst Performers in 2030 (additional mortality from 2030 baseline)

Percent change

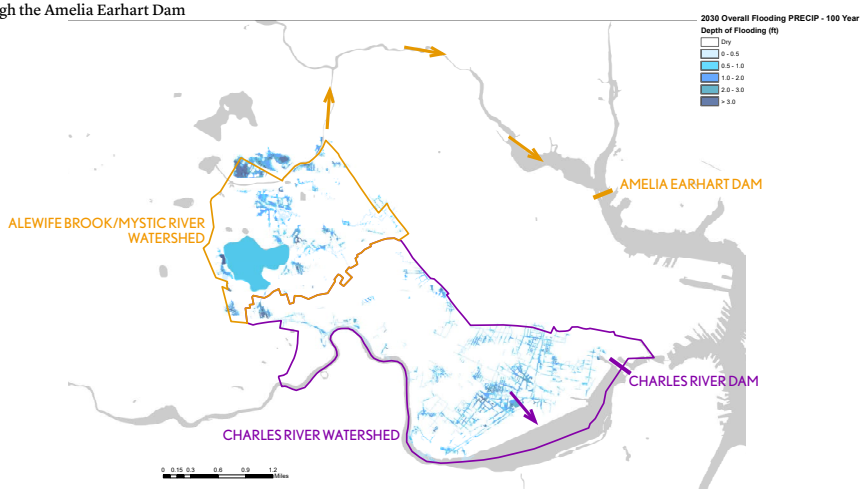
Most Common Cambridge 2030	
Common thornless honeylocust	0%
Norway maple	0%
Red maple	3 -8%
Pin oak	0-33%
Northern red oak	4-7%
London planetree	0%
Littleleaf linden	0-32%
Callery pear	0-21%
Zelkova	0-13%

Worst Performers Lower Bound	
Eastern Hemlock	35%
American Linden	19%
Eastern White Pine	18%
White Ash	10%
Grey Birch	9%
Magnolia	8%
Hornbeam	7%
Tree of Heaven	7%
American Hornbeam	4%

Worst Performers Upper Bound	
Eastern hemlock	59%
Ash	37%
American linden	21%
Red maple	20%
Eastern white pine	20%
Cherry	17%
Austrian pine	17%
Katsura	17%
Crabapple	16%

EXTREME EVENTS: FLOODING

One-third of Cambridge is part of the Alewife Brook watershed and discharges through the Amelia Earhart Dam



FROM RESEARCH TO TESTING

SOILS ANALYSIS

CLIMATE MODEL

RESPONSE STRATEGIES

PLANNING SYNERGIES

Today, Cambridge has **25.3%** of its land area covered by canopy.

Cambridge has had an average net loss of **31 acres** of canopy cover every year.

At this rate, canopy cover will be **16.2% in 2030**.

Factoring in climate change, it may be **10.5% in 2030** but with a moderate drought it could be 9.5%

RESPONSE STRATEGIES | OVERVIEW

There are two primary approaches to reversing the current trend of urban forest contraction —

Stem the loss of existing trees

Grow Canopy by planting new trees

STEM LOSS

Cambridge canopy trends in regional context

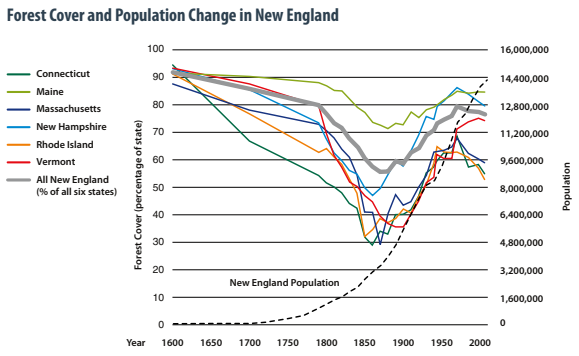


FIGURE 1: *Long-term trends in forest cover and human population in the six New England states shows that even as the population grew, forest cover increased between 1850 and the early 2000s. In recent years, forest cover has again declined due to conversion of forests to developed land.*

Source: "Changes to the Land: Four Scenarios for the Future of the Massachusetts Landscape", Harvard Forest, Thompson, et. al., 2014

STEM LOSS

Impacts of planting cycles in residential development

Properties with homes built around 1920 have unusually high percentage of tree canopy. These trees are now likely reaching maturity. Development tapered off after 1930 so we can surmise that the residential canopy will also begin to taper off as those trees age.

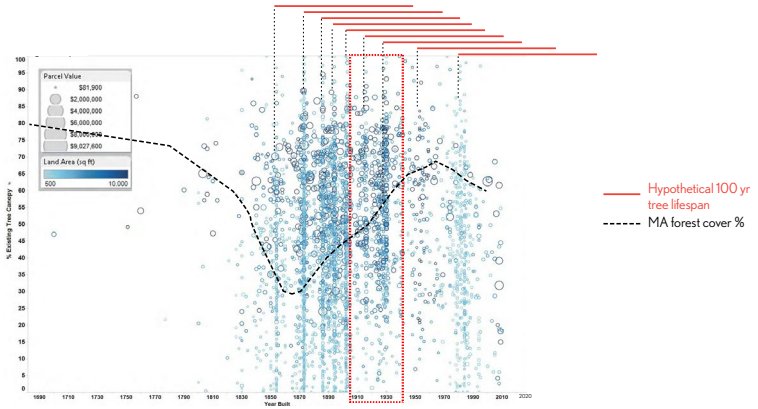
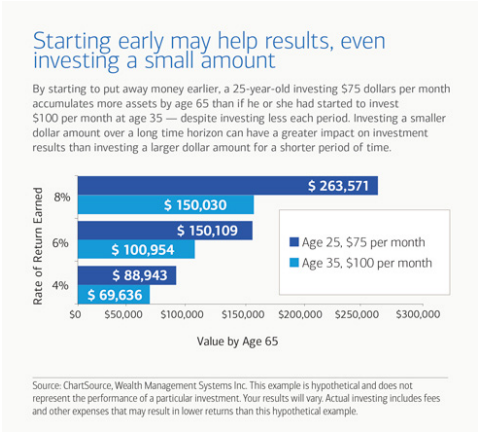


Figure 8: % Existing Tree Canopy in relation to year built, parcel value, and land area for single family residential parcels.

Source: UVM, "A Report on the City of Cambridge's Existing and Possible Tree Canopy", 6/1/12

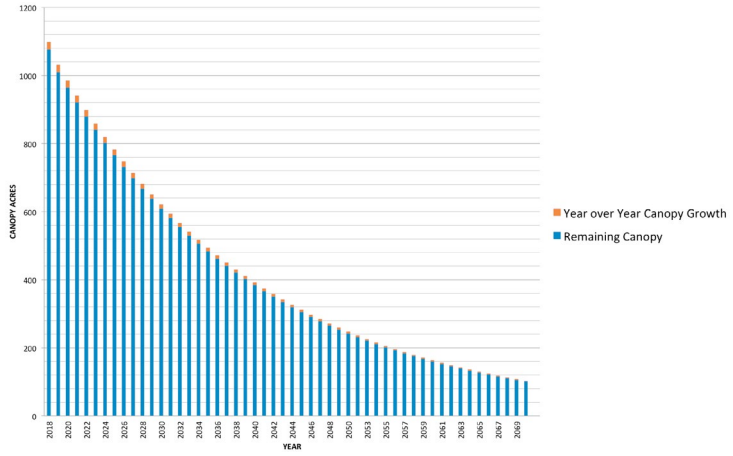
GROW CANOPY

Planting trees is like retirement investment; starting early counts



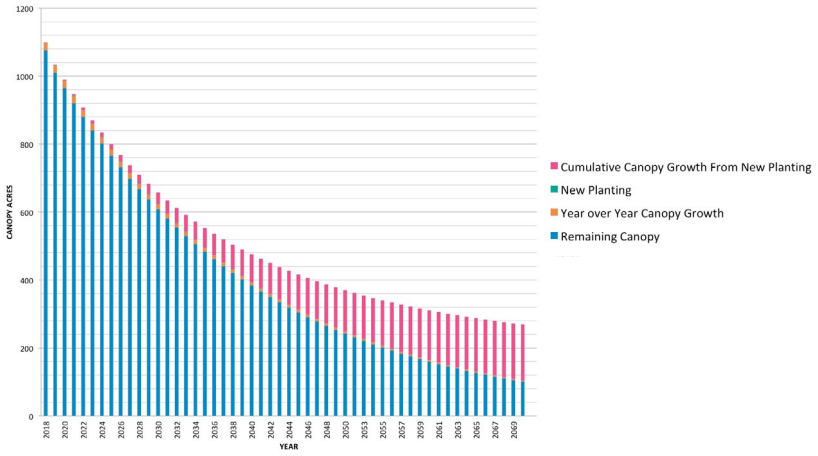
STEMMING LOSS AND GROWING CANOPY

Mortality rate unchanged (6.5%/yr) + No new plantings



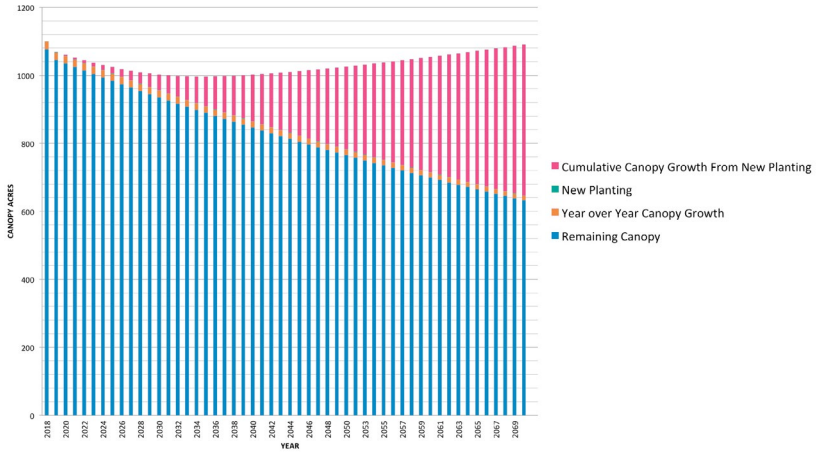
STEMMING LOSS AND GROWING CANOPY

Mortality rate unchanged (6.5%/yr) + Grow Canopy (2,500 trees/yr)



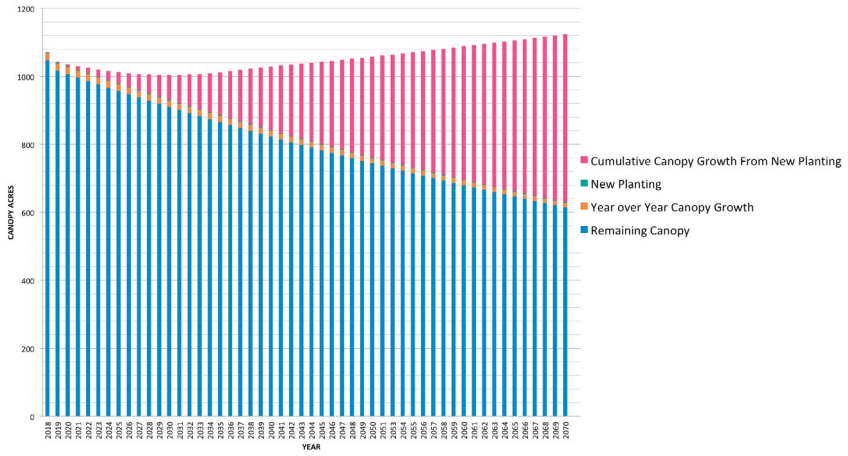
STEMMING LOSS AND GROWING CANOPY

Stem Loss (3%/yr) + Grow Canopy (2,500 trees/yr)



STEMMING LOSS AND GROWING CANOPY

Stem Loss (3%/yr) + Grow Canopy (5,000 trees/yr for 5 yrs then 2,500 trees/yr)



DECISION FRAMEWORK

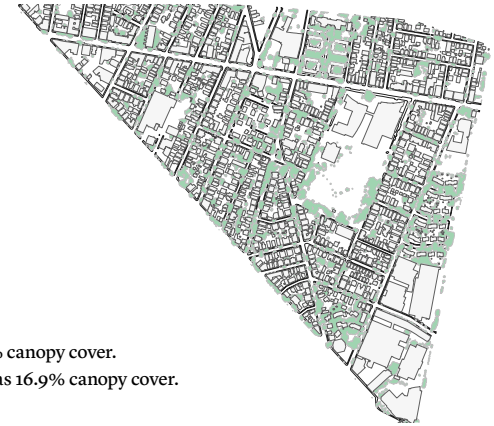
VISION	GOALS	EVALUATIVE CRITERIA	BASELINE	2030 TARGET	2070 TARGET
To build, maintain, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.	**People** A forest that contributes to residents' well-being and residents who contribute to the forest well-being	Enhance shading and cooling			
		Improve pedestrian thermal comfort	Ambient sidewalk temperatures, Connectivity		
		Reduce urban heat island effects	Degrees relative to city avg		
		Increase equity in distribution of canopy cover	Canopy cover by vulnerable population		
		Create pleasing environments	Well-being/stress levels (survey)		
		Increase residents' awareness of value of trees	Engagement, program adoption (survey)		
		Enhance citywide stormwater management	Rainfall interception		
		Increase carbon sequestration	Carbon capture rates		
	Trees A healthy forest whose trees live longer and thrive during predicted changing climate conditions	Improve soils health	Soil quality index		
		Improve tree health	% trees in good health		
		Improve street tree lifespan	Avg life of street tree		
	Forest A forest that supports a resilient, connected ecosystem	Enhance habitat	Canopy connectivity, species census		
		Diversify forest composition	City diversity index		
		Improve disaster response (noreaster, drought)	Projected impact and recovery rates		

STRATEGY MATRIX

GOALS	ACTION	RESPONSE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Strengthen Current Tree Protection Ordinance	Formalize City Practices	Strengthen Zoning Requirements	Strengthen City Planting Programs and Incentives	Align with Envision Cambridge and CCAPS planning studies	Restrict Street Tree Planting to Only Suitable Areas	Create New Opportunities for Street Tree Planting	Implement City-Wide Planting Plans to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
Increase equity in distribution of canopy cover	Curb loss	Mature canopy decline	•			•												
		Commercial land conversion	•		•	•	•		•					•			•	
		Residential loss				•												
		Poor tree condition		•				•				•	•	•	•	•	•	
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Enhance shading and cooling/ improve pedestrian thermal comfort	Curb loss	Narrow sidewalks						•										
		Inadequate soil volume												•				
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Create pleasing environments/ increasing wellbeing improving public health	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Reach	•		•	•	•											•
Ecological connectivity	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Diversify forest composition		New Species List								•					•			
Improve Soil and Tree Health												•	•	•	•	•		
Improve Street Tree Lifespan				•				•				•	•	•	•	•	•	
Improve Disaster Response				•			•			•		•			•	•	•	
Increase Resident Awareness of Value of Trees																•	•	

NEIGHBORHOOD CASE STUDY

Where is there opportunity for planting?



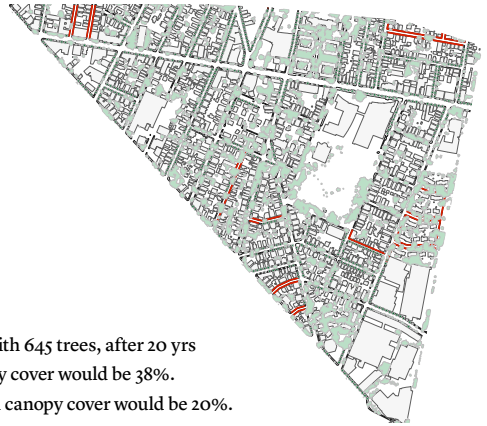
R.O.W. has 29.3% canopy cover.
Neighborhood has 16.9% canopy cover.

STRATEGY MATRIX

GOALS	ACTION	RESPONSE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Strengthen Current Tree Protection Ordinance	Formalize City Practices	Strengthen Zoning Requirements	Strengthen City Planting Programs and Incentives	Align with Envision Cambridge and CCAPS planning studies	Restrict Street Tree Planting to Only Suitable Areas	Create New Opportunities for Street Tree Planting	Implement City-Wide Planting Plans to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
Increase equity in distribution of canopy cover	Curb loss	Mature canopy decline	•			•												
		Commercial land conversion	•		•	•	•		•					•			•	
		Residential loss				•												
		Poor tree condition		•				•				•	•	•	•	•	•	
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Enhance shading and cooling/ improve pedestrian thermal comfort	Curb loss	Narrow sidewalks						•										
		Inadequate soil volume												•				
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Create pleasing environments/ increasing wellbeing improving public health	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Reach	•		•	•	•											•
Ecological connectivity	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Diversify forest composition		New Species List								•					•			

NEIGHBORHOOD CASE STUDY

Planting in the ROW does not sufficiently increase canopy cover



If R.O.W. planted with 645 trees, after 20 yrs
-the R.O.W. canopy cover would be 38%.
-the neighborhood canopy cover would be 20%.

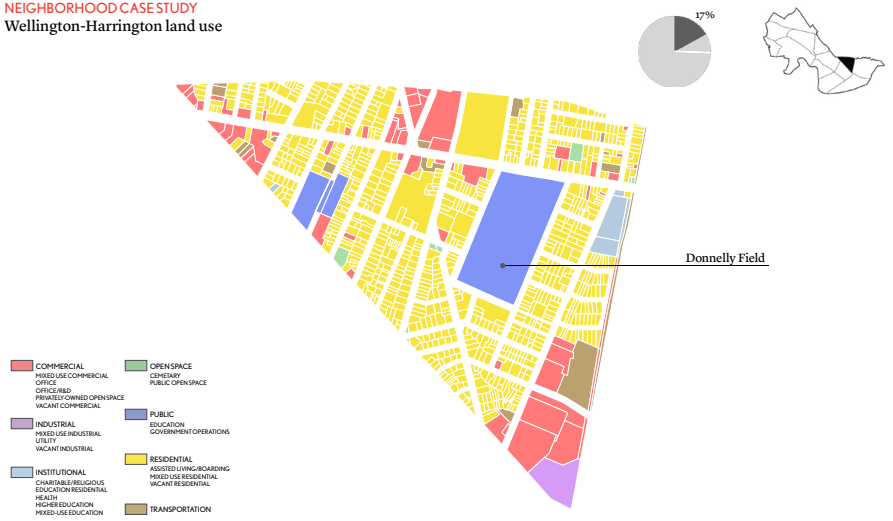
(assuming new tree has 20' diameter canopy after 20 years)

NEIGHBORHOOD CASE STUDY

To increase overall canopy cover more, we need to plant in residential yards, commercial areas, etc.

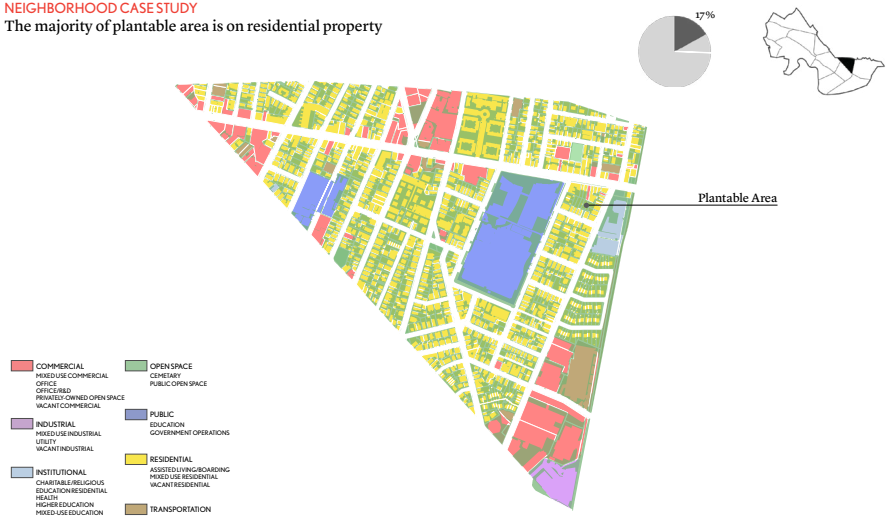
NEIGHBORHOOD CASE STUDY

Wellington-Harrington land use



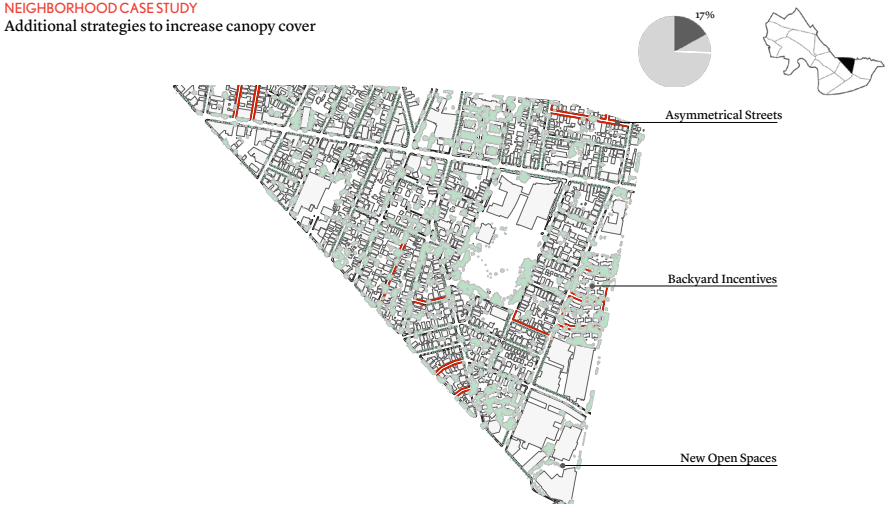
NEIGHBORHOOD CASE STUDY

The majority of plantable area is on residential property



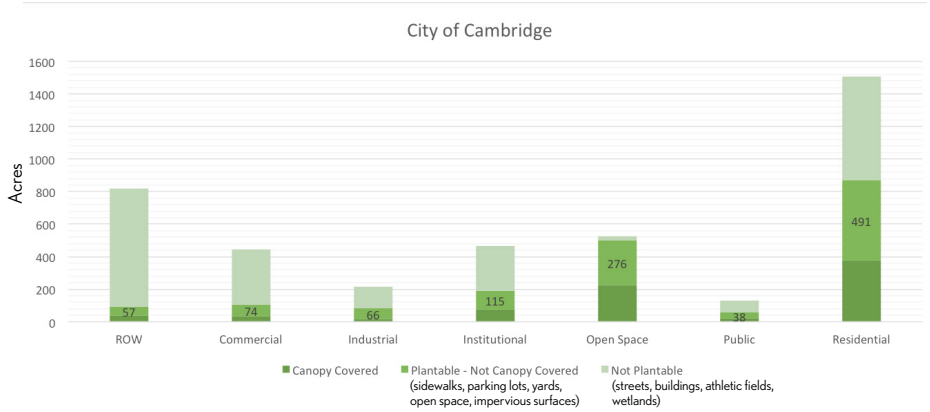
NEIGHBORHOOD CASE STUDY

Additional strategies to increase canopy cover



BEYOND MUNICIPAL TREES

The opportunities for planting are greatest on residential and open space land use types.



STRATEGY MATRIX

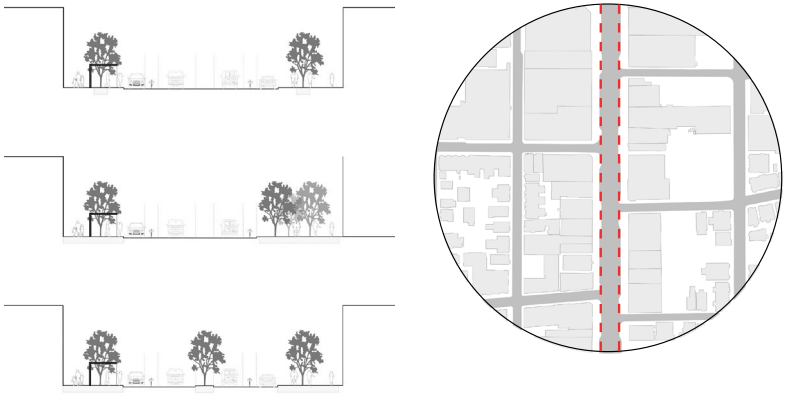
GOALS	ACTION	RESPONSE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			STRATEGIES: Policy				Planning/Design					Practices				Outreach/Other		
			Strengthen Current Tree Protection Ordinance	Formalize City Practices	Strengthen Zoning Requirements	Strengthen City Planting Programs and Incentives	Align with Envision Cambridge and CCPR planning studies	Assess Tree Planting to Only Suitable Areas	Create New Opportunities for Street Tree Planting	Implement City-Wide Planting Plan and Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
Increase equity in distribution of canopy cover	Curb loss	Mature canopy decline	•			•												
		Commercial land conversion	•		•	•	•		•					•			•	
		Residential loss				•												
		Poor tree condition		•				•				•	•	•	•	•	•	
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Enhance shading and cooling/ improve pedestrian thermal comfort	Curb loss	Narrow sidewalks						•										
		Inadequate soil volume												•				
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•									•	•	•
Create pleasing environments/ increasing wellbeing improving public health	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Reach	•		•	•	•									•	•	•
Ecological connectivity	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•									•	•	•
Diversify forest composition		New Species List								•					•			

STREETSCAPE DESIGN

Narrow commercial street

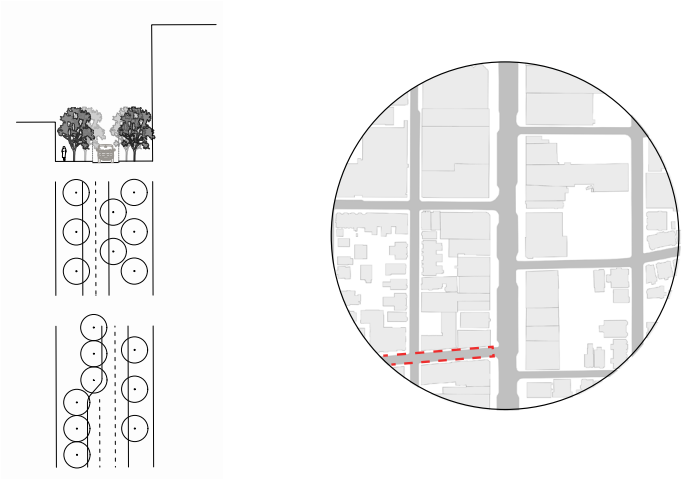
STREETSCAPE DESIGN

Major commercial avenue



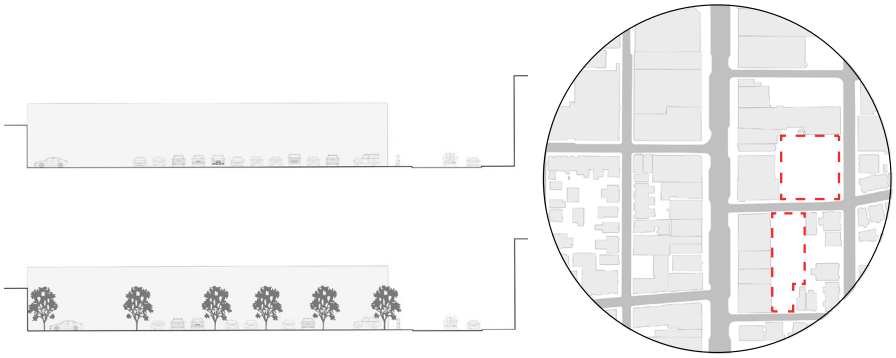
STREETSCAPE DESIGN

Shared street



STREETSCAPE DESIGN

Parking lot

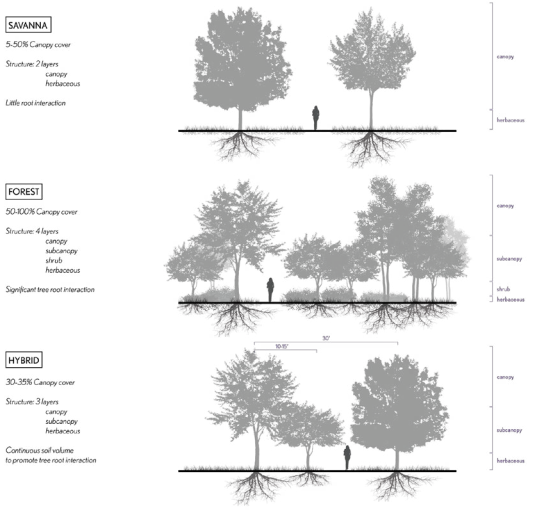


STRATEGY MATRIX

GOALS	ACTION	RESPONSE	Policy 1	2	3	4	Planning/Design 5	6	7	8	9	Practices 10	11	12	13	Outreach/Other 14	15	16
			Strengthen Current Tree Protection Ordinance	Formalize City Practices	Strengthen Zoning Requirements	Strengthen City Planting Programs and Incentives	Align with Envision Cambridge and CDD Heat Island Goals	Restrict Street Tree Planting to Only Suitable Areas	Create New Opportunities for Street Tree Planting	Increase Diversity in Planting Plan to Focus Efforts	Site New Parks/Open Space Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
Increase equity in distribution of canopy cover	Curb loss	Mature canopy decline	•			•												
		Commercial land conversion	•		•	•	•		•					•			•	
		Residential loss				•												
		Poor tree condition		•				•				•	•	•	•	•	•	
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Enhance shading and cooling/ improve pedestrian thermal comfort	Curb loss	Narrow sidewalks						•										
		Inadequate soil volume												•				
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•									•	•	•
Create pleasing environments/ increasing wellbeing improving public health	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Reach	•		•	•	•									•	•	•
Ecological connectivity	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•									•	•	•
Diversify forest composition		New Species List								•					•			

IMPROVE ECOLOGICAL CONDITIONS

Planting design



FROM RESEARCH TO TESTING

SOILS ANALYSIS

CLIMATE MODEL

RESPONSE STRATEGIES

PLANNING SYNERGIES

RESPONSE STRATEGIES | STRATEGY MATRIX

GOALS	ACTION	RESPONSE	1 Strengthen Current Tree Protection Ordinance	2 Formalize City Practices	3 Strengthen Zoning Requirements	4 Strengthen City Planting Programs and Incentives	5 Align with Envision Cambridge and CCPR planning studies	6 Prioritize Tree Planting to Only Suitable Areas	7 Create New Opportunities for Street Tree Planting	8 Implement City-Wide Planting Plan for Public Lots	9 Site New Parks/Open Spaces Strategically	10 Improve City Planting Practices	11 Improve City Maintenance and Care Practices	12 Implement Soils Management Program	13 Monitor Tree Canopy and Adapt	14 Invest in Educational Programs	15 Build Community Partnerships	16 Seek Alternative Green Strategies
			STRATEGIES: Policy				Planning/Design					Practices				Outreach/Other		
Increase equity in distribution of canopy cover	Curb loss	Mature canopy decline	•			•												
		Commercial land conversion	•		•	•	•		•					•			•	
		Residential loss				•												
		Poor tree condition		•				•				•	•	•	•	•	•	
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•											•
Enhance shading and cooling/ improve pedestrian thermal comfort	Curb loss	Narrow sidewalks						•										
		Inadequate soil volume												•				
	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•									•	•	•
Create pleasing environments/ increasing wellbeing improving public health	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Reach	•		•	•	•									•	•	•
Ecological connectivity	Grow canopy	Public	•	•	•	•	•		•	•	•	•	•	•	•			
		Private	•		•	•	•									•	•	•
Diversify forest composition		New Species List								•					•			

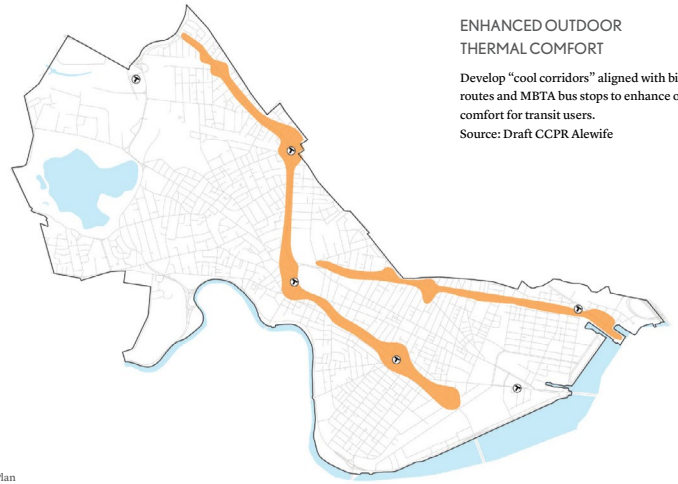
ENVISION – OPEN SPACE NETWORK

Where do you plant to enhance shading and cooling?

Source: Envision Plan

ENVISION – CORRIDORS

Where do you plant to enhance shading and cooling?



ENHANCED OUTDOOR THERMAL COMFORT

Develop "cool corridors" aligned with bike and pedestrian routes and MBTA bus stops to enhance outdoor thermal comfort for transit users.
Source: Draft CCPR Alewife

Source: Envision Plan

CITY EXISTING AND PROPSOED BIKE NETWORK

Where do you plant to enhance shading and cooling?

- Off-street path
- Separated bike facility
- Lower volume/speed
- Existing facility not in bicycle priority network

Source: Cambridge City Bike Plan

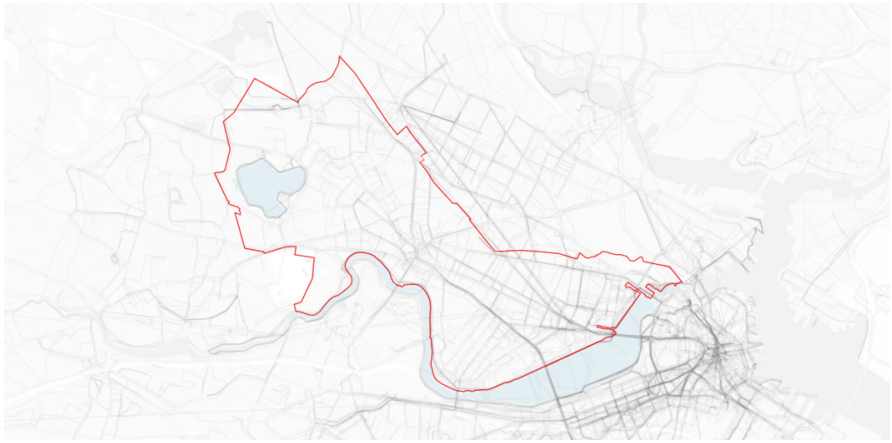
MOST USED RUNNING ROUTES

Where do you plant to enhance shading and cooling?

Source: Cityways, MIT Senseable City Lab

MOST USED WALKING ROUTES

Where do you plant to enhance shading and cooling?



Source: Cityways, MIT Senseable City Lab

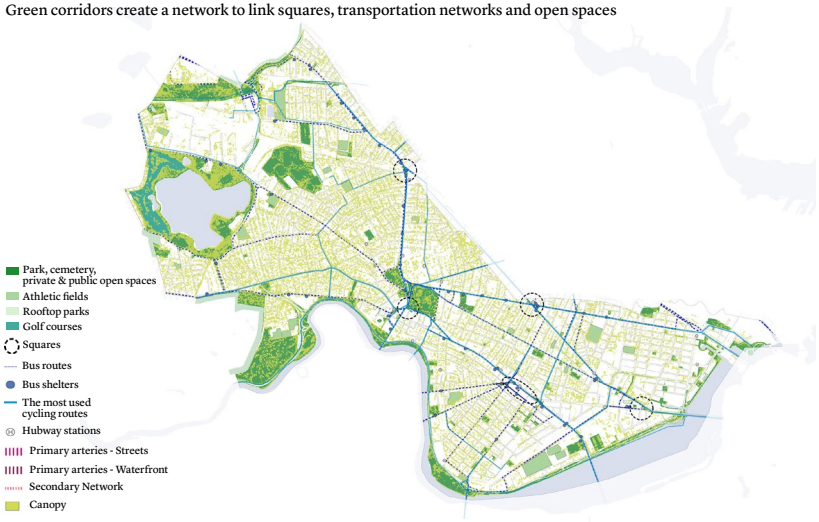
MOST USED CYCLING ROUTES

Where do you plant to enhance shading and cooling?

Source: Cityways, MIT Senseable City Lab

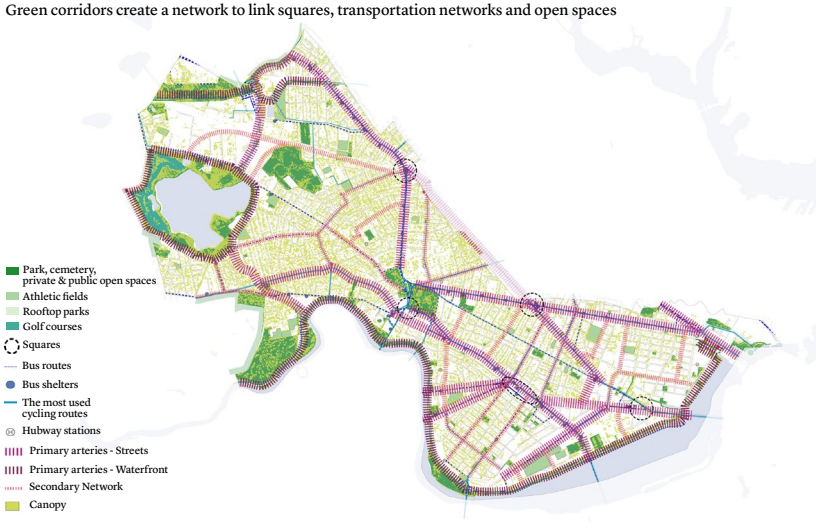
ALIGN URBAN FOREST GOALS AND CITY PLANNING GOALS

Green corridors create a network to link squares, transportation networks and open spaces



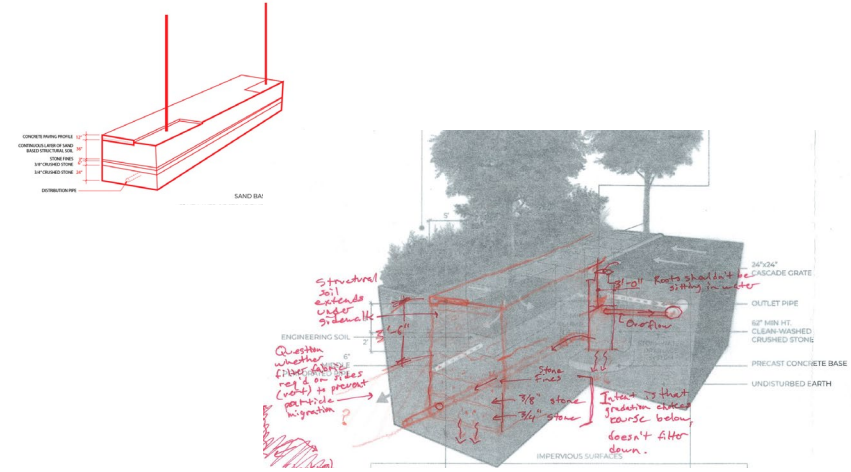
ALIGN URBAN FOREST GOALS AND CITY PLANNING GOALS

Green corridors create a network to link squares, transportation networks and open spaces



CCPR: LINK RESILIENCE AND HORTICULTURAL SUPPORT

Tree plantings as part of stormwater management system

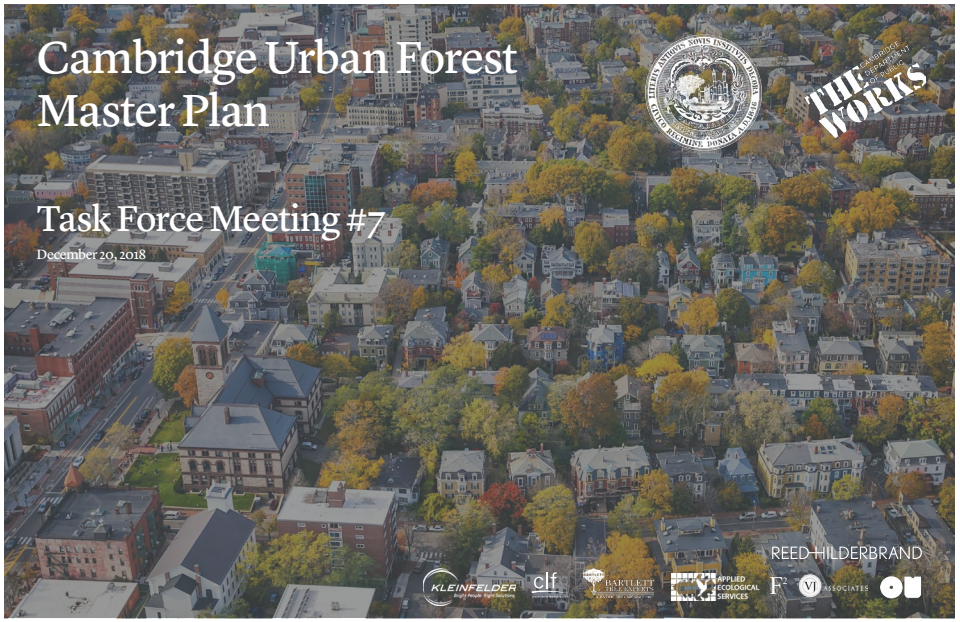


PUBLIC COMMENT

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling
SEPTEMBER 27	RESEARCH: Summary of Findings
OCTOBER 25	Cancelled
NOVEMBER 29	TESTING: Baseline Change Model
DECEMBER 20	TESTING: Impact Analysis
JANUARY 31	PROPOSAL DEVELOPMENT
FEBRUARY 28	PROPOSAL DEVELOPMENT
MARCH 28	DRAFT DOCUMENTATION
APRIL 25	DRAFT DOCUMENTATION

www.cambridgema.gov/ufmp



RESPONSE STRATEGIES | OVERVIEW

There are two primary approaches to reversing the current trend of urban forest contraction —

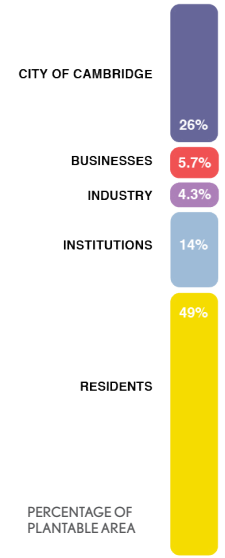
Stem the loss of existing trees

Grow Canopy by planting new trees

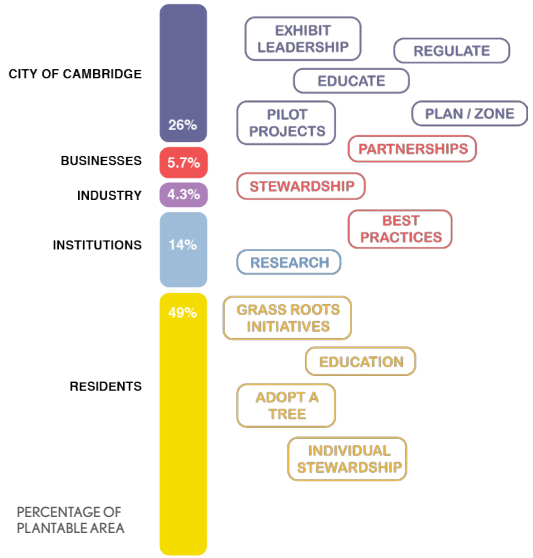
RESPONSE STRATEGIES

		STRATEGIES														
		Policy			Planning/Design					Practices				Outreach/Other		
		Enhance Current Tree Protection Ordinance	Formalize City Practices	Clarify Planning and Zoning	Leverage Envision Cambridge and CCPR planning studies	Restrict Street Tree Planting to Only Suitable Areas	Create New Typologies for Street Tree Planting	Implement City-Wide Planting Plan to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
ACTION	in response to ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
Grow canopy	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	
	Shading and cooling / pedestrian thermal comfort	•	•	•	•		•	•	•	•	•	•	•		•	
	Environmental quality / wellbeing and public health	•	•	•	•		•	•	•	•	•	•	•		•	•
	Ecological connectivity	•		•	•		•	•	•	•	•	•	•			•
	Diversity of forest composition						•	•		•			•			
	Disaster response preparedness				•			•		•			•	•	•	•

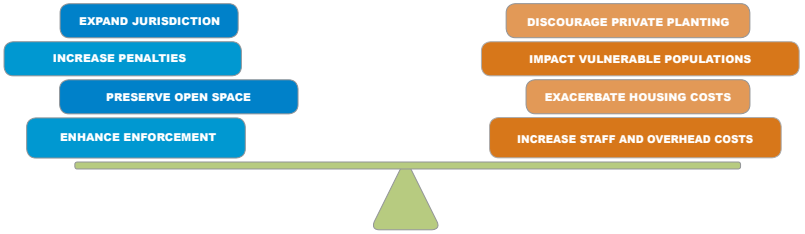
TAKE A MULTI-PRONGED APPROACH



TAKE A MULTI-PRONGED APPROACH



BALANCE COMPETING PRIORITIES

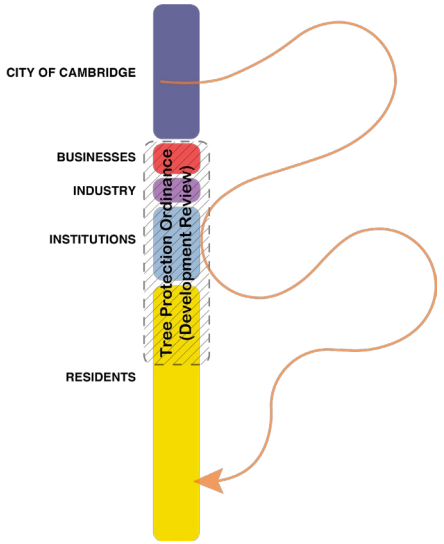


POLICY STRATEGIES

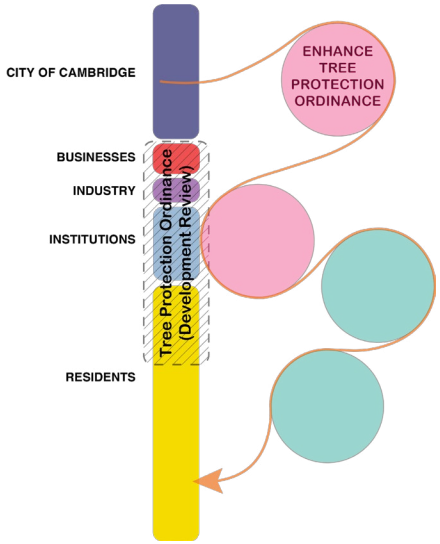
ACTION	in response to ...	STRATEGIES: Policy — 1 Enhance Current Tree Protection Ordinance	2 Formalize City Practices	3 Clarify Planning and Zoning	Planning/Design — 4 Leverage Envision Cambridge and CCPR planning studies	5 Restrict Street Tree Planting to Only Suitable Areas	6 Create New Typologies for Street Tree Planting	7 Implement City-Wide Planting Plan to Focus Efforts	8 Site New Parks/Open Spaces Strategically	Practices — 9 Improve City Planting Practices	10 Improve City Maintenance and Care Practices	11 Implement Soils Management Program	12 Monitor Tree Canopy and Adapt	Outreach/Other — 13 Invest in Educational Programs	14 Build Community Partnerships	15 Seek Alternative Green Strategies
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	

POLICY STRATEGIES – OBSERVATION

Strengthen current Tree Protection Ordinance



POLICY STRATEGIES – OBSERVATION
Strengthen current Tree Protection Ordinance



POLICY STRATEGIES – OBSERVATION
Strengthen current Tree Protection Ordinance

Trees have limited protection in Cambridge.

Only trees greater than 8" dbh require mitigation when part of new development projects.*

* applies to certain multifamily, townhouse and other projects requiring a special permit from the Planning Board or development projects of 25,000 square feet or more.

POLICY STRATEGIES – OPPORTUNITIES
Strengthen current Tree Protection Ordinance

Three Approaches

— Expand jurisdiction

— Increase deterrence

— Enhance mitigation

POLICY STRATEGIES – OPPORTUNITIES
Expand the **jurisdiction** of the Current Tree Protection Ordinance

Redefine "Significant Trees"

Add "Exceptional Tree" protections

Add triggers to expand the application of the Ordinance

Expand to all properties

POLICY STRATEGIES

If the city were to redefine **Significant Trees** to 6" dbh, it would expand the number of trees captured by the ordinance by approximately 49%.

8" DBH OR GREATER

6" DBH OR GREATER

For Example:
Atlanta; Seattle; Oakland, FL
Concord, Lexington, and Brookline
(Massachusetts)

POLICY STRATEGIES

If the city were to add an **Exceptional Trees** category that received additional scrutiny, this could reduce removals of very large, old, or special trees.

HERITAGE TREES, SEATTLE, WA

JACK LONDON OAK TREE, 100 YEARS OLD OAKLAND, CA

Potential Criteria:
Size, Age, Species, Location, Historical Significance

Precedents:
Seattle, Atlanta, Washington DC

POLICY STRATEGIES

Add **triggers** to expand the application of the Ordinance

Potential Triggers

— Number of trees to be removed

— Area of new impervious surface

— Project size

POLICY STRATEGIES

Expand jurisdiction to all **private properties**

Data shows that the majority of canopy loss is not happening on development sites but on private residences. Many cities across the country, and some locally, have expanded their tree protection ordinances to apply to all properties including those that are not currently being developed/redeveloped.

Pros

- Expands city's jurisdiction for tree protection and mitigation
- Fee associated with a tree removal permit could offset city's enforcement costs

Cons

- Increase cost and resources for the city to enforce the ordinance
- Costs associated with a lawful removal of a tree on private property (tree removal permit) could be unaffordable for the average property owner
- Could discourage property owners from planting new trees

POLICY STRATEGIES – DISCUSSION

Expand the **jusidiction** of the current Tree Protection Ordinance

Redefine "Significant Trees"

Add "Exceptional Tree" protections

Add triggers to expand the application of the Ordinance

Expand to all properties

POLICY STRATEGIES – OBSERVATION

Strengthen **mitigation** requirements for removals

To remove a Significant Tree, a property developer must either replace the tree on site or pay into the Tree Fund.

POLICY STRATEGIES – OBSERVATION

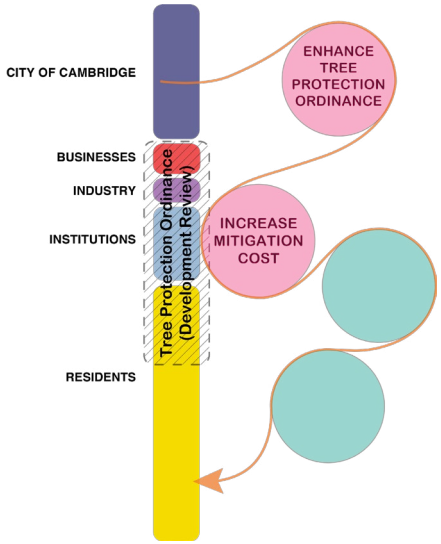
Strengthen **mitigation** requirements for removals

Current cost of mitigation is based on the cost of planting a number of 3" cal trees, approximately $1,500 per tree.

There is little incentive for a developer to minimize tree removal or to replant on site.

POLICY STRATEGIES – OBSERVATION

Strengthen **mitigation** requirements for removals



POLICY STRATEGIES – OPPORTUNITIES

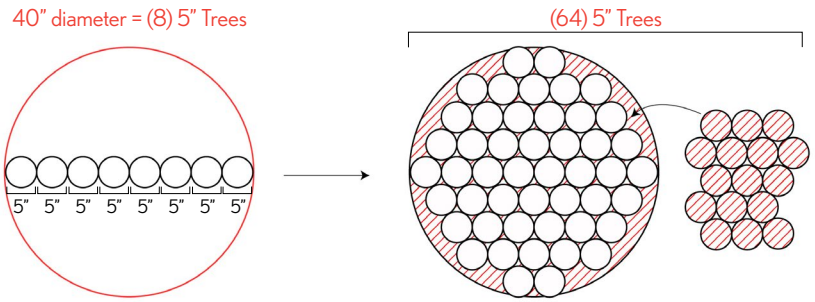
Increase deterrence — Strengthen **mitigation** requirements for removals

Develop more stringent requirements for replacing on site

Develop a more robust valuation process for off-site mitigation

POLICY STRATEGIES

Calculate tree replacement by **trunk area** rather than by diameter



Replacing trees by "caliper inch"

Replacing trees by "trunk area"

POLICY STRATEGIES

Consider alternative **valuation** strategies

REPLACEMENT COST

i-Tree Planting

ECOSYSTEM SERVICES

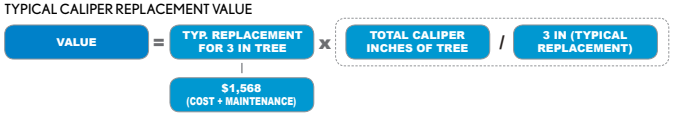
NYC Parks

CUSTOMIZED

POLICY STRATEGIES

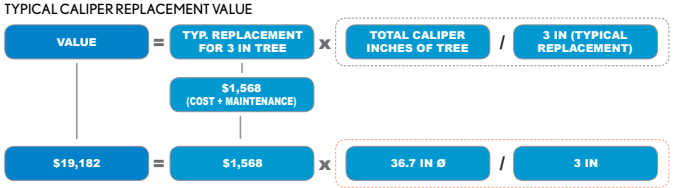
Increase mitigation costs to reflect lost value

TYPICAL CALIPER REPLACEMENT VALUE



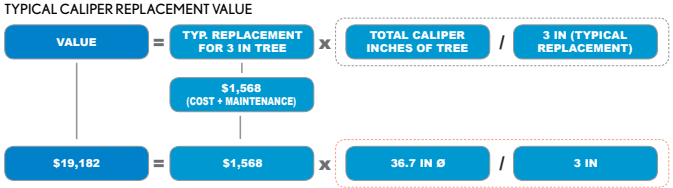
POLICY STRATEGIES
Increase mitigation costs to reflect lost value

TYPICAL CALIPER REPLACEMENT VALUE

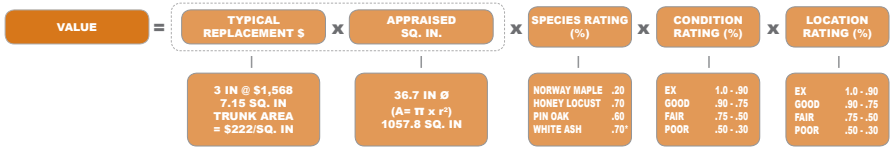


POLICY STRATEGIES
Increase mitigation costs to reflect lost value

TYPICAL CALIPER REPLACEMENT VALUE

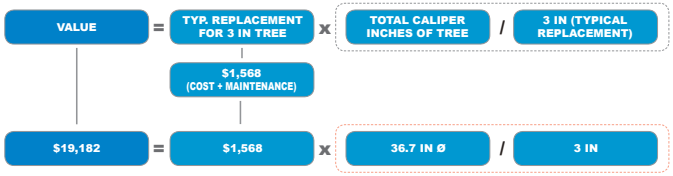


WEIGHTED TRUNK AREA REPLACEMENT VALUE

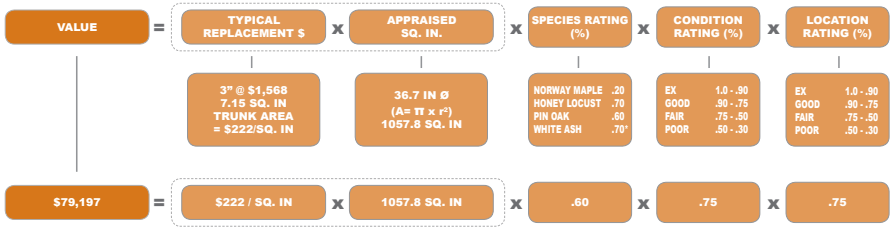


POLICY STRATEGIES
Increase mitigation costs to reflect lost value

TYPICAL CALIPER REPLACEMENT VALUE



WEIGHTED TRUNK AREA REPLACEMENT VALUE



POLICY STRATEGIES – DISCUSSION
Increase deterrence — Strengthen **mitigation** requirements for removals

Develop more stringent requirements for replacing on site

Develop a more robust valuation process for off-site mitigation

POLICY STRATEGIES – OBSERVATION
Increase **oversight** to ensure compliance

Currently, there is limited City oversight to ensure compliance.

The Tree Protection Ordinance does not currently define standards for tree protection during construction.

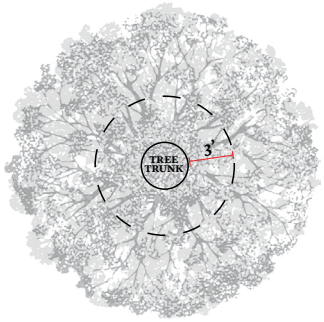
POLICY STRATEGIES – OPPORTUNITIES
Increase **oversight** to ensure compliance

Require increased offset from tree dripline to protect tree roots

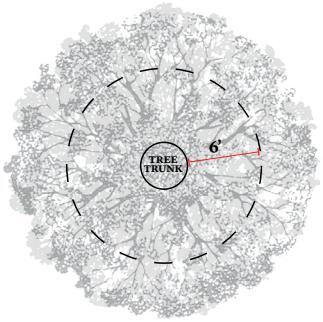
Require periodic review per an order of conditions to improve tree protection measures (fencing, watering) during construction

Require city arborist/city engineer inspection prior to obtaining Certificate of Occupancy

POLICY STRATEGIES
Expand Root Protection Zone

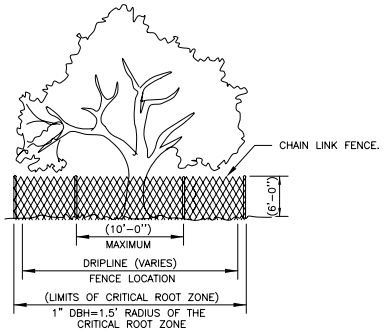


Current protection: 3' from trunk



Proposed protection: 6' from trunk

POLICY STRATEGIES
Trust but verify — Increase **inspections**



POLICY STRATEGIES – DISCUSSION
Increase oversight to ensure compliance

Require increased offset from tree dripline to protect tree roots

Require periodic review per an order of conditions to improve tree protection measures (fencing, watering) during construction

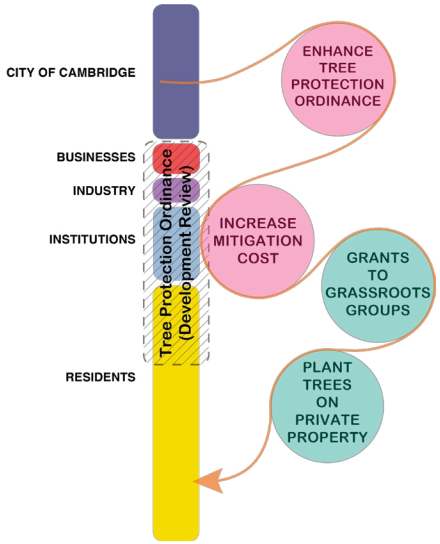
Require city arborist/city engineer inspection prior to obtaining Certificate of Occupancy

POLICY STRATEGIES – OBSERVATION
Engage with private property owners

While a significant proportion of canopy loss is taking place on private residential lots, the City does not have a way to directly **plant trees on private properties** outside of the Back of Sidewalk Program.

Under state law the city is only permitted to plant Public Shade Trees (with property owner consent) up to 20 feet from the public right-of-way. This limits the potential planting area for the Back of Sidewalk Program. In addition, the permanent protections afforded to Public Shade Trees may deter property owners from wanting to participate in the program.

POLICY STRATEGIES – OBSERVATION
Engage with private property owners



POLICY STRATEGIES – OBSERVATION
Engage with private property owners

Empower grass-roots community organizations and NGOs to plant trees on private property with grants from the Tree Fund.

Align grants with priority planting areas.

POLICY STRATEGIES – OBSERVATION

Leverage existing community organizations

Green Cambridge's Tree Task Force / Tree Group Advocates
Charles River Watershed Association
Charles River Conservancy
The Cambridge Community Gardens
A Better Cambridge
Cambridge Residents Alliance
Agassiz Baldwin Community
East Cambridge Planning Team
East End House
Neighborhood Association of East Cambridge
Mid-Cambridge Neighborhood Association
Cambridgeport Neighborhood Association
Cambridge Residents Alliance
Wellington-Harrington Neighborhood Association
Area Four Neighborhood Coalition
Essex Street Neighbors
Margaret Fuller House
Cambridge Community Center
Riverside Neighborhood Association
Mystic River Watershed Association
Taylor Square Neighborhood Association
Fresh Pond Residents Alliance
North Cambridge Stabilization Committee
Cambridge Highlands Neighborhood Association
Harvard Square Neighborhood Association
Inman Square Neighborhood Association
Porter Square Neighbors Association
Central Square Business Association

CITY PRACTICES

CITY PRACTICES – OBSERVATION

Formalize Internal City Priorities and Practices

The Committee on Public Planting is an existing city-sanctioned body that could build on the work of the Urban Forest Master Plan.

CITY PRACTICES – OPPORTUNITIES

Formalize Internal City Priorities and Practices

Provide the Public Planting Committee with resources to extend the discussion of subjects raised by the UFMP, including

— interpreting recommendations
— updating analysis based on current research
— reviewing pilot projects
— reviewing progress toward targets

CITY PRACTICES – OPPORTUNITIES
Formalize Internal City Priorities and Practices

Set up technical review panel to meet with the Public Planting Committee periodically to provide assistance and support, per the model of the Chicago Region Trees Initiative ...

Executive Advisory Council

CITY PRACTICES – OBSERVATION
Formalize Internal City Priorities and Practices

Many concurrent planning efforts have overlapping but different priorities.

As the city determines top priorities, we should consider formalizing which efforts and initiatives take priority over others.

CITY PRACTICES – OBSERVATION
Integrate equity and environmental justice criteria

New City tree plantings occur by request and at the discretion of the City Arborist.

This may have the unintended consequence that some areas of the City have fewer new street trees than others.

CITY PRACTICES
Integrate equity and environmental justice criteria

Boston's rich and poor neighborhoods show sidewalk repair disparity

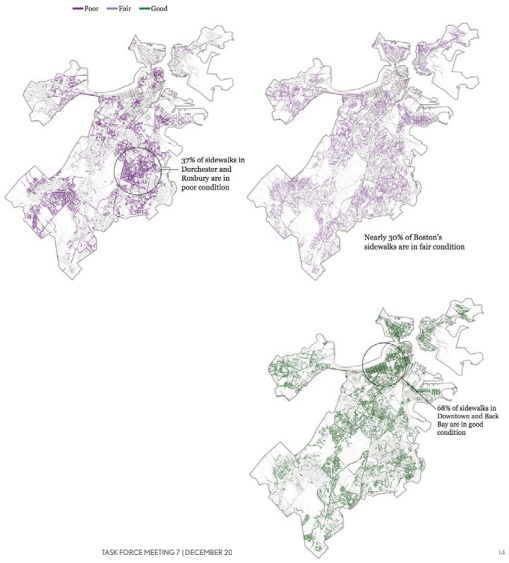
JESSICA RINALDI/GLOBE STAFF

The sidewalk outside of the entrance to the playground behind the Trotter School in Dorchester is a spiderweb of cracks.

By Meghan E. Irons | GLOBE STAFF MARCH 04, 2018

The divide between the haves and have-nots in Boston has always been stark, often measured by the quality of schools and the safety of streets.

Source: The Boston Globe



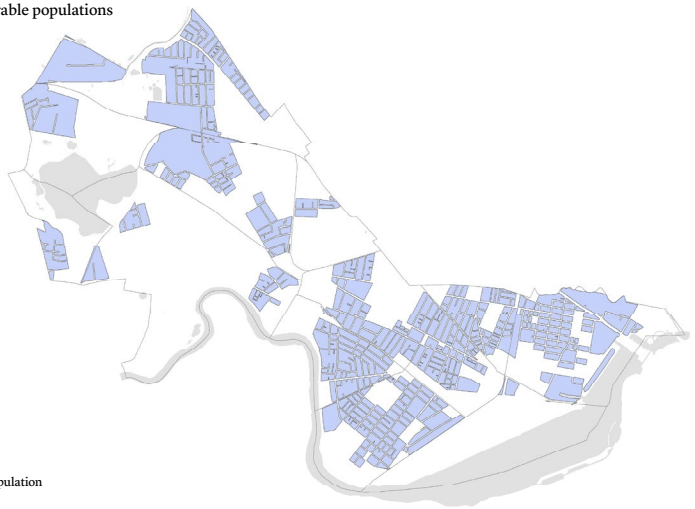
CITY PRACTICES

Integrate equity and environmental justice criteria

Define priority areas and target outreach/city funded planting to align with equity and planning goals.

PLANTING PRIORITY AREAS

Environmentally vulnerable populations



CRITERIA 1

Minority population
Low income population
Non English speaking population

PLANTING PRIORITY AREAS

Heat island hotspots

CRITERIA 2

Greater than 92 degrees
on a 90 degree day
as modeled by KLF for 2030
ambient air temperature

PLANTING PRIORITY AREAS

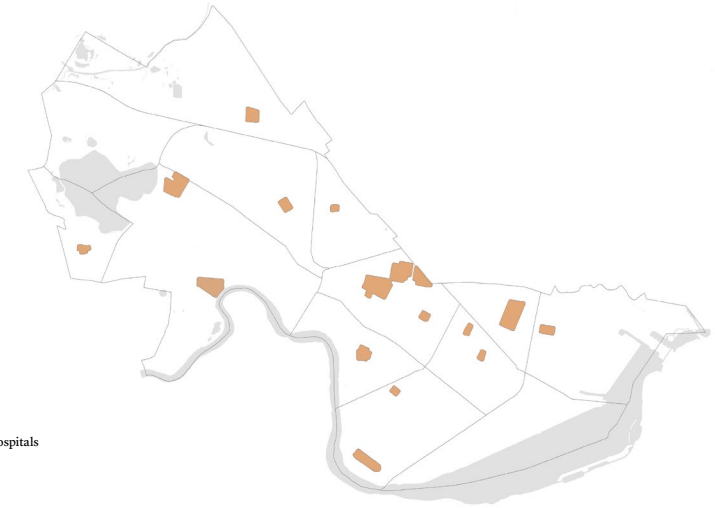
Transportation corridors

CRITERIA 3

Highest concentration of
pedestrian and bike traffic
and important corridors for
connecting green spaces

PLANTING PRIORITY AREAS

Social infrastructure

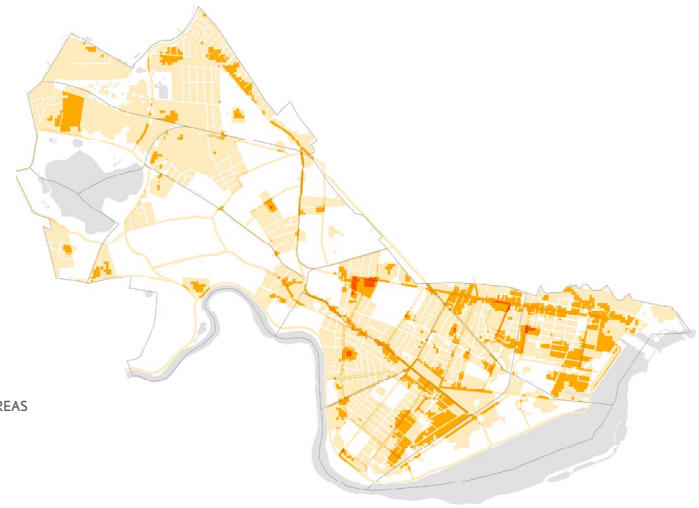


CRITERIA 4

Public Schools and Hospitals

PLANTING PRIORITY AREAS

Overlap of criterias

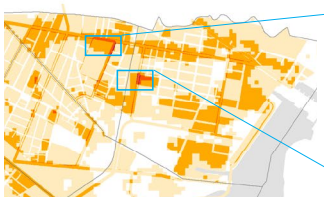


PLANTING PRIORITY AREAS

Highest Priority
High Priority
Medium Priority

PLANTING PRIORITY AREAS

High priority area (example)



CAMBRIDGE STREET & COLUMBIA STREET

FULKERSON STREET

POLICY STRATEGIES 3

		STRATEGIES														
		Policy			Planning/Design					Practices				Outreach/Other		
		Enhance Current Tree Protection Ordinance	Formalize City Practices	Clarify Planning and Zoning	Leverage Envision Cambridge and CDP Planning Efforts	Restrict Street Tree Planting to Only Suitable Areas	Create New Typologies for Street Tree Planting	Implement City-Wide Planting Plan to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
ACTION	In response to ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	

PLANNING STRATEGIES – OBSERVATIONS
Broaden and align zoning requirements

Tree protections and new planting mandates are scattered throughout Cambridge's Zoning Ordinances.

Requirements are tied to specific site uses (such as construction of a parking garage) and districts (such as the Parkway Overlay District).

PLANNING STRATEGIES – OPPORTUNITIES
Broaden and align zoning requirements

Consolidating requirements into a single tree-related zoning article could increase compliance and consistency.

PLANNING STRATEGIES
Broaden and align zoning requirements

Parking Lot Tree Planting — Article 6 (6.48.1)

The off street parking facility shall contain at least one tree, a minimum of 3" caliper at planting and shall be suitable for location in parking lots. Existing and new trees shall be protected by bollards, high curbs or other barriers sufficient to minimize damage.

Front Yards — Article 20 (20.66.4)

Front yards must contain at least one three-inch caliper tree for every twenty-five linear feet of street frontage. Each tree planted in a paved area shall have a minimum of fifty square feet of porous surface area surrounding the tree.

PLANNING STRATEGIES
Broaden and align zoning requirements

Setbacks and Open Space — Article 5

In a multifamily residential district, two of the yards on a lot shall consist entirely of green area, including permanently maintained trees and shrubs.

Article 5 also mandates a 20-foot setback requirement for business lots abutting a residential district. This setback is to consist exclusively of landscaped green area, including permanently maintained trees and shrubs.

Consolidate and strengthen zoning ordinances relating to trees. Define performance characteristics for ...

— overlay districts
— canopy cover by land use
— setback/open space by land use
— parking space/tree ratios
— develop a Green Factor evaluation tool

Current zoning requires one tree for every 25 feet of frontage and at least fifty square feet of porous surface around the tree within the Parkway and Prospect Street Overlay Districts.

Create an "urban heat" or "urban forest" overlay district and have this standard apply across the city in high priority planting areas.

Salem, VA has an "urban forest" overlay district to increase the quantity of trees in new development along seven designated corridors. New development is required to have at least one tree per acre and at least one tree per 100 feet of frontage.

NYC requires one new tree for every 25 feet of frontage for all new buildings and enlargements exceeding 20 percent of floor space as a condition of occupancy.

Create canopy coverage requirements for lots by land use type and / or for open spaces

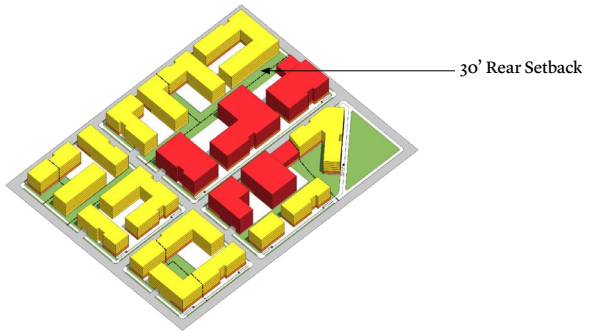
Zoning District	Providence, RI
Residential	30%
Open Space	30%
Downtown (Business)	15%
Institutional	30%
All Others	15%

Population: 180,393
Population Density: 9,803/square mile

Land Use	Chapel Hill, NC
Multi-Family Residential	30%
Commercial	30%
Mixed Use	40%
Institutional	40%

Population: 59,862
Population Density: 2,850/square mile

Increase setback and open space requirements in high priority areas to increase suitable planting areas



Source: Alewife District Plan - Envision Cambridge

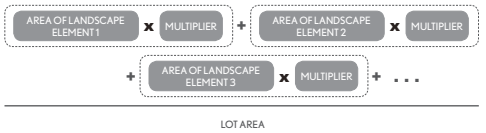
PLANNING STRATEGIES – OPPORTUNITIES

Increase **parking lot** cover

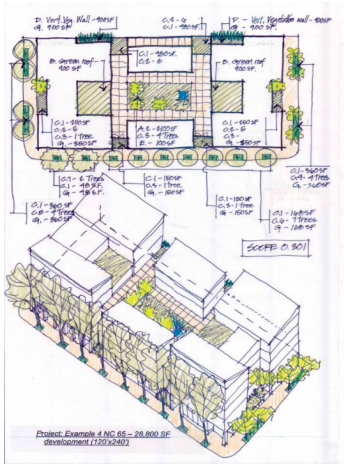
PORTER SQUARE, CAMBRIDGE

PLANNING STRATEGIES – OPPORTUNITIES

Develop a "**Green Factor**" rating system



Seattle Green Factor and Washington DC Green Area Ratio are alternative ways to promote new plantings while providing flexibility for sites where planting new trees (or many new trees) may not be feasible.



PLANNING STRATEGIES – DISCUSSION

Broaden and align Zoning Requirements

Consolidate and strengthen zoning ordinances relating to trees. Define performance characteristics for ...

— overlay districts

— canopy cover by land use

— setback/open space by land use

— parking space/tree ratios

— develop a Green Factor evaluation tool

RESPONSE STRATEGIES

		STRATEGIES														
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Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
Grow canopy	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	
	Shading and cooling / pedestrian thermal comfort	•	•	•	•		•	•	•	•	•	•	•		•	
	Environmental quality / wellbeing and public health	•	•	•	•		•	•	•	•	•	•	•		•	•
	Ecological connectivity	•		•	•		•	•	•	•	•	•	•			•
	Diversity of forest composition						•	•		•			•			
	Disaster response preparedness				•			•		•			•	•	•	•

PUBLIC COMMENT

www.cambridgema.gov/ufmp

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling
SEPTEMBER 27	RESEARCH: Summary of Findings
OCTOBER 25	Cancelled
NOVEMBER 29	TESTING: Baseline Change Model
DECEMBER 20	PROPOSAL DEVELOPMENT
JANUARY 31	PROPOSAL DEVELOPMENT
FEBRUARY 28	PROPOSAL DEVELOPMENT
MARCH 28	DRAFT DOCUMENTATION
APRIL 25	DRAFT DOCUMENTATION

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PUBLIC SURVEY

POLICY

PRACTICES

PUBLIC SURVEY

POLICY

PRACTICES

SURVEY RESULTS | OVERVIEW

1,643 total respondents over three month period (Sept. 5 - Dec. 6, 2018)

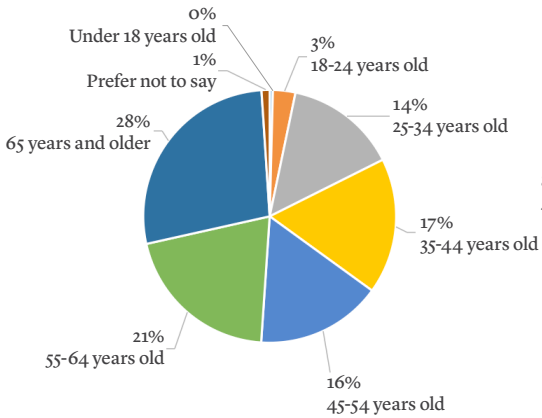
Based on self-selected, not random, sample

Survey offered in eight languages
(only six surveys completed in a language other than English)

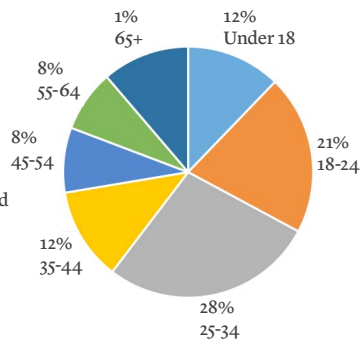
Question types:
- Perceptions of existing tree canopy and condition
- Awareness of existing programs and policies
- Attitudes toward tree preservation and growth

SURVEY RESULTS | OVERVIEW

Repondents represent a broad cross section of ages



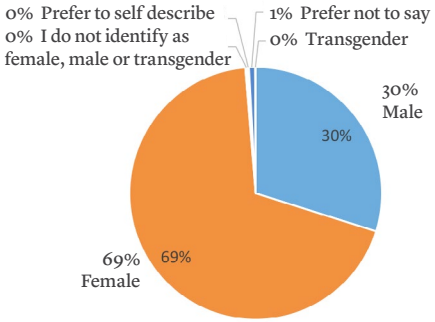
SURVEY DEMOGRAPHICS



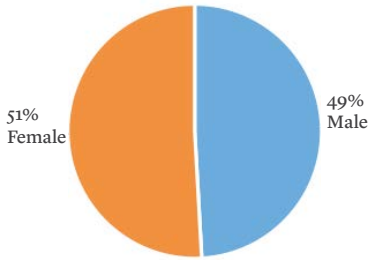
CENSUS DEMOGRAPHICS

SURVEY RESULTS | OVERVIEW

69% of respondents were women



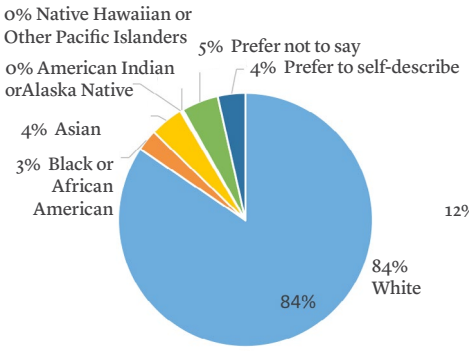
SURVEY DEMOGRAPHICS



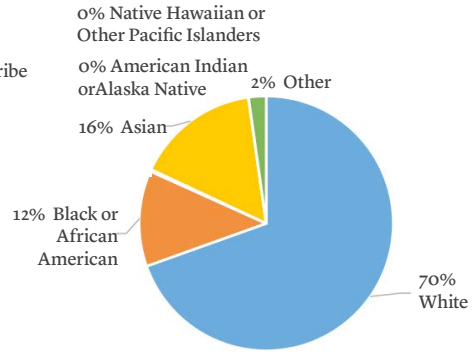
CENSUS DEMOGRAPHICS

SURVEY RESULTS | OVERVIEW

85% of respondents were white



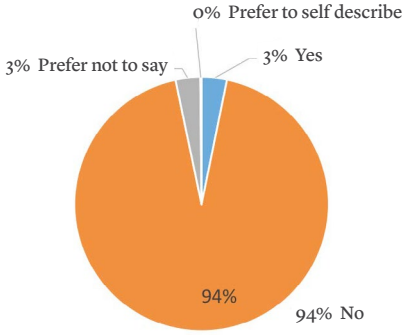
SURVEY DEMOGRAPHICS



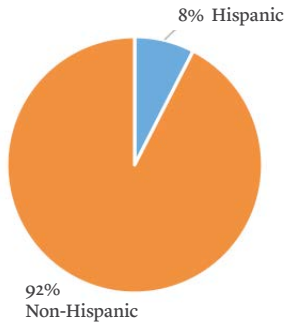
CENSUS DEMOGRAPHICS

SURVEY RESULTS | OVERVIEW

3% of respondents identify as Hispanic



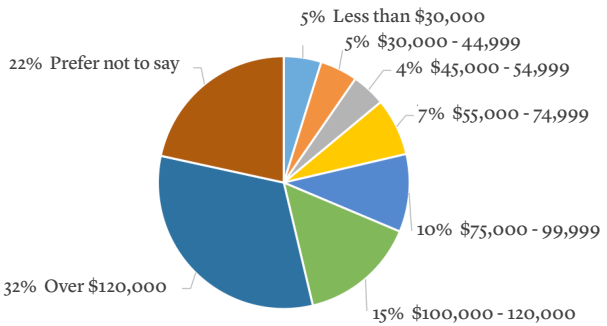
SURVEY DEMOGRAPHICS



CENSUS DEMOGRAPHICS

SURVEY RESULTS | OVERVIEW

47% of respondents earn more than $100,000
Median household income is $83,122



SURVEY DEMOGRAPHICS

SURVEY RESULTS | OVERVIEW

Based on the findings of the Public Survey:

What are the **opportunities** or **constraints** around

stemming the loss of existing trees or

growing canopy by planting new trees?

SURVEY RESULTS | VALUE

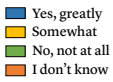
Respondents generally understand

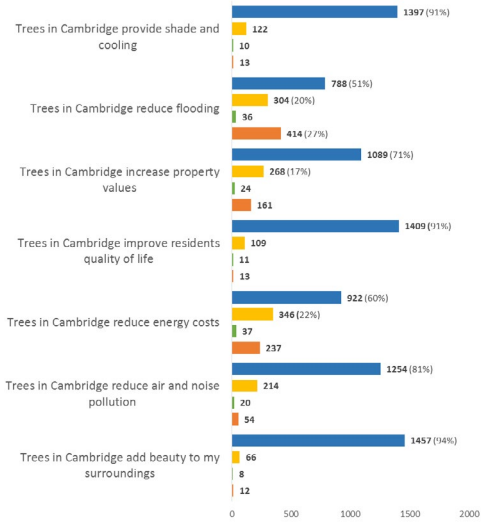
the value of trees in the urban environment.

SURVEY RESULTS | VALUE

Benefits of Trees

"In your opinion, how do Cambridge's trees contribute to the following items?"



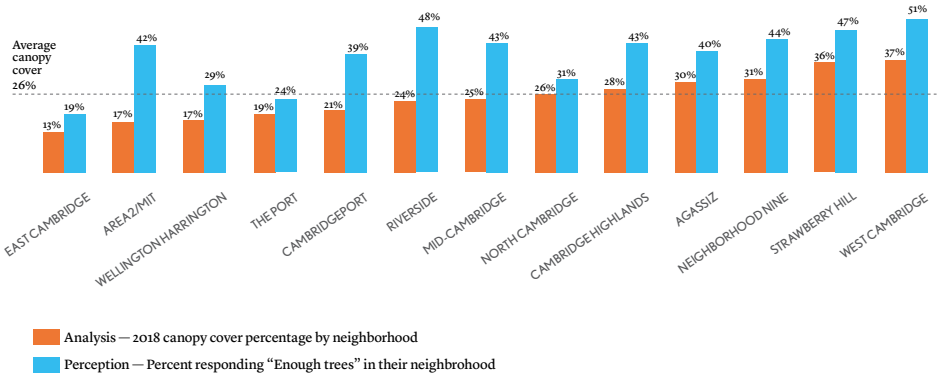


Respondents generally believe there are

not enough trees in the city,

especially in neighborhoods with less than average

canopy cover.

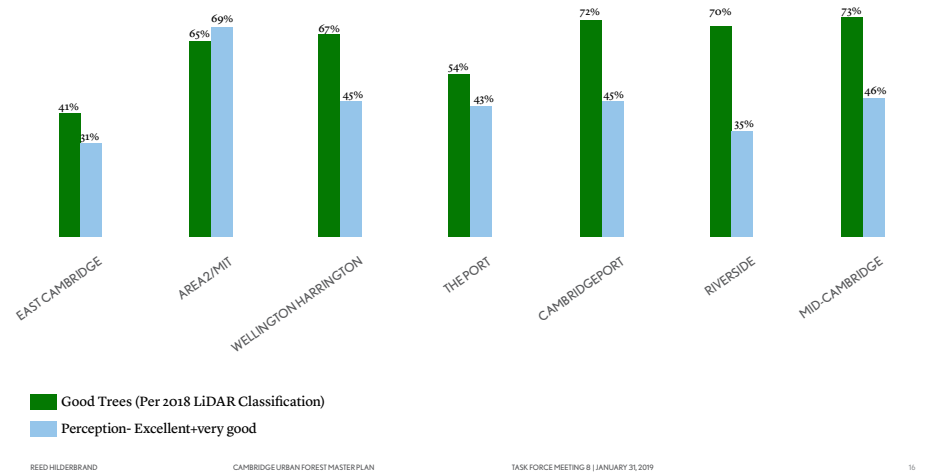


Respondents generally believe city trees

are **not as healthy** as they should be,

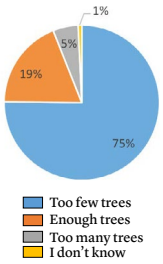
especially in neighborhoods with less than average

canopy cover.



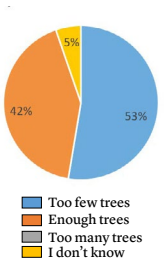
SURVEY RESULTS | CANOPY COVER
East Cambridge — 13% Coverage

"In your opinion, which best describes the amount of trees in your neighborhood?"



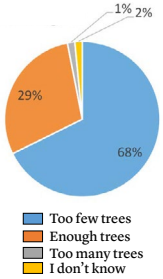
SURVEY RESULTS | CANOPY COVER
Area 2 / MIT — 17% Coverage

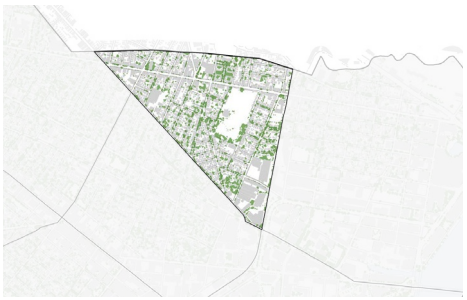
"In your opinion, which best describes the amount of trees in your neighborhood?"



SURVEY RESULTS | CANOPY COVER
Wellington-Harrington — 17% Coverage

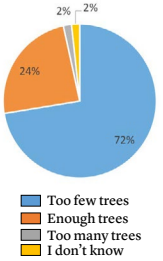
"In your opinion, which best describes the amount of trees in your neighborhood?"

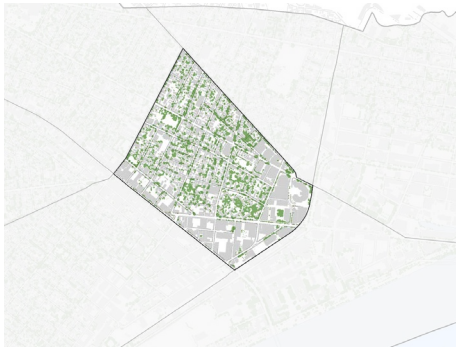




SURVEY RESULTS | CANOPY COVER
The Port — 19% Coverage

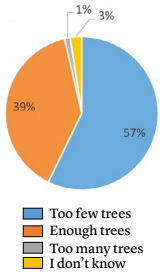
"In your opinion, which best describes the amount of trees in your neighborhood?"





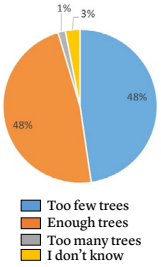
SURVEY RESULTS | CANOPY COVER
Cambridgeport — 21% Coverage

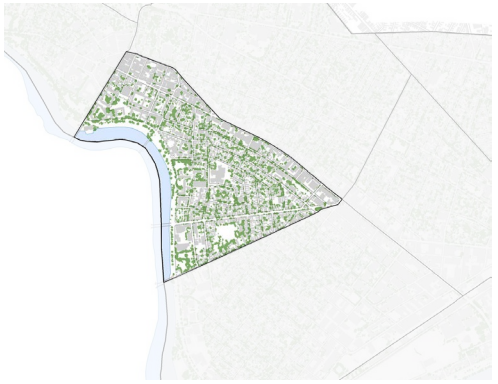
"In your opinion, which best describes the amount of trees in your neighborhood?"



SURVEY RESULTS | CANOPY COVER
Riverside — 24% Coverage

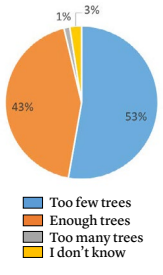
"In your opinion, which best describes the amount of trees in your neighborhood?"





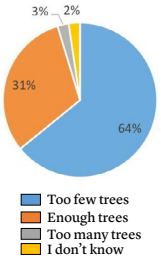
SURVEY RESULTS | CANOPY COVER
Mid-Cambridge — 25% Coverage

"In your opinion, which best describes the amount of trees in your neighborhood?"



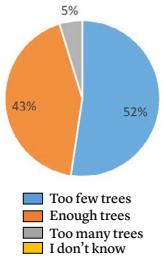
SURVEY RESULTS | CANOPY COVER
North Cambridge — 26% Coverage

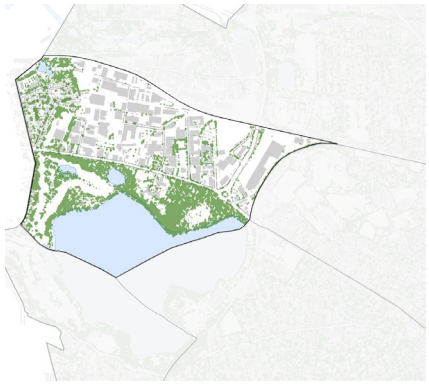
"In your opinion, which best describes the amount of trees in your neighborhood?"



SURVEY RESULTS | CANOPY COVER
Cambridge Highlands — 28% Coverage

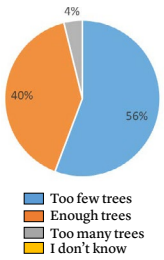
"In your opinion, which best describes the amount of trees in your neighborhood?"

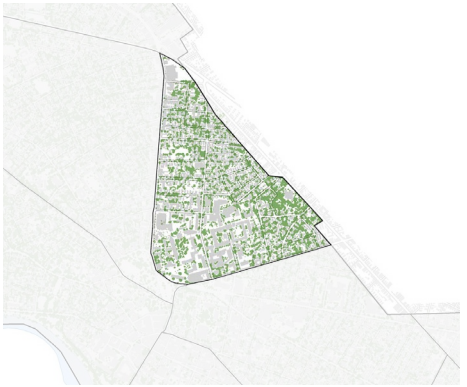




SURVEY RESULTS | CANOPY COVER
Agassiz — 30% Coverage

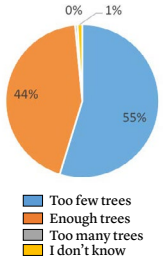
"In your opinion, which best describes the amount of trees in your neighborhood?"





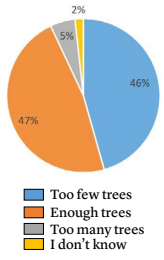
SURVEY RESULTS | CANOPY COVER
Neighborhood Nine — 31% Coverage

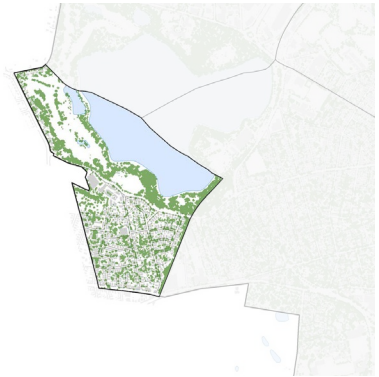
"In your opinion, which best describes the amount of trees in your neighborhood?"



SURVEY RESULTS | CANOPY COVER
Strawberry Hill — 36% Coverage

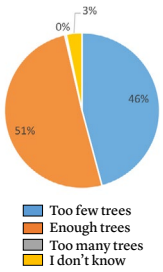
"In your opinion, which best describes the amount of trees in your neighborhood?"





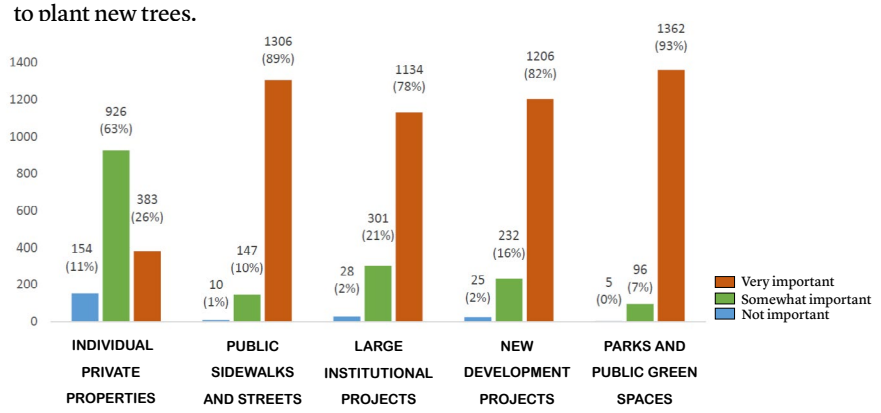
SURVEY RESULTS | CANOPY COVER
West Cambridge — 37% Coverage

"In your opinion, which best describes the amount of trees in your neighborhood?"

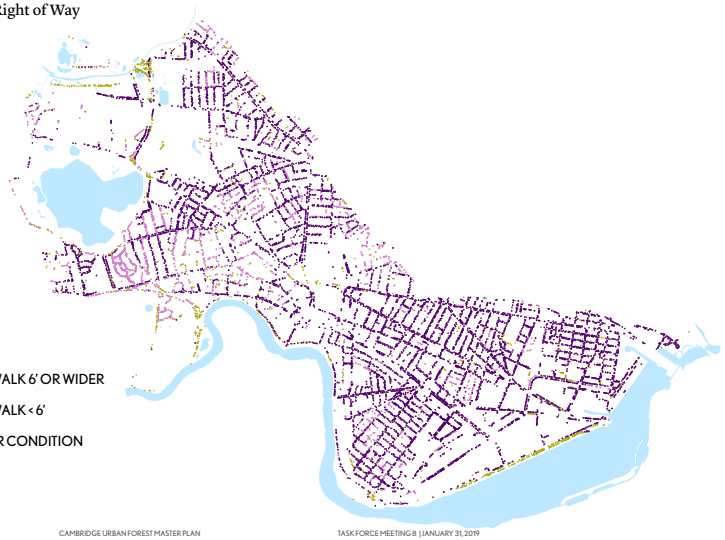


SURVEY RESULTS | CANOPY PRIORITIES

A majority (55%) stated that **public sidewalks and streets** were the **single most important** location to plant new trees when asked a follow up question about the single most important location to plant new trees.

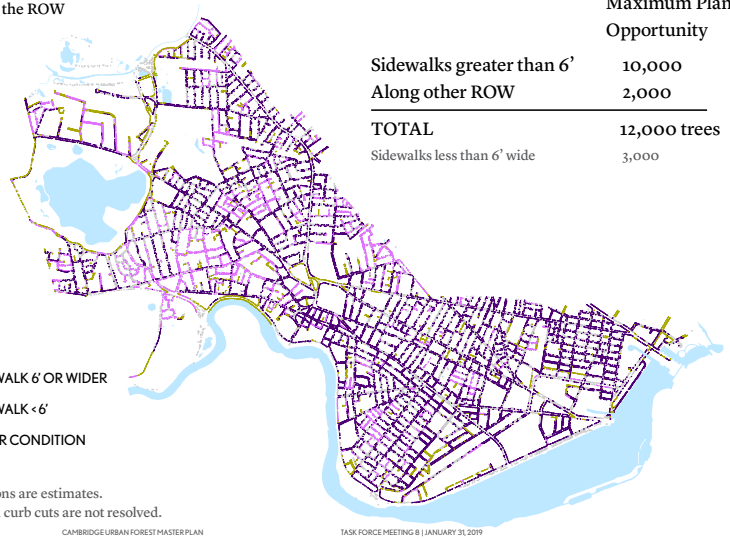


ANALYSIS | PUBLIC REALM CANOPY COVER
Current trees in the Right of Way



- STREET TREE ON SIDEWALK 6' OR WIDER
- STREET TREE ON SIDEWALK < 6'
- ROW TREE IN ANOTHER CONDITION

ANALYSIS | PUBLIC REALM CANOPY COVER
Potential Planting in the ROW



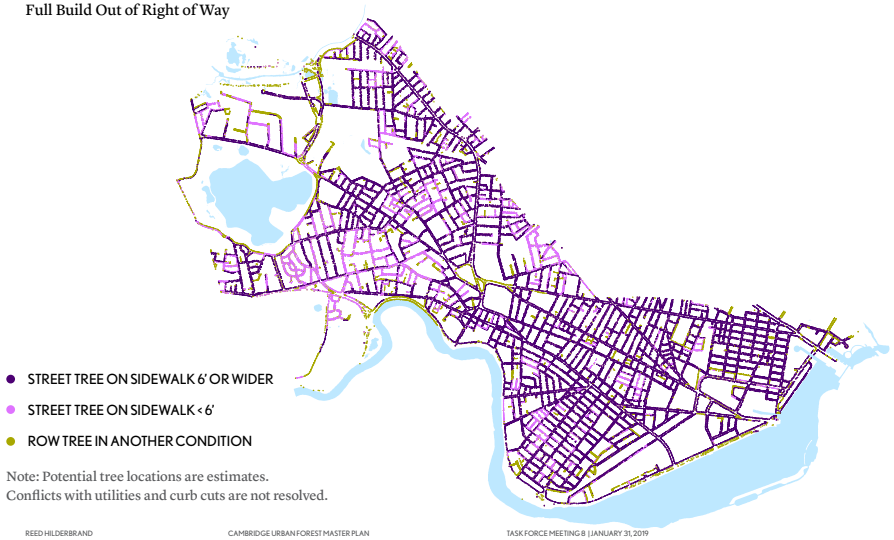
- STREET TREE ON SIDEWALK 6' OR WIDER
- STREET TREE ON SIDEWALK < 6'
- ROW TREE IN ANOTHER CONDITION
- EXISTING ROW TREES

Note: Potential tree locations are estimates.
Conflicts with utilities and curb cuts are not resolved.

	Maximum Planting Opportunity
Sidewalks greater than 6'	10,000
Along other ROW	2,000
TOTAL	12,000 trees
Sidewalks less than 6' wide	3,000

ANALYSIS | PUBLIC REALM CANOPY COVER

Full Build Out of Right of Way



Note: Potential tree locations are estimates.
Conflicts with utilities and curb cuts are not resolved.

ANALYSIS | PUBLIC REALM CANOPY COVER

Maximizing planting in ROW could increase canopy cover by 3.7% citywide

	2019	2030	2050
No. of Trees	Approx. 13,000	Plant 1,200 trees at 2" cal. per year for 10 years	Approx. 25,000
Canopy area (acres)	229	+10	+37
% Canopy citywide	26.0%	26.3%	26.9%
% Canopy cover in ROW (812 total acres)	28.2%	29.2%	31.7%

Assumptions:

9.5" dia canopy growth per year up to year 20 and 4.25" dia growth after that.

3% mortality rate for new plantings

SURVEY RESULTS | TREE PRESERVATION

93% agree that the city should have laws to protect large, healthy trees **on public property.** (70% strongly agree, 23% agree)

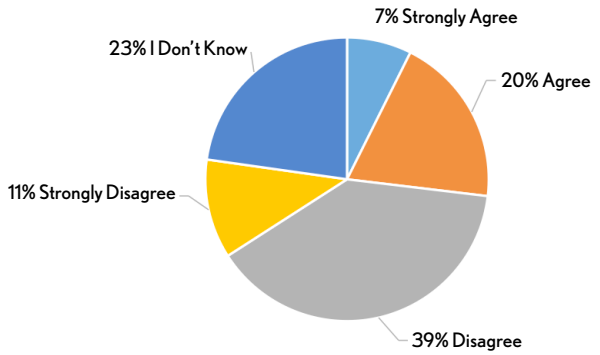
and

58% agree that the city should have laws to protect large, healthy trees **on private property.** (27% strongly agree, 31% agree)

SURVEY RESULTS | TREE PRESERVATION

50% disagree (11% strongly disagree, 39% disagree) with the statement:

"private property owners should make decisions about trees on their property without input from the city."



86% agree that the city should **regulate removal** of trees during construction.

and

88% agree that the city should **require planting of new trees** on site if existing trees cannot be preserved.

81% agree that the city should use more resources to maintain and protect existing trees. (46% strongly agree, 35% agree)

but

43% said "I don't know" when asked whether the city should prioritize resources for other services over tree planting and maintenance.

67% agree that the city should **incentivize, not require**, tree planting and maintenance on private property.

and

77% agree that the city should **provide resources to residents** to plant trees on private property.

Respondents are broadly

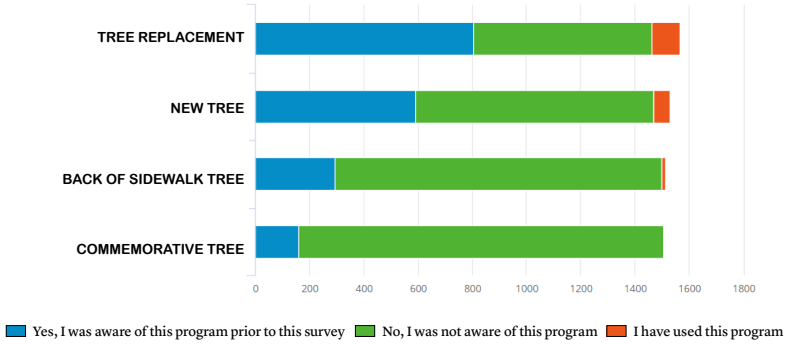
unaware of city tree-related programs,

and in cases where they were aware,

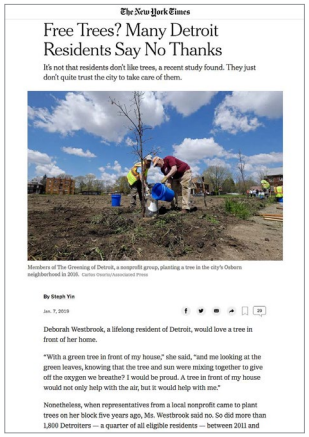
use of the programs is very limited.

SURVEY RESULTS | PLANTING PROGRAMS

"Please tell us whether you are aware of each program and whether you have participated in them."



SURVEY RESULTS | PLANTING PROGRAMS



The New York Times

Free Trees? Many Detroit Residents Say No Thanks

It's not that residents don't like trees, a recent study found. They just don't quite trust the city to take care of them.

Members of The Greening of Detroit, a nonprofit group, planting a tree in the city's Osborn neighborhood in 2018. Carlos Osorio/Associated Press

By Steph Yin

Jan. 7, 2019

Deborah Westbrook, a lifelong resident of Detroit, would love a tree in front of her home.

"With a green tree in front of my house," she said, "and me looking at the green leaves, knowing that the tree and sun were mixing together to give off the oxygen we breathe? I would be proud. A tree in front of my house would not only help with the air, but it would help with me."

Nonetheless, when representatives from a local nonprofit came to plant trees on her block five years ago, Ms. Westbrook said no. So did more than 1,800 Detroiters — a quarter of all eligible residents — between 2011 and

CITYLAB

DESIGN | TRANSPORTATION | ENVIRONMENT | EQUITY | LIFE

Why Detroit Residents Pushed Back Against Tree-Planting

BRENTIN MOCK JAN 11, 2019

Detroiters were refusing city-sponsored "free trees." A researcher found out the problem: She was the first person to ask them if they wanted them.

A landmark report conducted by University of Michigan environmental sociologist Dorceta Taylor in 2014 warned of the "arrogance" of white environmentalists when they introduce green initiatives to black and brown communities. One black environmental professional Taylor interviewed for the report, Elliot Payne, described experiences where green groups "presumed to

Distrust of city and nonprofit planting group led to failure of planting program in Detroit.

PUBLIC SURVEY

POLICY

PRACTICES

POLICY STRATEGIES

		STRATEGIES: Policy			Planning/Design					Practices				Outreach/Other		
		Enhance Current Tree Protection Ordinance	Formalize City Practices	Clarify Planning and Zoning	Leverage Emission Cummings and CDBG Planning Blocks	Restrict Street Tree Planting to Only Suitable Areas	Create New Typologies for Street Tree Planting	Implement City-Wide Planting Plan to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
ACTION	in response to ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	

POLICY STRATEGY 1

Change the definition of "Significant Trees"

SUMMARY
For projects requiring a special permit from the Planning Board or development projects subject to large project review (25,000 sq. ft. or more), the city's tree protection ordinance provides certain protections. These protections only apply to "Significant Trees," which are defined as trees greater than 8" diameter at breast height (DBH).

ANALYSIS
It is unclear how the city determined the DBH threshold for significant trees but other cities and towns locally and across the country offer protections for trees with a lower DBH. In particular, protections for trees with 6" DBH or greater is common. Bartlett's inventory of Cambridge's tree canopy found that of 4,118 trees inventoried, 41 percent measured greater than 8 inch DBH versus 60 percent which measured 6" DBH or greater. If the city were to redefine Significant Trees as 6" DBH or greater, this would increase the number of trees captured under the ordinance for the purposes of private development by about 49 percent.

PROS
Increases the number of trees protected by the provisions of the ordinance

Primary burden placed on developers rather than individual residents or the city

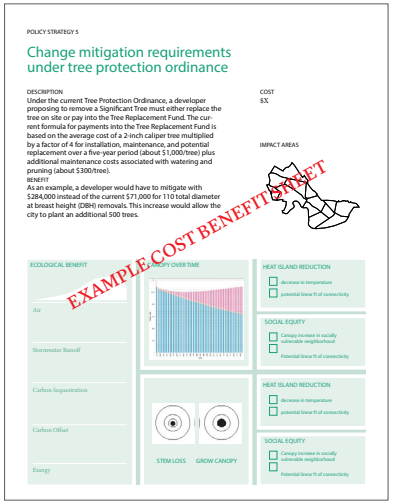
CONS
Would apply to more proposed development projects and thus require additional city resources to review and approve associated tree studies, mitigation, and protection plans

May require more city resources for enforcement because of the increased number of sites

PRECEDENTS
National
Atlanta, Georgia
Seattle, Washington
Oakland, Florida
Miami, Florida
Anna, Texas

Local
Concord, Massachusetts
Lexington, Massachusetts
Brookline, Massachusetts

EXAMPLE POLICY SHEET



POLICY STRATEGY 5

Change mitigation requirements under tree protection ordinance

DESCRIPTION
Under the current Tree Protection Ordinance, a developer proposing to remove a Significant Tree must either replace the tree on site or pay into the Tree Replacement Fund. The current formula for payments into the Tree Replacement Fund is based on the average cost of a 2-inch caliper tree multiplied by a factor of 4 for installation, maintenance, and potential replacement over a five-year period (about $1,000/tree) plus additional maintenance costs associated with watering and pruning (about $300/tree).

BENEFIT
As an example, a developer would have to mitigate with $284,000 instead of the current $71,000 for 110 total diameter at breast height (DBH) removals. This increase would allow the city to plant an additional 500 trees.

COST
$X

IMPACT AREAS

ECOLOGICAL BENEFIT
CANOPY OVER TIME
Air
Stormwater Runoff
Carbon Sequestration
Carbon Offset
Energy
STEM LOSS
GROW CANOPY
HEAT ISLAND REDUCTION
decrease in temperature
potential linear ft of connectivity
SOCIAL EQUITY
Canopy increase in socially vulnerable neighborhood
Potential linear ft of connectivity

EXAMPLE COST BENEFIT SHEET

1. Enhance Tree Protection Ordinance
    a. Change the definition of Significant Trees
    b. Create an "Exceptional Tree" category
    c. Change mitigation requirements
2. Enhance the role of the Committee on Public Planting
3. Expand tree protections to private property
4. Earmark Tree Replacement Fund dollars for community grants
5. Align planting protocols with City's commitment to equity
6. Increase oversight to ensure compliance
7. Strengthen zoning ordinance requirements
    a. Establish canopy coverage requirements
    b. Increase ratios for trees to parking spaces and/or dwelling units
    c. Increase setback and open space requirements in priority areas
    d. Establish flexible landscape mandate like Green Factor or Green Area Ratio

1. a. Change the definition of Significant Trees

Today, only trees greater than 8" dbh require mitigation and only when part of new development projects.*

Many cities regulate trees 6" dbh and greater.

* applies to certain multifamily, townhouse and other projects requiring a special permit from the Planning Board or development projects of 25,000 square feet or more.

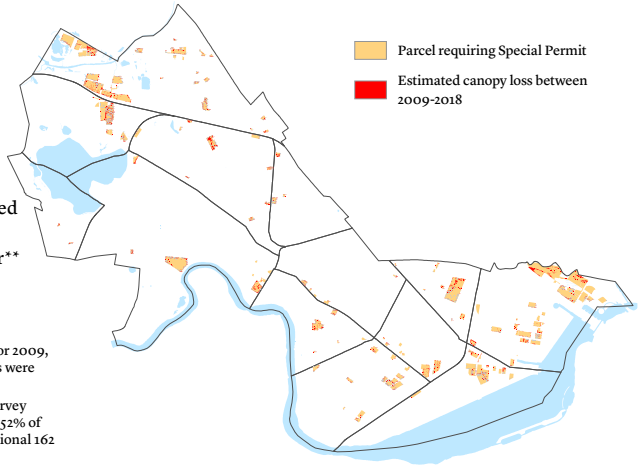
Special Permits 2009-2018

207 acres (148 projects)

20.1 acres of canopy in 2009

12.9 acres (1484 trees*)removed

162 additional trees are estimated to be covered by the ordinance if it pertained to 6" dbh or greater**



Assumptions:

*Use the 2018 ratio of canopy acres to trees for 2009, (115 trees/acre), then we can infer 1,484 trees were loss in the special permits area.

**Based on age class distribution per 2018 survey (41% of the forest is greater than 8"dbh, and 52% of the forest is 6" dbh or greater), then an additional 162 trees would be protected.

Compensation to the tree fund

162 trees at 7" dbh = 1134" dbh to be mitigated

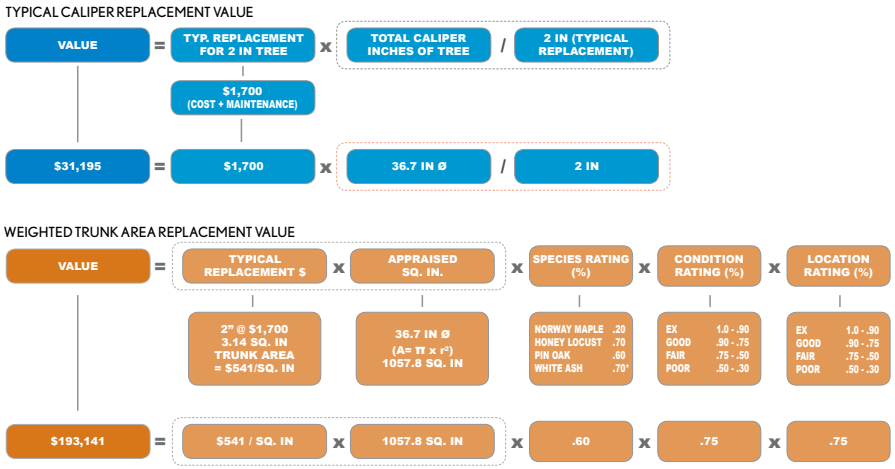
567 total trees at 2" caliper x $1,700 = $963,900 to tree fund*

*2009-2018 timeframe

1. b. Create an "Exceptional Tree" category

The addition of an "Exceptional Tree" category in the City's Tree Protection Ordinance would allow for a more stringent set of protections than those currently applied to Significant Trees in order to protect the city's most valuable trees.

1.c. Increase mitigation costs to reflect lost value



1.c. Increase mitigation costs to reflect lost value

Special permits example:
162 trees at 7" dbh*

153.95 sq. in
x $541/sq. in
x 162 trees
x 0.7 (species rating)
x 0.8 (condition)
x 0.75 (location)
= $5,666,844

*2009-2018 timeframe, assuming honey locust in good condition/location

POLICY STRATEGIES | ENHANCE CURRENT TREE PROTECTION ORDINANCE

2. Enhance role of Committee on Public Planting

Provide the Public Planting Committee with resources to extend the discussion of subjects raised by the UFMP, including

— interpreting recommendations
— updating analysis based on current research
— reviewing pilot projects
— reviewing progress toward targets

POLICY STRATEGIES | ENHANCE CURRENT TREE PROTECTION ORDINANCE

3. Expand tree protections to private property

Many cities locally and across the country have expanded the jurisdiction of local governments through tree protection ordinances by r**equiring a removal permit for all trees**, regardless of whether they are **on public or private property**.

Circumstances under which the city approves a tree removal permit vary in stringency but could range from approving every request to prohibiting removal of any healthy tree. However, the success of this approach has not been well established.

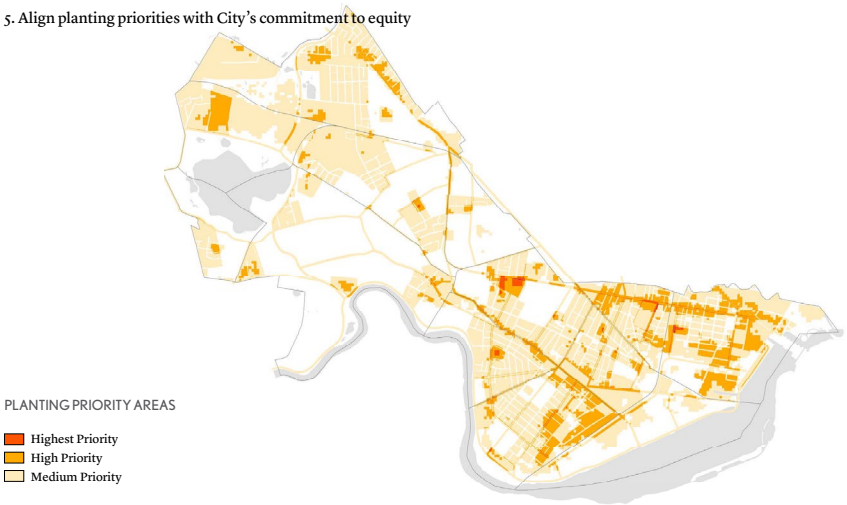
POLICY STRATEGIES | ENHANCE CURRENT TREE PROTECTION ORDINANCE

4. Earmark Tree Replacement Fund dollars for community grants

The city could earmark some of the funds in the Tree Replacement Fund for **community-based grant making** that could help fund operations to encourage planting on private property.

POLICY STRATEGIES | FORMALIZE CITY PRACTICES

5. Align planting priorities with City's commitment to equity



POLICY STRATEGIES | FORMALIZE CITY PRACTICES
6. Increase oversight to ensure compliance

Currently, there is limited City oversight to ensure compliance.

The Tree Protection Ordinance does not currently define standards for tree protection during construction.

POLICY STRATEGIES | FORMALIZE CITY PRACTICES
6. Increase oversight to ensure compliance

Require increased offset from tree dripline to protect tree roots

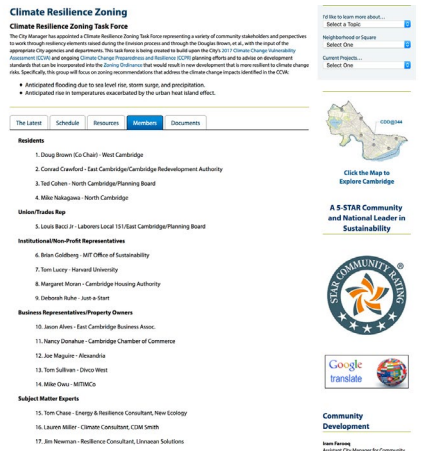
Require periodic review per an order of conditions to improve tree protection measures (fencing, watering) during construction

Require city arborist/city engineer inspection prior to obtaining Certificate of Occupancy

POLICY STRATEGIES | CITY PLANNING & ZONING
7. Broaden and align zoning requirements

a. Establish canopy coverage requirements
b. Increase ratios for trees to parking spaces and/or dwelling units
c. Increase setback and open space requirements in priority areas
d. Establish flexible landscape mandate like Green Factor or Green Area Ratio

POLICY STRATEGIES | CITY PLANNING & ZONING
Integrate canopy goals and resilience zoning



POLICY STRATEGIES | SUMMARY

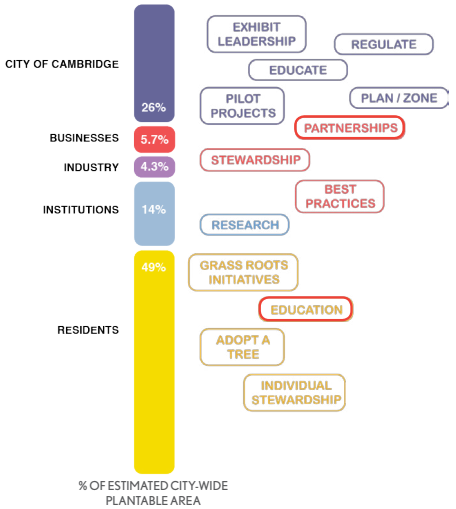
Did we miss any strategies?

Any clarification required?

Where are gaps?

POLICY STRATEGIES | EFFECTIVENESS GAPS

Among strategies proposed, policy is least effective at growing canopy on private property.

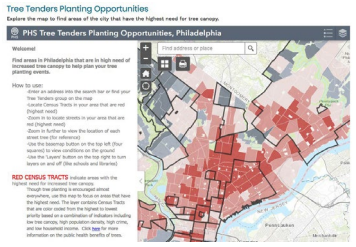


POLICY STRATEGIES | EDUCATION/OUTREACH

Empower existing NGOs to plant and maintain more trees, including on private property.

TREE TENDERS (PENNSYLVANIA HORTICULTURAL SOCIETY)

- Hands-on tree care training, covering biology, identification, planting and proper care
- Tree Planting Opportunities Map for tree planting events
- Tree Tenders Book Club
- Video Library



POLICY STRATEGIES | EDUCATION/OUTREACH

Support community employment and involvement in tree planting and constructing bioswales.

YALE URBAN RESOURCES INITIATIVE

Community Greenspace provides material supplies, technical advice, and clasroom-based and hands-on training to support resident-driven community greening projects.

GreenSkills is a local green jobs program that employs high school students and adults with employment barriers through the planting of trees.

Green Infrastructure, a partnership with the City of New Haven to construct bioswales.

Build capacity of existing NGOs through partnerships with national organizations.

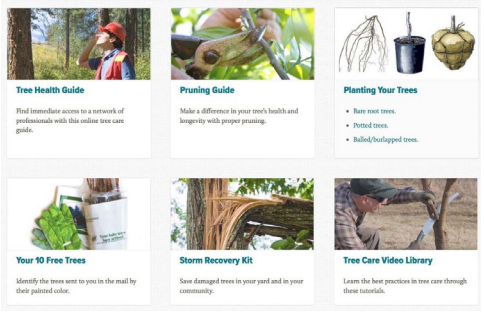
ABROR DAY FOUNDATION – ALLIANCE FOR COMMUNITY NETWORK

- Nonprofit organizations, urban forest councils, municipalities and individuals can join the alliance.
- Arbor Day offers education & training to its members and provides online tree planting and care resources.

A Strong Network Focused on Trees

With more than 90% of Americans living and working in towns and metropolitan areas, the need for informed action on a local level is greater than ever.

The Arbor Day Foundation's Alliance for Community Trees network is composed of community-based organizations dedicated to planting and caring for trees. These passionate nonprofits are the boots on the ground — the purest and best definition of grass roots. Their hands are in the dirt; their impact is undeniable. And as a unified force, they are changing towns and cities across the country.



Educate city staff, institutions, and other grounds managers on the value of trees and how to be stewards of them.

DAVEY TREE

- Employee education programs
- Davey Tree Fund supports arboriculture and urban forestry education

Educate the public on the value of trees and how to be stewards of them.

PENNSYLVANIA HORITCULTURAL SOCIETY

Green City Teachers
a training program that enables educators to start school gardens

Garden Tenders
a training program for starting community gardens on vacant lots, in parks, around schools and churches etc.

City Harvest
thousands of seedlings are started at neighborhood-based greenhouses by nonprofit partners as well as by inmates of the Philadelphia Prison System at a prison greenhouse through a training program.

Green Cambridge
Charles River Watershed Association
Mystic River Watershed Association
Charles River Conservancy
The Cambridge Community Gardens
A Better Cambridge
Cambridge Residents Alliance
Agassiz Baldwin Community
East Cambridge Planning Team
East End House
Neighborhood Association of East Cambridge
Mid-Cambridge Neighborhood Association
Cambridgeport Neighborhood Association
Cambridge Residents Alliance
Wellington-Harrington Neighborhood Association
Area Four Neighborhood Coalition
Essex Street Neighbors
Margaret Fuller House
Cambridge Community Center
Riverside Neighborhood Association
Taylor Square Neighborhood Association
Fresh Pond Residents Alliance
North Cambridge Stabilization Committee
Cambridge Highlands Neighborhood Association
Harvard Square Neighborhood Association
Inman Square Neighborhood Association
Porter Square Neighbors Association
Central Square Business Association

PUBLIC SURVEY

POLICY

PRACTICES

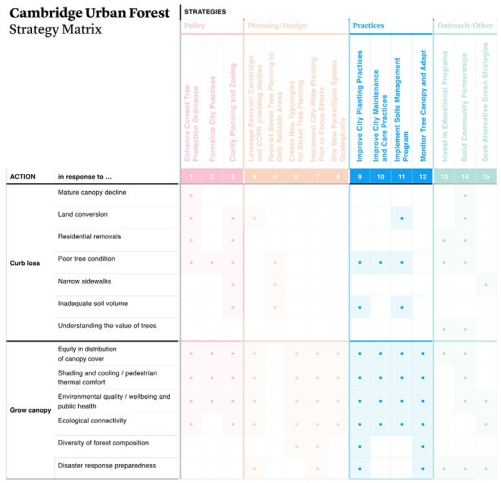
MANAGEMENT PRACTICES

The City of Cambridge forest management practices are generally aligned with best industry standards.

To stem loss and increase gain
enhanced practices fall into four categories:

improve monitoring and responsiveness
remediate causes of decline
improve planting and soils details
expand routine maintenance

ENHANCE PRACTICES | OVERVIEW



ENHANCE PRACTICES | OVERVIEW

MONITOR
—Enhance tree assessments
—Expand pest monitoring
—Expand Cartegraph tracking to monitor success of practices

REMEDIATE
—Manage soils
  —Liquid biological amendments
  —Decompaction/Aeration
—Treat private trees during severe pest outbreaks (EAB)

PLANT
—Enhance soil specs
—Ensure proper drainage
— Plant bare root trees
—Revise tree species list
—Prune and water more frequently and longer

MAINTAIN
—Formalize a City-wide management plan
—Manage soils
  —Mulching
  —Liquid biological amendments
—Expand irrigation program

Increase frequency of city-wide tree assessments.

BENEFITS
allows identification of stressed trees for remediation practices

SCOPE
High: Survey trees on a 3 year cycle
Low: Survey trees on a 5 year cycle

Expand pest/disease monitoring.

BENEFITS
Allows treatment at start of outbreak

SCOPE OF APPLICATION
Monitor specifically for pests/diseases that are systemic city-wide threat

SCOPE OF WORK
High: Traps and tree assessments
Low: Traps

Track all treatments (ie., soil management) in Cartegraph (City inventory software).

BENEFITS
Ability to assess success of treatments

SCOPE OF APPLICATION
All trees when pruned by contractors
All trees treated with liquid biological amendments and decompaction measures

SCOPE OF WORK
Record treatment in Cartegraph through mobile device at time of treatment

Treat private trees during city-wide pest/disease outbreaks.

BENEFITS

In the case of Emerald Ash Borer (EAB) the City is currently treating 883 City trees, approx. 2% of City canopy

LiDAR survey indicates there are 1,536 Ash in the City, approx. 4% of the City canopy

Expanding EAB treatment to private trees could save additional 2% of canopy

SCOPE

Treat approx. 650 private trees with TreeAzin injections per City spec

650 trees x $142/tree = $92,300 / year

Treat underperforming trees with liquid biological amendments.

BENEFITS
Improve nutrient availability
Reduce compaction

SCOPE OF APPLICATION
High: all publicly owned trees
Medium: all publicly-owned trees under 20 years of age
Low: all trees showing signs of fair-poor cond. (per city-wide tree assessment)

SCOPE OF WORK
Soil injections of 10 gallon liquid (compost tea) @ 4 points per tree
Approximately 10 minutes per tree

FREQUENCY
High: yearly, half of the trees in spring and half in fall
Low: 1/3 of trees each year, 3 year cycle of treatment

Treat compacted soil through mechanical decompaction.

BENEFITS
Reduce compaction
Enhance moisture retention

SCOPE OF APPLICATION
High: All publicly owned non-street trees
Low: Park trees in areas of high use

SCOPE OF WORK
Airspade zones within dripline of each tree or group of trees
Incorporate high-quality compost with airspade
Approximately 60 minutes per tree

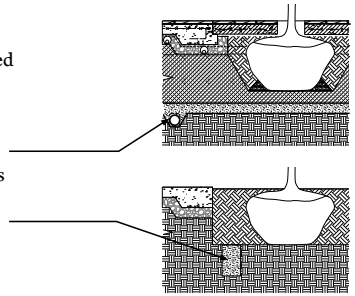
FREQUENCY
High: each tree every year, half of the trees in spring and half in fall
Medium: each tree every two years, a quarter of the trees in spring and quarter in fall
Low: once, half the trees in the spring, half in the fall

Incorporate drainage measures in new plantings.

BENEFITS
Prevent roots from potentially sitting in water and dying

SCOPE OF APPLICATION
Test all new plantings, remediate where needed

SCOPE OF WORK
High: Underdrains at bottom of pits for new trees associated with large projects
Low: Augur sand wicks at bottom of pit for tree pits with poor drainage



Enhance soil specifications.

BENEFITS
A) Improve tree health and root capacity
B) Improve survival rates and growth rates

SCOPE OF APPLICATION
A) High: All publicly planted trees
B) Low: All publicly planted street trees

SCOPE OF WORK
A) Develop multiple soils blends to respond to specific conditions
   i. Structural soils
   ii. Suspended pavements
   iii. Parkland Turf
   iv. Beds and mixed planting
   v. Wetland
B) Incorporate biological guidelines into soil specification
C) Incorporate biochar within soils
D) Measure compaction by standard proctor
E) Require compliance testing by contractor

Increase frequency of structural pruning for young trees.

BENEFITS

Improve vitality and life span of young trees

SCOPE OF APPLICATION

High: All new City plantings + Require structural pruning of new trees planted under Special Permits for 5 yrs

Low: All new City plantings

SCOPE OF WORK

Selectively prune branches and stems larger than about half the diameter of the trunk.

FREQUENCY

High: Prune young trees on 3 year pruning cycle for 12 years of tree's life (Fourfold increase over current frequency)

Low: Prune young trees on 3 year pruning cycle for 6 years of tree's life (Twofold increase over current frequency)

Evaluation Criteria:

— Climate Resiliency Score
pest/disease susceptibility + drought + flood*
— Relative Urban Stress Tolerance (RUST) Score
pH, hardiness, sun, insect/diseases, physiological/environmental, moisture, salt, texture, compaction
— Size
— Location
— Sun Exposure
— Flooding tolerance

*flooding is weighted x0.5

NAME			CLIMATE RESILIENCY SCORE					ORIGIN		SIZE				TYPOLOGIES	
Genus	Species	Comm_Name	Flood score	Drought Score	Pest Score	Total score	RUST (Relative Urban Stress Tolerance)	Native	Non-native	Typical Range of Mature Crown Width	Small (Mature height less than 35 ft tall)	Medium (Mature height greater than 35 ft but less than 50 ft tall)	Large (Mature height greater than 50 ft tall)	CANOPY STREET TREES	UNDERWIRE STREET TREES
Abies	concolor	Fir-White	1	2	2	5.5			Yes	15-20'		X			
Acer	negundo	Boxelder	3	3	1	4.5	1.40	Yes		40-50'		X		X	
Acer	ginnala	Maple-Amur	1	2	1	6.5			Yes	15-25'	X				
Acer	nigrum	Maple-Black	1	2	1	6.5			Yes	40-50'			X		
Acer	platanoides	Maple-Crimson King	No1	3	1	5.5			Yes	30-45'			X		
Acer	x freemanii	Maple-Freeman	2	2	1	6			Yes	35-40'			X		
Acer	campestre	Maple-Hedge	1	3	1	5.5	4.14		Yes	25-35'	X				X
Acer	palmatum	Maple-Japanese	1	2	1	6.5			Yes	10-25'	X				
Acer	griseum	Maple-Paperbark	1	2	1	6.5			Yes	15-25'	X				
Acer	rubrum	Maple-Red	3	1	1	6.5	1.4	Yes		20-35'			X	X	
Acer	saccharinum	Maple-Silver	3	2	1	5.5	1.73	Yes		40-60'			X	X	
Acer	saccharum	Maple-Sugar	2	1	1	7	-0.72	Yes		30-50'			X		
Acer	tataricum	Maple-Tatarian	1	3	1	5.5			Yes	15-20'	X				
Acer	buergeranum	Maple-Trident	1	2	1	6.5	2.18		Yes	20-30'	X				X
Aesculus	glabra	Buckeye-Ohio	2	1	1	7	1.68		Yes	40-50'			X	X	
Aesculus	hippocastanum	Horsechestnut	2	2	1	6			Yes	40-50'			X		
Aesculus	x carnea	Horsechestnut-Red	2	2	1	6	0		Yes	30-40'		X			
Albizia	julibrissin	Mimosa	1	2	1	6.5			Yes	25-35'		X			
Alnus	glutinosa	Alder-Common	2	2	2	5	1.21		Yes	15-20'			X	X	
Amelanchier	x grandiflora	Serviceberry-Apple	2	2	3	4			Yes	15-25'	X				
Amelanchier	arborea	Serviceberry-Downy	2	1	3	5	0.72	Yes		10-20'	X				
Betula	pendula	Birch-European White	1	1	1	7.5			Yes	15-30'		X			
Betula	populifolia	Birch-Gray	1	1	1	7.5	1.43	Yes		10-20'		X		X	
Betula	papyrifera	Birch-Paper	2	1	1	7	2.95	Yes		25-50'			X	X	
Betula	nigra	Birch-River	2	2	1	6	3.03	Yes		40-60'			X	X	
Carpinus	caroliniana	Hornbeam-American	2	1	1	7	1.82	Yes		15-30'		X		X	
Carpinus	betulus	Hornbeam-European	2	3	3	3	0.12		Yes	35-40'		X			
Carya	tomentosa	Hickory-Mockernut	1	3	2	4.5	1.72	Yes		50-75'			X	X	
Carya	ovata	Hickory-Shagbark	1	2	2	5.5	4.11	Yes		50-75'			X	X	
Castanea	dentata	Chestnut-American	1	2	1	6.5			Yes	50-75'			X		
Cedrus	libani	Cedar of Lebanon	1	3	3	3.5			Yes	40-60'			X		

Plant bare root trees and manage a gravel bed nursery.

BENEFITS

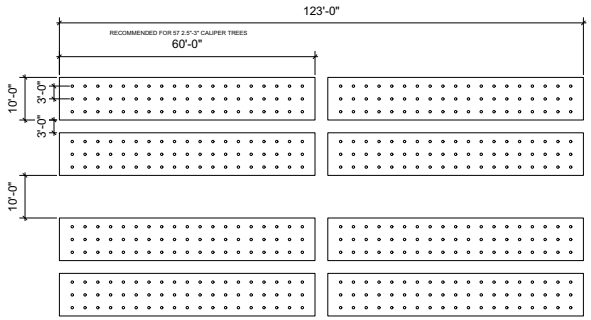
Increase survival rates
Increase species selection
Lower installation costs
Expand season for planting

SCOPE OF WORK

Manage a gravel bed nursery on city-owned land

ENHANCE PRACTICES | NEW PLANTINGS

Plant bare root trees and manage a gravel bed nursery.



ENHANCE PRACTICES | ANNUAL MAINTENANCE

Stem loss and enhance growth

Create City-wide Management Plan
BENEFITS: Codify management goals and delineate clear steps to achieve outcomes

Expanded mulching
BENEFITS: Improve soils and suppress weeds

Liquid biological amendments
BENEFITS: Improve soils and reduce compaction

Expanded irrigation program
BENEFITS: Improve tree survival rates and enhance growth

ENHANCE PRACTICES | OVERVIEW

MONITOR
—Enhance tree assessments
—Expand pest monitoring
—Expand Cartegraph tracking to monitor success of practices

REMEDIATE
—Manage soils
  —Liquid biological amendments
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PLANT
—Enhance soil specs
—Ensure proper drainage
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—Revise tree species list
—Prune and water more frequently and longer

MAINTAIN
—Formalize a City-wide management plan
—Manage soils
  —Mulching
  —Liquid biological amendments
—Expand irrigation program

PUBLIC COMMENT

www.cambridgema.gov/ufmp

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling
SEPTEMBER 27	RESEARCH: Summary of Findings
OCTOBER 25	Cancelled
NOVEMBER 29	TESTING: Baseline Change Model
DECEMBER 20	PROPOSAL DEVELOPMENT
JANUARY 31	PROPOSAL DEVELOPMENT
FEBRUARY 28	PROPOSAL DEVELOPMENT
MARCH 28	DRAFT DOCUMENTATION
APRIL 25	DRAFT DOCUMENTATION

www.cambridgema.gov/ufmp

PRINCIPLES

PLANNING APPROACH

DESIGN CONCEPTS

PRACTICES

PRINCIPLES

PLANNING APPROACH

DESIGN CONCEPTS

PRACTICES

ENVISION VALUES

Vision and Core Values

The Envision Cambridge team worked with the community through workshops, one-on-one discussion, surveys, and more to craft a vision statement for the city.

Following extensive community outreach, the plan identified six core values expressed by the Cambridge community that shape the plan's goals and recommendations. The vision and core values together form the foundation upon which the plan's recommendations for the evolution of Cambridge are built.

Vision

"Cambridge is a forward-thinking, welcoming, and diverse city. We enjoy a high quality of life and thrive in a sustainable, inclusive, and connected community."

Core Values

Livability
We value a vibrant built and natural environment and support sustainable transportation with affordable and convenient access to daily needs and recreational resources.

Economic Opportunity
We provide opportunity and stability through access to quality jobs, workforce development and training, and livable wages that support economic security for residents.

Community Health and Wellbeing
We promote healthy and active lifestyles in a supportive, safe community with diverse opportunities to connect with our neighbors and nature and to engage in civic life.

Diversity and Equity
We are a welcoming community that celebrates our diversity and ensures access to affordable housing choices and opportunities to succeed.

Sustainability and Resilience
We take responsible action to reduce our impact on the environment and build a resilient city and strong community.

Learning
We embrace lifelong learning and celebrate art and creativity in our culturally rich community.

Core Concepts

To maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.

1. **Value the forest as a public resource**
2. **Invest in canopy in the public realm**
3. **Share responsibility for a healthy forest**

1

Value the forest as a public resource

The urban forest is a public resource and has MEASURABLE VALUE AND IMPACTS EVERYONE. It provides shade to cool our environment, gives scale and character to our streets, provides habitat for diverse species, improves our air quality, reduces stormwater impacts, and improves our health and well-being.

To shift the trend from increasing loss to sustainable growth, we must manage the urban forest as URBAN INFRASTRUCTURE (like water, sewer, power) investing for the long term, managing resources collectively, and understanding the value (i.e., ecosystem services) of the canopy.

To balance the value of the forest with the complex needs of the city, we should focus on the performance of the FOREST AS A SYSTEM over the specific value of individual trees.

2

Invest in canopy in the public realm

The urban forest is felt most strongly in our PUBLIC REALM AND COMMON SPACES (sidewalks, parks, schoolyards, and commercial and institutional campuses).

Enhancing the canopy within the public realm, where the impact of loss is felt most strongly and the significance of gain is most equitably distributed, deserves our PRIMARY ATTENTION AND INVESTMENT.

SPECIFICALLY PRIORITIZE ↴

Canopy corridor

A resilient, connected ecosystem that enhances shading and cooling along networks and connects green spaces across the City, which relies on thriving trees within the public right of way, publicly accessible spaces, and front yards and private lands that front on the public realm.

Areas of canopy deficit and inequity

A more evenly distributed forest increases equity in the distribution of canopy cover, reduces disproportionate impacts from urban heat island effects, and increases the well-being of vulnerable populations.

3

Share responsibility for a healthy forest

A thriving urban forest requires the MUTUAL CARE OF MANY PARTIES, including city government, homeowners, businesses, developers, local organizations, institutions and state agencies.

Policy should be BALANCED AND FAIR, linking the interests of all parties around smart solutions that encourage tree preservation, planting of new trees, and effective maintenance.

The city should support EDUCATION efforts as a catalyst for PARTNERSHIPS between interest groups to encourage stewardship of the urban forest.

DRAFT

Enact values through a multi-pronged approach

Curb loss

- Enhance management practices, especially around soil health, that improve tree vitality and longevity
- Protect exceptional trees of unique age and size
- Increase the cost of removals for large projects (de-incentivize removal and increase mitigation when retention is not possible)
- Enhance the city permitting and review process to track and seek alternatives to tree removals
- Educate residents on the value of their canopy as an important ecological/health resource for themselves and their community

Grow canopy

- Increase rate of planting within the public realm
- Enhance soil specifications and planting details to improve establishment and long-term success
- Develop alternative approaches to public realm design that increase opportunities, expand plantable areas, and enhance viability
- Provide resources for planting and maintenance to private landowners, especially in front yards
- Educate the public about the resources that are available and increase trust within the community
- Partner with local institutions and landowners to make commitments, set internal targets, and support community-wide goals
- Implement comprehensive zoning guidelines that represent the value of trees
- Modify recommended species and diversify forest to respond to a changing climate and increased risks of pests and diseases

Encourage alternative approaches that advance the goals of the Urban Forest Master Plan

- De-pave and enhance permeability
- Implement green roofs and living structures
- Encourage alternative shade structures where trees are not viable

PRINCIPLES

PLANNING APPROACH

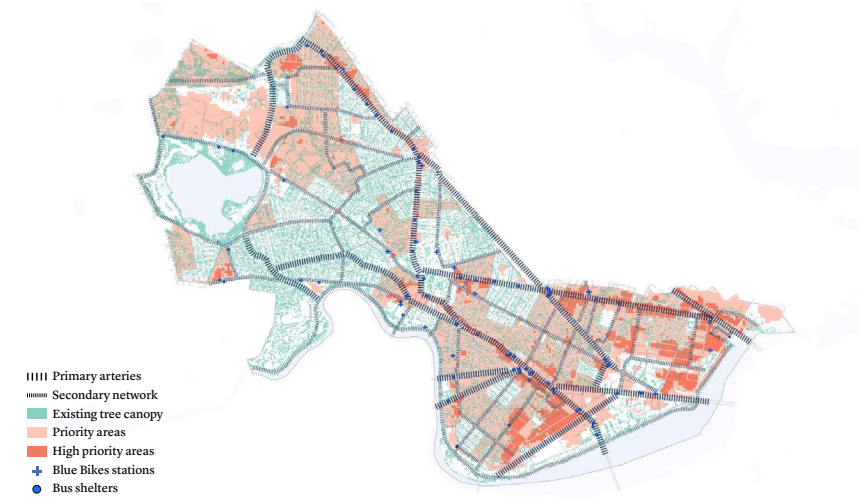
DESIGN CONCEPTS

PRACTICES

WHERE TO APPLY THE STRATEGIES?

ACTION	in response to ...	Policy: Enhance Current Tree Protection Ordinance (1)	Policy: Formalize City Practices (2)	Policy: Clarify Planning and Zoning (3)	Planning/Design: Leverage Envision Cambridge and CCAPR planning studies (4)	Planning/Design: Direct Street Tree Planting to Only Suitable Areas (5)	Planning/Design: Create New Typologies for Street Tree Planting (6)	Planning/Design: Implement City-Wide Planting Plan to Focus Efforts (7)	Planning/Design: Site New Parks/Open Spaces Strategically (8)	Practices: Improve City Planting Practices (9)	Practices: Improve City Maintenance and Care Practices (10)	Practices: Implement Soils Management Program (11)	Practices: Monitor Tree Canopy and Adapt (12)	Outreach/Other: Invest in Educational Programs (13)	Outreach/Other: Build Community Partnerships (14)	Outreach/Other: Seek Alternative Green Strategies (15)
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•												
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
Grow canopy	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	
	Shading and cooling / pedestrian thermal comfort	•	•	•	•		•	•	•	•	•	•	•		•	
	Environmental quality / wellbeing and public health	•	•	•	•		•	•	•	•	•	•	•		•	•
	Ecological connectivity	•		•	•		•	•	•	•	•	•	•			•
	Diversity of forest composition						•	•		•			•			
	Disaster response preparedness				•			•		•			•	•	•	•

BEGIN WITH AREAS OF NEED



PRIORITY AREA CRITERIA

ENVIRONMENTALLY VULNERABLE POPULATIONS

- Minority population
- Low income population
- Non English speaking population

HEAT ISLAND HOT SPOTS

- Greater than 92 degrees on a 90 degree day as modeled by KLF for 2030 ambient air temperature

COMMUNITY INFRASTRUCTURE

- Public Schools and Hospitals

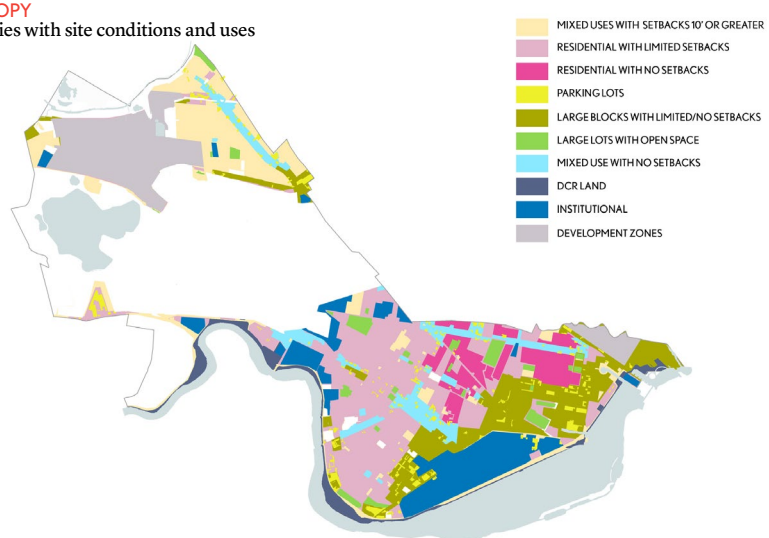
PLANNING APPROACH
Curb loss by maintaining existing trees

PLANNING APPROACH
Grow canopy by planting trees in areas of canopy deficit

PLANNING APPROACH
Focus on creating robust canopy corridors

GROW CANOPY

Align strategies with site conditions and uses

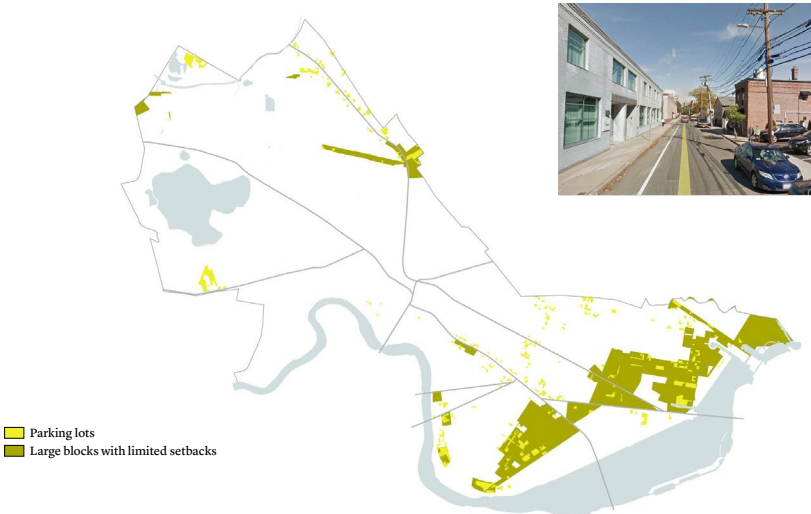


MIXED USE WITH SETBACKS GREATER THAN 10'

RESIDENTIAL WITH LIMITED SETBACKS

RESIDENTIAL WITH NO SETBACKS

LARGE BLOCKS WITH LIMITED OR NO SETBACKS



Parking lots
Large blocks with limited setbacks

MIXED USE WITH NO SETBACKS

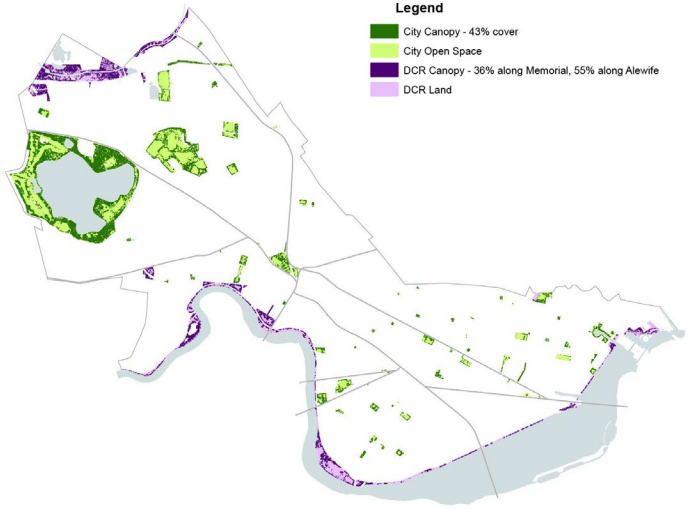
LARGE LOTS WITH OPEN SPACE

INSTITUTIONAL

DEVELOPMENT ZONES

DCR LAND

OPEN SPACE



PRIORITIZE STRATEGIES BY CONDITION

		STRATEGIES														
		Policy			Planning/Design					Practices				Outreach/Other		
		Enhance Current Tree Protection Ordinance	Formalize City Practices	Clarify Planning and Zoning	Leverage Envision Cambridge and CCPR planning studies	Restrict Street Tree Planting to Only Select Species	Create New Policies for Street Tree Planting	Implement City-Wide Planting Plan to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
ACTION	in response to ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
Grow canopy	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	
	Shading and cooling / pedestrian thermal comfort	•	•	•	•		•	•	•	•	•	•	•		•	
	Environmental quality / wellbeing and public health	•	•	•	•		•	•	•	•	•	•	•		•	•
	Ecological connectivity	•		•	•		•	•	•	•	•	•	•			•
	Diversity of forest composition						•	•		•			•			
	Disaster response preparedness				•			•		•			•	•	•	•

PRINCIPLES

PLANNING APPROACH

DESIGN CONCEPTS

PRACTICES

BUILD ROBUST CANOPY CORRIDORS

TREES IN THE RIGHT OF WAY

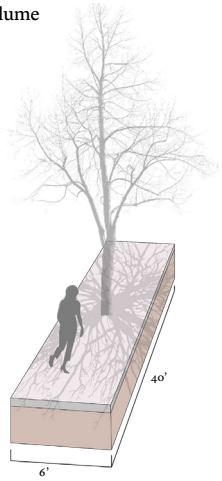
Existing street trees often have limited resources

EAST CAMBRIDGE

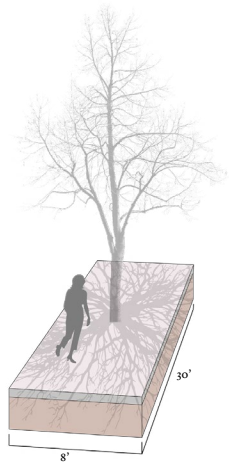
Image from Google Street View

CONDITIONS THAT SUPPORT A THRIVING FOREST

Adequate soil volume

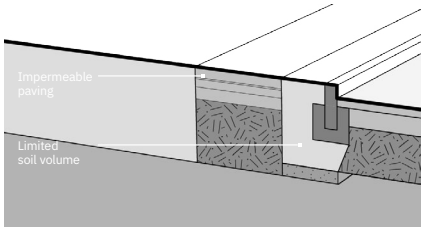


Soil volume: 750 cu ft

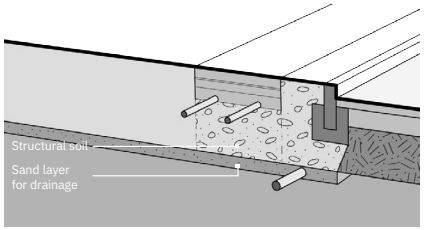


Soil volume: 750 cu ft

CONDITIONS THAT SUPPORT A THRIVING FOREST
Adequate soil volume

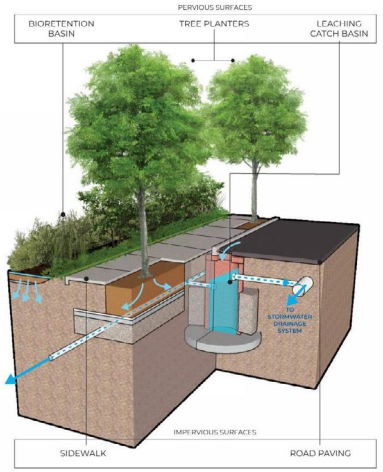


EXISTING STREET TREE SOIL CONDITION

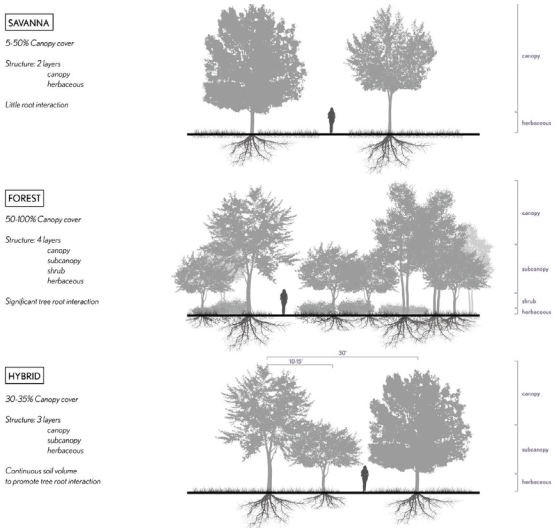


STRUCTURAL SOIL SECTION

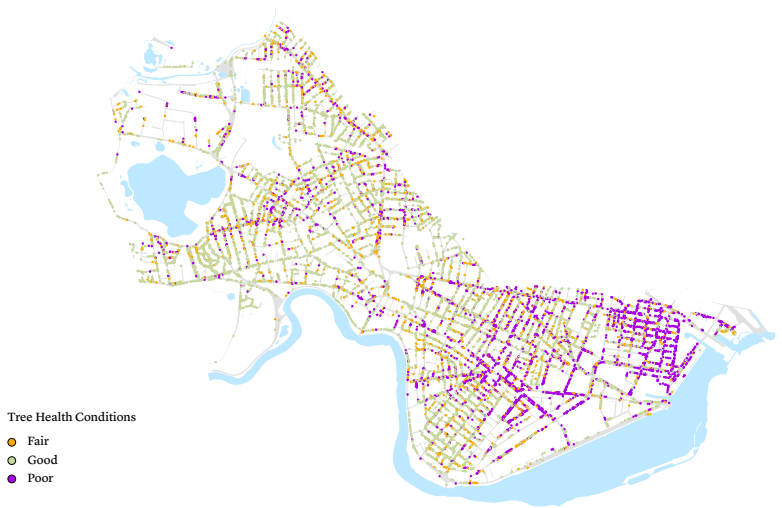
CONDITIONS THAT SUPPORT A THRIVING FOREST
Tree plantings as part of stormwater system



CONDITIONS THAT SUPPORT A THRIVING FOREST
Plant communities



CONDITION OF STREET TREES

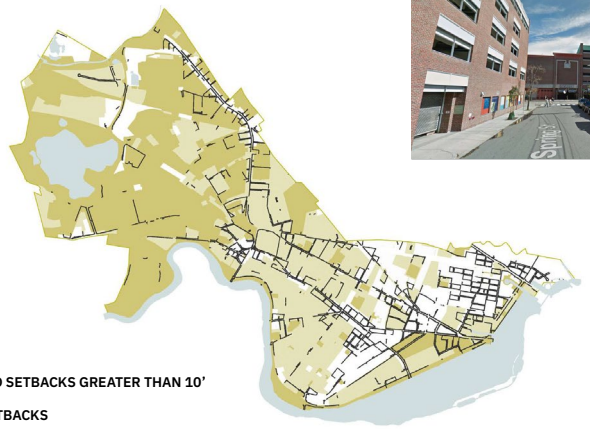


CONDITION OF STREET TREES ON SIDEWALKS 8' OR GREATER

SIDEWALKS LESS THAN 6' WIDE

SIDEWALKS BETWEEN 6' AND 8'

SIDEWALKS 8' OR GREATER



ON SIDEWALKS WITH....

SIDEWALK WIDTH	SUFFICIENT FRONT YARD SETBACK		INSUFFICIENT FRONT YARD SETBACK			
	ENCOURAGE FRONT YARD PLANTINGS	NEW STREET TREES SHOULD FOCUS ON PRACTICES	NO NEW STREET TREE PLANTINGS	ALTERNATIVE STREET DESIGN	ALTERNATIVE STRATEGIES	FOCUS ON PRACTICES
< 6' WIDE	√		√	√	√	
6' to 8'	√	√		√	√	√
> 8'	√	√		√	√	√

R.O.W. CANOPY

Areas without front yard setbacks rely on street trees for canopy

WEST CAMBRIDGE

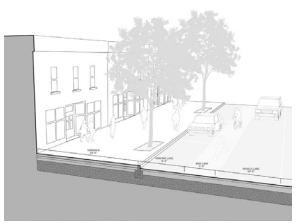
EAST CAMBRIDGE

STREET TREE CANOPY

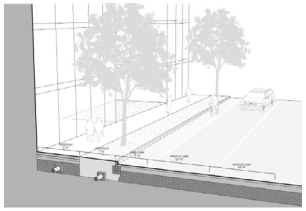
OTHER CANOPY

CONSTRAINTS REQUIRE INNOVATIVE APPROACHES

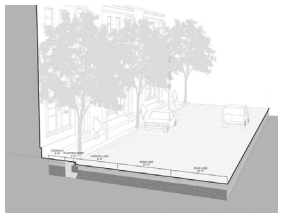
COMMERCIAL STREETS WITH NARROW SIDEWALK



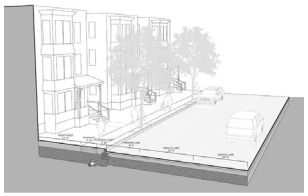
COMMERCIAL STREETS WITH WIDE SIDEWALK



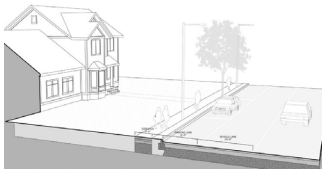
COMMERCIAL STREETS WITH WIDE COURTYARDS



NARROW RESIDENTIAL STREETS WITH NO SETBACK



NARROW RESIDENTIAL STREETS WITH FRONT YARDS



NARROW RESIDENTIAL STREETS WITH LARGE FRONT YARDS

MAJOR STREETS, WIDE SIDEWALK

Existing conditions

MAJOR STREETS, WIDE SIDEWALKS
Staggered trees with permeable paving

MAJOR STREETS, WIDE SIDEWALKS
Mixed scales of trees with permeable paving

MAJOR STREETS, WIDE SIDEWALKS
Double row of trees with permeable paving

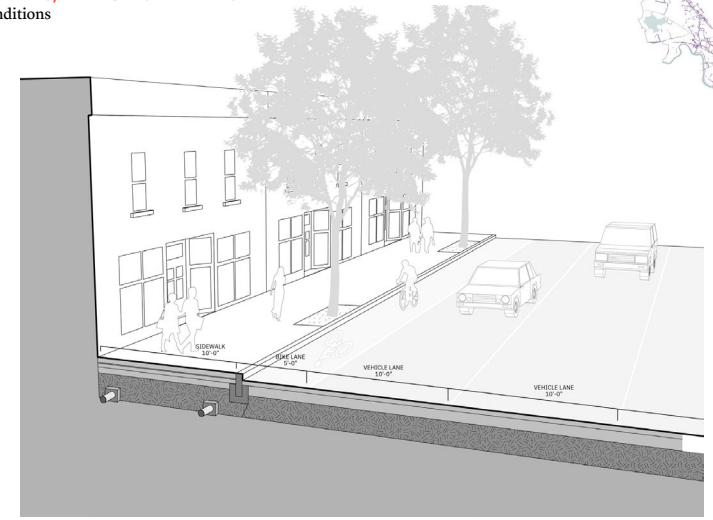
Boston

MAJOR STREETS, WIDE SIDEWALKS
Double row of trees with permeable paving

Passeig de Sant Joan, Barcelona

MAJOR STREETS, WIDE SIDEWALKS
Integrated plant community

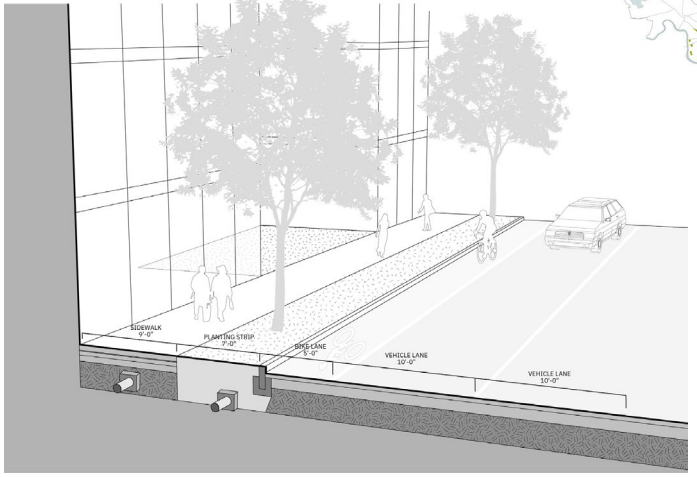
MAJOR STREETS, NARROW SIDEWALKS
Existing conditions



MAJOR STREETS, NARROW SIDEWALKS
Mixed scale planting and permeable paving

A Alternate tree sizes to increase density
B Install porous pavement
C Increase the soil volume
D Extend soil volume to the buildings

MAJOR STREETS WITH COMMERICAL BUILDINGS
Existing conditions



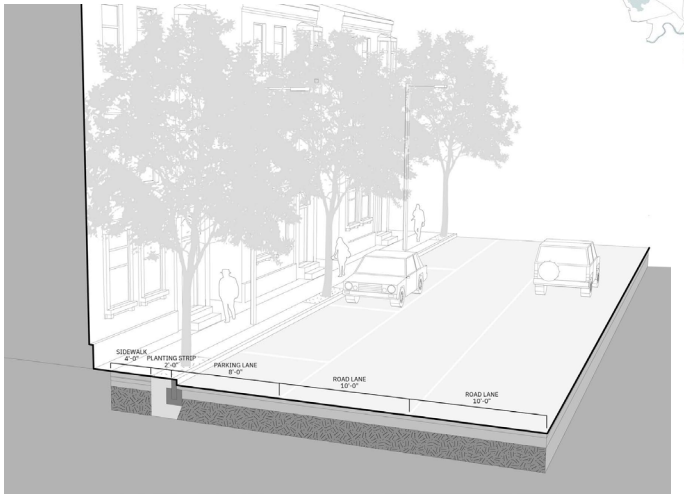
MAJOR STREETS WITH COMMERICAL BUILDINGS

Frontage planting and layered vegetation

- **A** Encourage varied frontage and landscaped spaces
- **B** Include multiple stories of vegetation in verges

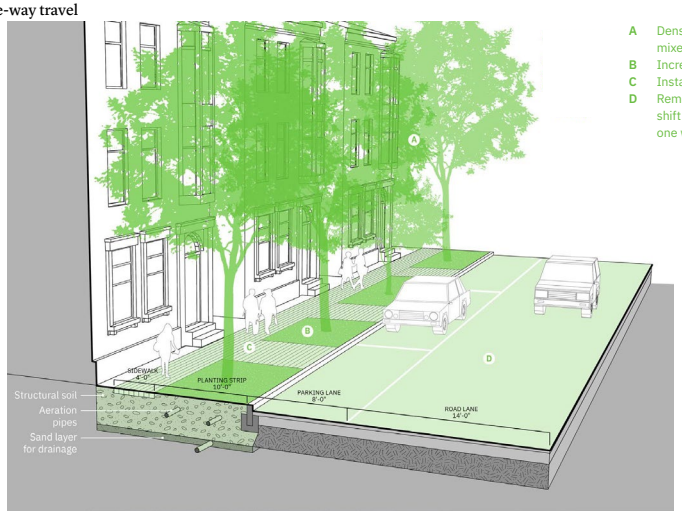
NARROW RESIDENTIAL STREETS, NO SETBACK

Existing conditions



NARROW RESIDENTIAL STREETS, NO SETBACK

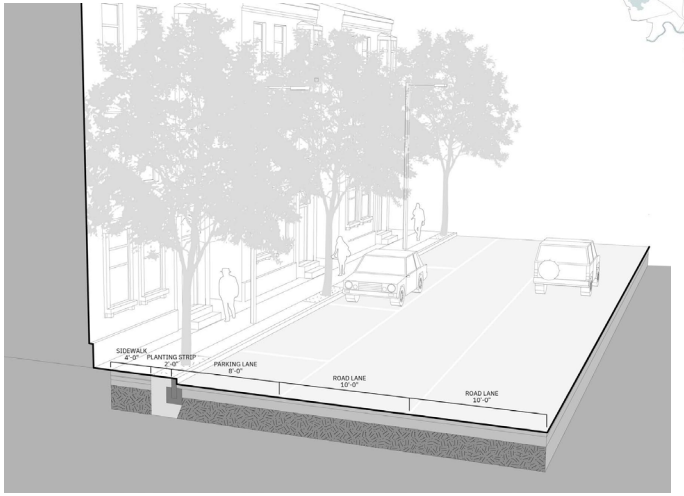
Lane diet, one-way travel



- **A** Densify planting with mixed species
- **B** Increase the soil volume
- **C** Install porous pavement
- **D** Remove pavement - shift two way traffic to one way

NARROW RESIDENTIAL STREETS, NO SETBACK

Existing conditions



NARROW RESIDENTIAL STREETS, NO SETBACK

Pavement removal, shared street

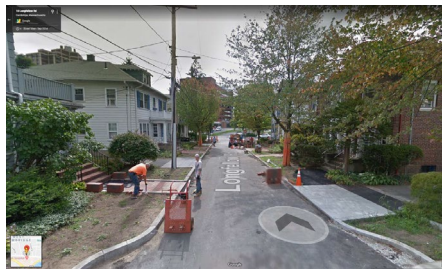
- **A** Plant mixed groves of trees
- **B** Increase the soil volume
- **C** Extend soil volume to the buildings
- **D** Narrow pavement - share streets between pedestrians and vehicles

NARROW RESIDENTIAL STREETS, NO SETBACK

Pavement removal, shared street

BEFORE

Image from Google Street View



AFTER

Image from Google Street View

LONGFELLOW ROAD, CAMBRIDGE

NARROW RESIDENTIAL STREETS WITH FRONT YARD

Existing conditions

NARROW RESIDENTIAL STREETS WITH FRONT YARD

De-paved and connected front yards

- **A** Encourage depaving of front yards
- **B** Increase the soil volume

NARROW RESIDENTIAL STREETS WITH FRONT YARD
Planting area fit into parking lane

NARROW RESIDENTIAL STREETS WITH FRONT YARD
Planting area fit into parking lane

Image from Google Street View

Chilton Street redesign as part of sewer separation project in Cambridge

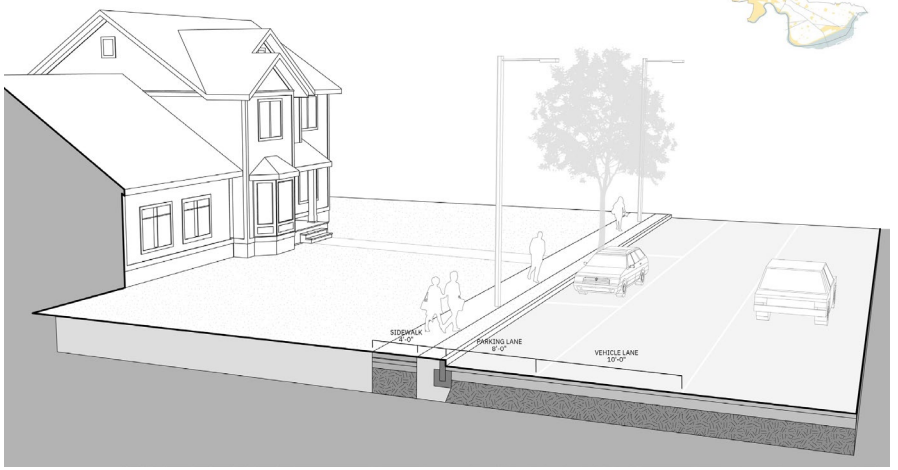
Image from Google Street View

Western Avenue redesign

NARROW RESIDENTIAL STREETS WITH FRONT YARD
Planting area fit into parking lane

DOUBLE ROW OF TREES IN CURB BUMP OUTS IN SAN FRANCISCO

RESIDENTIAL STREETS WITH LARGE FRONT YARDS
Existing conditions

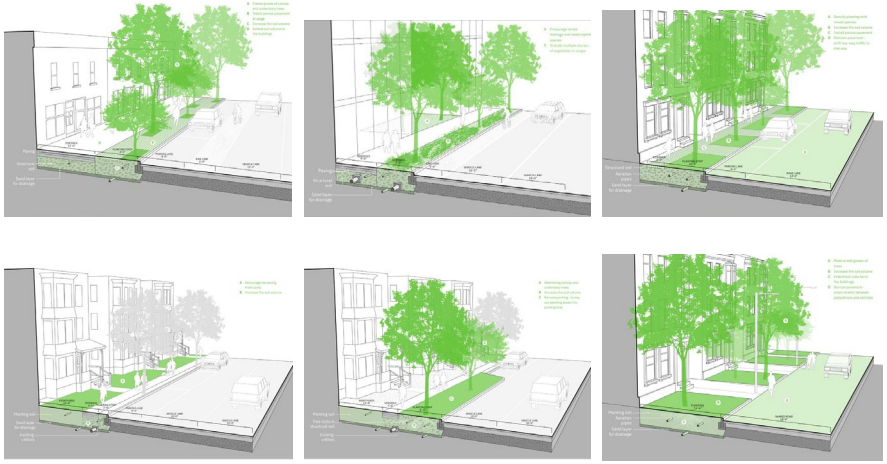


RESIDENTIAL STREETS WITH LARGE FRONT YARDS

More front yard planting

A Encourage front yard planting with expanded back of sidewalk program

CONSTRAINTS REQUIRE INNOVATIVE APPROACHES



PRINCIPLES

PLANNING APPROACH

DESIGN CONCEPTS

PRACTICES

MANAGEMENT PRACTICES

The City of Cambridge forest management practices are generally **aligned with best industry practices**.

To curb loss and grow canopy, enhanced practices fall into four categories:

improve monitoring and responsiveness
remediate causes of decline
improve planting and soils details
expand routine maintenance

ENHANCE PRACTICES | OVERVIEW

MONITOR
—Increase tree assessments
—Expand pest monitoring
—Expand Cartegraph tracking to monitor success of practices

REMEDIATE
—Manage soils
  —Liquid biological amendments
  —Decompaction/Aeration
—Treat private trees during severe pest outbreaks (EAB)

PLANT
—Enhance soil specs
—Ensure proper drainage
— Plant bare root trees

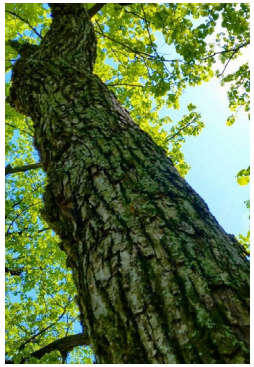
MAINTAIN
—Formalize a City-wide management plan
—Manage soils
  —Mulching
  —Liquid biological amendments
—Structural pruning for young trees
—Expand watering program

MONITOR | TREE CANOPY ASSESSMENT

DRAFT

Increase frequency of city-wide tree assessments.

BENEFITS
Allows identification of stressed trees for remediation practices



SCOPE OF WORK
High: 3 zones for annual assessment cycle
Low: 5 zones for annual assessment cycle

FREQUENCY
High: Survey trees on a 3 year cycle
Low: Survey trees on a 5 year cycle

MONITOR | PESTS & DISEASES MONITORING

DRAFT

Expand pest/disease monitoring.

BENEFITS
Allows treatment at start of outbreak

SCOPE OF APPLICATION
Monitor specifically for pests/diseases that are systemic city-wide threat
Formalize coordination protocols with surrounding municipalities

Emerald Ash Borer trap

SCOPE OF WORK
High: Traps and tree assessments
Low: Traps

MONITOR | MAINTENANCE TRACKING

DRAFT

Track all treatments (ie., soil management) in Cartegraph (City inventory software).

BENEFITS
Ability to assess success of treatments

SCOPE OF APPLICATION
All trees when pruned by contractors
All trees treated with liquid biological amendments and decompaction measures

SCOPE OF WORK
Record treatment in Cartegraph through mobile device at time of treatment
Follow up inspection to assess efficacy of treatment

Treat private trees during city-wide pest/disease outbreaks.

BENEFITS

In the case of Emerald Ash Borer (EAB) the City is currently treating 883 City trees, approx. 2% of City canopy

LiDAR survey indicates there are 1,536 Ash in the City, approx. 4% of the City canopy

Expanding EAB treatment to private trees could save additional 2% of canopy

SCOPE

Treat approx. 650 private trees with TreeAzin injections per City spec

650 trees x 12" DBH avg x $15/caliper inch = approx. $117,000/year

Treat underperforming trees with liquid biological amendments.

BENEFITS

Improve nutrient availability
Reduce compaction

SCOPE OF APPLICATION

High: all publicly owned trees showing signs of fair-poor condition
Medium: all publicly owned trees showing signs of poor condition
Low: 1/2 publicly owned trees showing signs of poor condition

SCOPE OF WORK

Soil injections of 10 gallon liquid (compost tea) @ 4 points per tree
Approximately 10 minutes per tree

FREQUENCY

High: yearly, half of the trees in spring and half in fall
Low: 1/3 of trees each year, 3 year cycle of treatment

Treat compacted soil through mechanical decompaction.

BENEFITS

Reduce compaction
Enhance moisture retention

SCOPE OF APPLICATION

High: All publicly owned non-street trees
Low: Park trees in areas of high use

SCOPE OF WORK

Treat zones with Aera-vator within dripline of each tree or group of trees
Incorporate high-quality compost during treatment
Approximately 60 minutes per tree

FREQUENCY

High: each tree every year, half of the trees in spring and half in fall
Medium: each tree every two years, a quarter of the trees in spring and quarter in fall
Low: once, half the trees in the spring, half in the fall

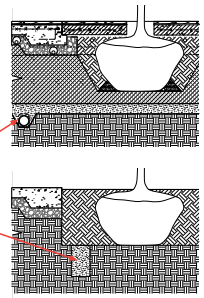
Incorporate drainage measures in new plantings.

BENEFITS

Prevent roots from potentially sitting in water and dying

SCOPE OF APPLICATION

Test all new plantings, remediate where needed



SCOPE OF WORK

High: Underdrains at bottom of pits for new trees associated with large projects

Low: Augur sand wicks at bottom of pit for tree pits with poor drainage

Enhance soil specifications.

BENEFITS

A) Improve tree health and root capacity
B) Improve survival rates and growth rates

SCOPE OF APPLICATION

A) High: All publicly planted trees
B) Low: All publicly planted street trees

SCOPE OF WORK

A) Develop multiple soils blends to respond to specific conditions
    i. Structural soils
    ii. Suspended pavements
    iii. Parkland Turf
    iv. Beds and mixed planting
B) Incorporate biological guidelines into soil specification
C) Continue to incorporate biochar within soils
D) Measure compaction by standard proctor
E) Require compliance testing by contractor

Plant bare root trees and manage a gravel bed nursery.

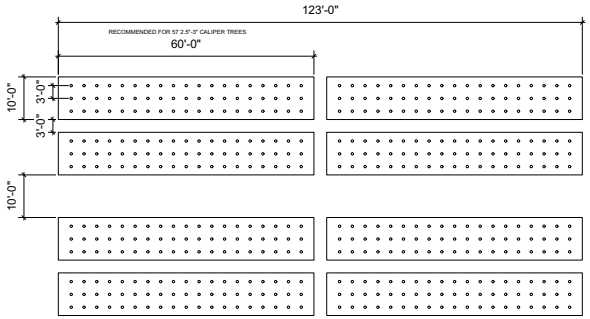
BENEFITS

Increase survival rates
Increase species selection
Lower installation costs
Expand season for planting

SCOPE OF WORK

Manage a gravel bed nursery on city-owned land

Manage a gravel bed nursery.



8,200 sf required to store 456 bare root trees.

Create City-wide Management Plan

BENEFITS

Clarity of annual goals, ability to track performance

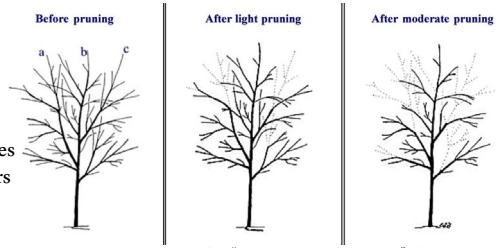
SCOPE OF WORK

Formalize management goals and objectives
Documentation of all aspects of tree management practices
Institute annual assessment of progress

Implement structural pruning for young trees.

BENEFITS
Improve storm resiliency and life span of trees

SCOPE OF APPLICATION
High: All new City plantings +
Require structural pruning of new trees planted under Special Permits for 6 yrs
Low: All new City plantings



Graphic from "Structural Pruning of Shade Trees," Gilman and Eisner

SCOPE OF WORK
Selectively prune branches and stems larger than about half the diameter of the trunk.

FREQUENCY
High: Prune young trees on 3 year pruning cycle for first 6 years after planting (two visits), 5 year cycle for next 15 years (three visits)
Low: Prune young trees on 3 year pruning cycle for first 9 years after planting (three visits)

Expand watering program

BENEFITS
Improve resistance to pests and disease

SCOPE OF APPLICATION
High: all publicly owned trees
Medium: all publicly owned trees under 20 years of age (where impacts are believed to be highest)
Low: Trees in high risk areas

SCOPE OF WORK
Soak soil around tree
Approx. 10 mins per tree

FREQUENCY
High: Irrigate each tree in scope once per month during June-August
Low: Irrigate trees when showing signs of stress

Expand mulching program

BENEFITS
Improve soils and tree health

SCOPE OF APPLICATION
High: all publicly owned trees with exposed soil (NIC flexipave, tree grates, etc) (use Bartlett's survey to make an estimate of % bare soil trees)
Medium: all publicly owned non-street trees
Low: all trees showing signs of stress (per yearly city-wide tree assessment)

SCOPE OF WORK
Spread mulch on exposed soil areas
Approximately 15 minutes per tree

FREQUENCY
High: Each tree every year in spring
Med: ¼ of trees per year in spring
Low: Adopt-a-tree mulching with mulch barrels

Liquid biological amendments

BENEFITS
Improve nutrient availability
Reduce compaction

SCOPE OF APPLICATION
High: all publicly owned trees
Low: all publicly-owned trees under 20 years of age

SCOPE OF WORK
Soil injections of 10 gallon liquid (compost tea) @ 4 points per tree
Approximately 10 minutes per tree

FREQUENCY
High: yearly, half of the trees in spring and half in fall
Low: 1/3 of trees each year, 3 year cycle of treatment

MAINTAIN | SOILS HEALTH

DRAFT

De-icing

SCOPE OF WORK

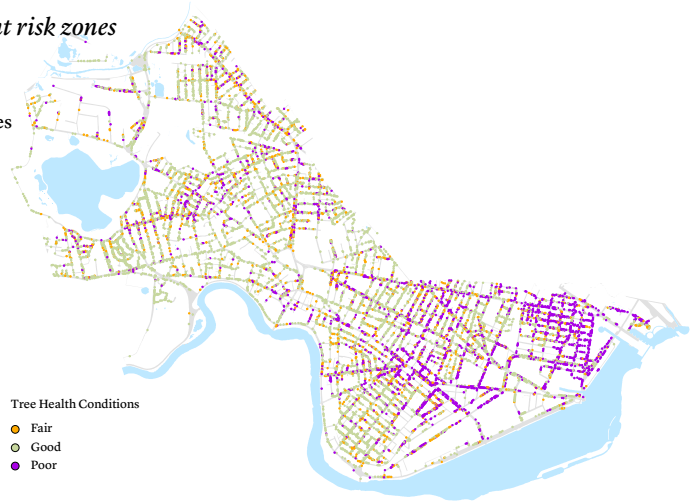
Continue to investigate alternative deicing methods, e.g. brine treatments on sidewalks.
After winters with heavy deicer use, flush tree pits in spring

MAINTAIN | RISK ZONES

Create management risk zones

BENEFITS

Improve efficiency by tracking most at-risk trees



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PUBLIC COMMENT

www.cambridgema.gov/ufmp

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling
SEPTEMBER 27	RESEARCH: Summary of Findings
OCTOBER 25	Cancelled
NOVEMBER 29	TESTING: Baseline Change Model
DECEMBER 20	DRAFT: Policy
JANUARY 31	DRAFT: Policy
FEBRUARY 28	DRAFT: Planning and Practice
MARCH 28	DRAFT: Outreach, Cost / Benefit
APRIL 25	DRAFT: Prioritization

www.cambridgema.gov/ufmp

OUTREACH

FOREST RESILIENCY

CANOPY VALUATION

NEXT STEPS

CORE CONCEPTS

Share responsibility for a healthy forest

How do we communicate the value of trees?

OUTREACH / EDUCATION
Build on existing curriculum

Cambridge Public Schools Curriculum

Kindergarten:
Exploring woodland and freshwater habitats through class-maintained terraria and aquaria.

Grade 1:
Animals and plants of the same kind share similar characteristics with others of the same kind but they are not exactly the same.

Grade 2: Plants and animals depend on other living things and their environment to grow, thrive, and survive.

Grade 3: Students plant and observe the growth of Wisconsin Fast Plants from seed to flower to seed. They also learn about bees and pollination.

WISCONSIN FAST PLANT SEED PACKET

Source: https://www.cpsd.us/departments/science/

OUTREACH / EDUCATION
Utilize ready-made lesson content

Mass Audubon, STEM Preschool Teaching Unit

Trees are found just about everywhere, so they are familiar to young children. Trees are kid friendly to explore, interesting to learn about, and easy to appreciate. This unit offers seven different investigations about trees.

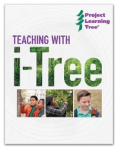
1. Introduction to trees
2. What are the parts of a tree?
3. How are trees classified?
4. How does a tree grow? How does a tree make pinecones or acorns?
5. Why do leaves change color in the fall?
6. Who lives in trees?
7. How do trees help us?

Source: https://www.massaudubon.org/content/download/13467/209564/file/PreKTeachingUnits-TREES.pdf

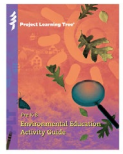
OUTREACH / EDUCATION
Utilize ready-made lesson content

Project Learning Tree (educational non-profit organization)

Project Learning Tree (PLT) is an award-winning environmental education program that provides ready-made lessons and activities for educators. PLT uses the forest as a "window to the world," helping young people gain an awareness and knowledge of the world around them and their place within it.[1]



TEACHING WITH I-TREE


PRE K-8 GUIDE

PLT's instructional materials for early childhood through grade 12 can be used with students in formal school settings and with youth in nonformal settings.[2]

K- GRADE 2 E-UNIT TREMENDOUS SCIENCE

GRADES 3-5 E-UNIT ENERGY IN ECOSYSTEMS

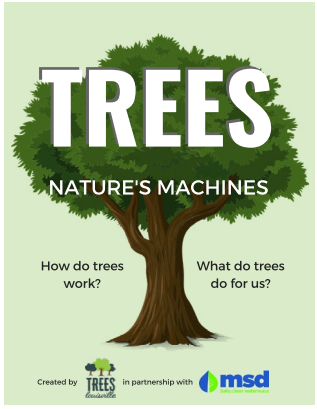
GRADES 6-8 E-UNIT CARBON & CLIMATE

Sources: 1. Indiana Dept. of Natural Resources https://www.in.gov/dnr/forestry/5750.htm
2. Project Learning Tree https://www.plt.org/curriculum-offerings/elementary-middle/

OUTREACH / EDUCATION
Example of science curriculum unit on ecosystem services

Trees Louisville

Trees Louisville's science curriculum unit shows students how to calculate the ecosystem benefits of specific trees on campus or at home.



Steps to identifying tree benefits

1. Using your tree identification guide, determine the species of your tree.

2. Using your measuring tape, measure in inches the diameter of the tree at a point about 4 feet from ground level.

3. Calculate an estimate of the ecosystem benefits that this tree provides using the National Tree Benefit Calculator.

4. Share a write-up about the tree you measured, why you chose it and what its benefits mean to you.

5. Monitor the tree over the course of the year to observe any changes.

* Bonus! - Learn more about your tree using other online resources.

2

Source: https://treeslouisville.org/wp-content/uploads/2019/03/Trees_-Natures-Machines-01_19.pdf

OUTREACH / EDUCATION
Support citizen science projects

Air quality monitoring

COLORADO STATE UNIVERSITY

AIR SENSOR TOOLBOX BY EPA

Source: https://www.nasa.gov/feature/new-citizen-science-projects-funded-for-earth-studies

Source: https://www.citizenscience.gov/catalog/489/#

OUTREACH / EDUCATION
Organize tree tours for citizens to engage with trees

Tree Tours

Friends of the Urban Forest arranges walking and bicycling tours of the beautiful trees, parks, and natural spaces of San Francisco.

FRIENDS OF THE URBAN FOREST, SAN FRANCISCO

Source: https://www.fuf.net/programs-services/community-engagement-education/tree-tours/

OUTREACH / EDUCATION
Continue to publicize ecosystem benefits

Public Installations

CAMBRIDGE, MA

CHICAGO

Source: https://earthshare.typepad.com/.a/6a00e554936bef883401901e82100f970b-pi

OUTREACH / EDUCATION
Support alternative educational approaches

Public Installations

David Buckley Borden (design)
John Cronan (hand-painting)

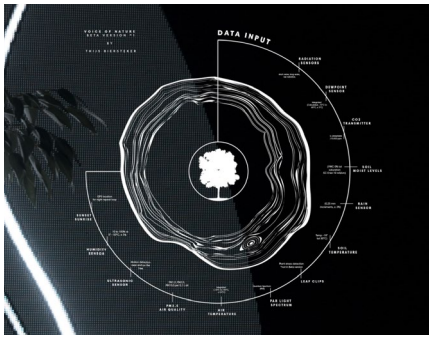
OUTREACH / EDUCATION

Support alternative educational approaches

Public Installations

Voice of Nature by Thijs Biersteker

Sensors connected to a tree in Chengdu, China monitor environmental conditions such as CO_2 level, temperature, moisture in the soil, and light level. This data then generates digital rings every second and document the tree's health in real time.



Source: https://motherboard.vice.com/en_us/article/59v42d/this-tree-is-an-artwork-thijs-biersteker

OUTREACH / EDUCATION

Publish annual reports to give feedback on progress

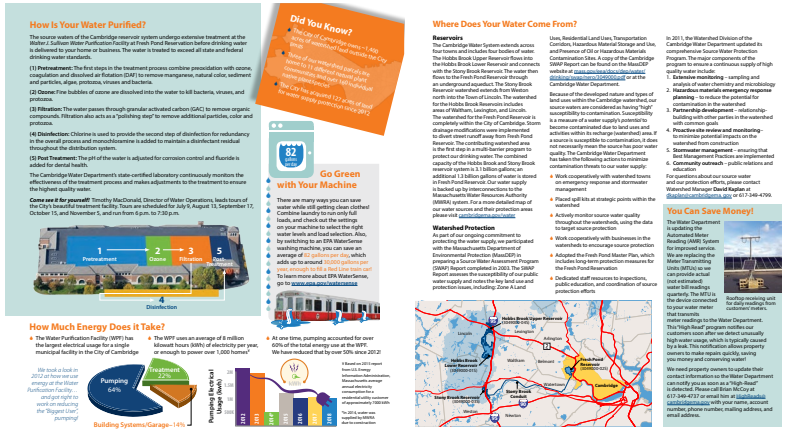
Tree Report Card, Washington D.C.

Source: https://caseytreesdc.github.io/treereportcard/

OUTREACH / EDUCATION

Publish annual reports to give feedback on progress

Cambridge MA Annual Drinking Water Quality Report



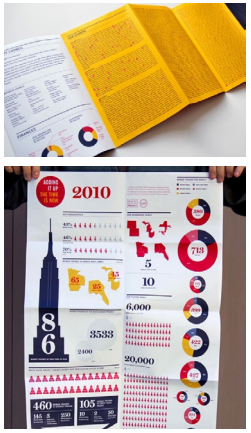
Source: https://www.cambridgema.gov/Water/wateroperationsdivision/watertreatment/waterqualityreport

OUTREACH / EDUCATION

Publish annual reports to give feedback on progress

Other examples

GLOBAL FOOTRPRINT NETWORK
2010 ANNUAL REPORT



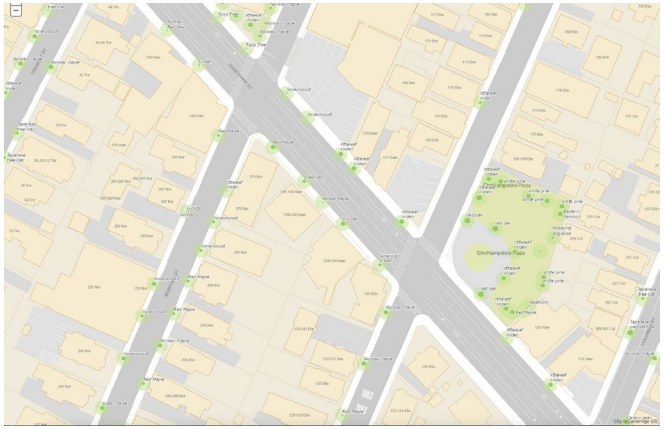
THE WHITE HOUSE PROJECT
2010 ANNUAL REPORT

POWER TO BE
2015 ANNUAL REPORT

How do we get people to take action?

OUTREACH / EDUCATION
Improve the online tree map to engage citizens

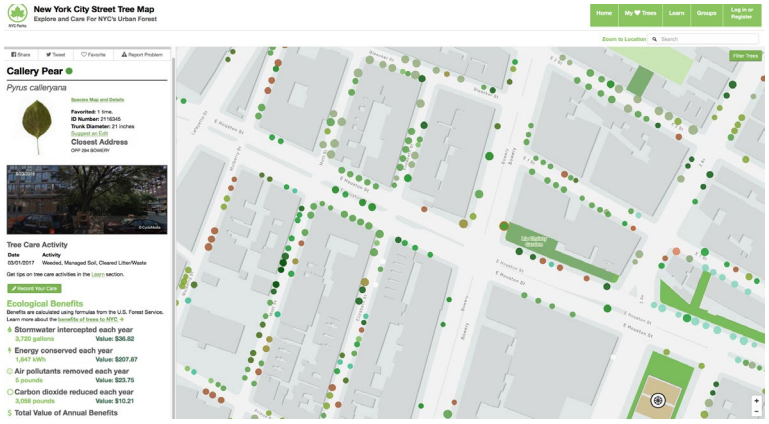
Tree health monitoring



TREE WALK CAMBRIDGE

OUTREACH / EDUCATION
Improve the online tree map to engage citizens

Tree health monitoring



NEW YORK CITY STREET TREE MAP

OUTREACH / EDUCATION
Support community tree planting efforts

Keep Indianapolis Beautiful

Community Forestry:

Residents can apply for tree planting, if they find at least 20 spots for trees in their neighborhood. Applicants need to form a small group and need to share with their neighbors and business owners to commit to tree preservation.

Urban Naturalists:

Employing young adults, providing them with job skills and professional development so they are prepared for impactful careers in environmental fields.

Source: https://www.kibi.org

OUTREACH / EDUCATION

Promote existing programs for citizens to take responsibility for trees

Adopt-a-Tree / Junior Forester

CAMBRIDGE JUNIOR FORESTER APPLICATION

I WOULD LIKE TO ADOPT A TREE

I UNDERSTAND IT IS MY RESPONSIBILITY TO :

1. WEED AROUND THE BASE OF THE TREE
   Pull weeds by hand and throw away.
2. WATER THE TREE - FILL THE GATOR BAG ONCE A WEEK
   Dpw will provide a 'gator bag' to hold 20 gallons of water
3. MULCH OR ADD COMPOST TO THE SOIL
   Apply 2 – 3 inches of mulch or compost to planting area.
   Not touching the trunk of the tree.
4. PICK UP LITTER – It is important to keep the tree well clean
5. LET THE DPW KNOW IF THERE IS INJURY TO THE TREE.
   617 349-4885

Name_____ Address_____

_____ _____

Email:_____ Phone # _____

Signature:

Jr. Forester_____ Parent/Guardian_____

www.cambridgema.gov/trees Mail to: Dave Lefcourt, 147 Hampshire Street, Cambridge, MA 02139

How do you stem loss?

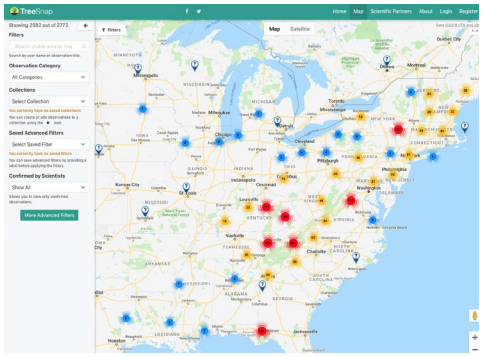
OUTREACH / EDUCATION

Engage with citizen science projects to protect threatened species

Tree Snap

Tree Snap enables foresters, landowners, and citizens to record the location of healthy trees of particular threatened species that scientists can then study for genetic diversity or breeding programs.

In the northeast, the species of concern are American chestnut, elm, ash, white oak, hemlock, and eastern larch.



OUTREACH / EDUCATION

Engage with citizen science projects to protect threatened species

Pest monitoring

This citizen science project provides a rare opportunity for the public to participate in real-world scientific research. Participants help to advance the understanding of bark and ambrosia beetles, which will help to protect forests and the species that depend on them.

BACKYARD BARK BEETLES,
UNIVERSITY OF FLORIDA/MICHIGAN STATE

SOD-blitzes inform and educate the community about Sudden Oak Death, get locals involved in detecting the disease, and produce detailed local maps of disease distribution. The map can then be used to identify those areas where the infestation may be mild enough to justify proactive management.

SUDDEN OAK DEATH (S.O.D.) BLITZ,
UNIVERSITY OF CALIFORNIA AT BERKELEY

OUTREACH / EDUCATION
Educate local businesses about dangers of pest outbreaks

Re: inspection of wood products

In 2008 the Asian Longhorn Beetle was found in Worcester, MA, presumably brought in through wood pallets.

The city lost 35,000 trees either killed by the beetle or felled by foresters looking to contain the infestation.

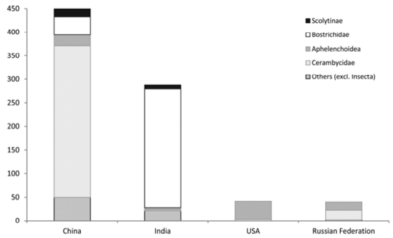
Businesses can help protect the forest by ensuring all wood products are pest free.

WORCESTER, MA

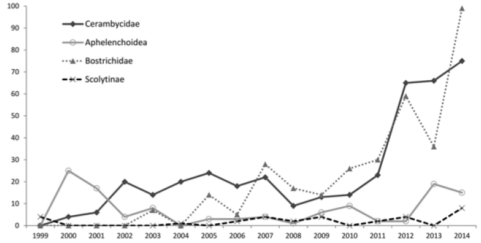
Source: https://www.telegram.com/news/20170109/beetle-infestation-to-claim-more-trees-in-worcester

OUTREACH / EDUCATION
Educate local businesses about dangers of pest outbreaks

Re: inspection of wood products



NUMBER OF INTERCEPTIONS OF HARMFUL ORGANISMS FOUND IN ASSOCIATION WITH WOOD PACKAGING IMPORTED TO THE EU BETWEEN 1999 AND 2014 FOR THE FOUR SOURCE COUNTRIES WITH THE MOST INTERCEPTIONS DIVIDED BY PEST ORGANISM TYPE.



ANNUAL NUMBER OF INTERCEPTIONS OF THE FOUR MOST IMPORTANT GROUPS OF HARMFUL ORGANISMS INTERCEPTED IN THE EU BETWEEN 1999 AND 2014 ON WPM ASSOCIATED WITH WORLDWIDE IMPORTS.

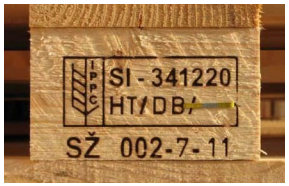
Source: Variation in Inspection Efficacy by Member States of Wood Packaging Material Entering the European Union

OUTREACH / EDUCATION
Educate local businesses about dangers of pest outbreaks

Re: inspection of wood products

ISPM 15 regulates wood packaging material in international trade.

The standard describes phytosanitary measures that reduce the risk of introduction and spread of quarantine pests associated with the movement in international trade of wood packaging material made from raw wood. Wood packaging material covered by this standard includes dunnage but excludes wood packaging made from wood processed in such a way that it is free from pests (e.g. plywood).



Source: https://www.ippc.int/static/media/files/publication/en/2016/06/ISPM_15_2013_En_2016-06-07.pdf

How do you grow canopy?

OUTREACH / EDUCATION

Publicize Back of Sidewalk Program at public events

Back of Sidewalk Program

The Back of Sidewalk tree planting program was designed to improve our urban forest through public/private tree planting partnerships. The term, Back of Sidewalk" refers to the edge of the sidewalk where public way meets private properties. In the case of this program, the City will plant trees along the back of sidewalk, (up to 20 feet off the public way) on private property of interested, eligible owners.

This program provides the city a means of planting trees where in the past either the sidewalk was too narrow or overhead utilities were in the way. This program will allow the city to plant trees in more desirable growing conditions, making it likely they will survive and thrive. A typical sidewalk tree faces harsher conditions along the curb (such as oil or salt from roadway runoff). Soil conditions at the back of sidewalk are generally more suitable for plant growth. The improved environment, larger rooting area, and lack of overhead competition will help ensure a healthier tree canopy in Cambridge.

Pedestrians benefit by this program when sidewalks widths are maintained. The narrow nature of sidewalks in Cambridge make it difficult to find appropriate places to plant new trees. A growing tree not only crowds the sidewalk, but its root system.

Source: https://www.cambridgema.gov/theworks/ourservices/urbanforestry/citystreeplantingprograms/backofsidewalk

OUTREACH / EDUCATION

Multi-agency partnerships for tree planting efforts

MA Greening Gateway Cities

- Multi-agency partnership among MA EEA, DCR, DOER, and DHCD and gateway cities (including Chelsea, Fall River, and Holyoke)
- Trees planted by DCR crews and local labor field crews, led by DCR foresters

Funding: State grant program funded with energy efficiency and state capital funds

GREENING
THE GATEWAY CITIES
MA Urban Canopy Project

Source: https://www.shieldsdesignstudio.com/news/greening-gateway-cities-o
https://www.mass.gov/service-details/greening-the-gateway-cities-program

OUTREACH / EDUCATION

Public and private partnerships for tree planting efforts

Green Tacoma Partnership

- Public-private partnership between City of Tacoma, Metro Parks Tacoma, Forterra, Citizens for a Healthy Bar, Pierce Conservation District and local businesses
- Connects stewardship groups through resources/trainings, and organizing public outreach

Funding: City of Tacoma, individual donations, corporate sponsorship. Forterra appears to be the nonprofit sponsor that houses the operations of the partnership and is likely the fiscal agent.

Source: https://forterra.org/subpage/green-tacoma-partnership-why

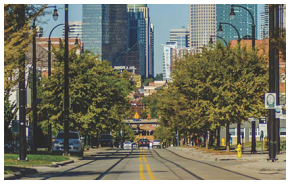
OUTREACH / EDUCATION

Carbon credits from tree plantings to meet carbon reduction goals

Trees Charlotte

- Two-year partnership with Greensboro-based Urban Offsets and higher ed (Davidson College, Duke, and Elon University)
- Creates carbon credits from tree plantings that are sold to higher education institutions seeking ways to meet carbon reduction goals (goal of 900 trees planted)

Funding: Trees Charlotte is a 501 c3 funded by City of Charlotte, individual donations, foundation support, corporate sponsorship. The carbon offset initiative in particular is a model where the City is paid for every tree it plants, universities with a commitment to neutralize their carbon impact pay.



Source: https://treescharlotte.org

OUTREACH / EDUCATION

Partnerships with institutions and organizations for educational opportunities

Tree Pittsburgh

- Public-private partnership between Tree Pittsburgh and Pennsylvania Urban and Community Forestry Council, Penn State University and conservation groups (Friends of the Riverfront, Western Pennsylvania Conservancy, Pittsburgh Parks Conservancy).
- Community tree plantings, Tree Tender volunteer program
- A variety of engaging classroom and field learning opportunities year-round. Tree Pittsburgh staff, ISA Certified Arborists, guest lecturers, or Heritage Nursery staff run all programs

Funding: Tree Pittsburgh is a registered 501(c)3 funded by individual donations, corporate matching gifts, corporate sponsorships.

Source: https://www.treepittsburgh.org

OUTREACH / EDUCATION

Recommendations

— Advocate for the value of trees in education curriculum
—Support citizen science projects
— Organize tree tours for citizens to engage with trees
— Continue to publicize ecosystem benefits of trees
— Support alternative education approaches, art installations
— Publish annual reports to give feedback on progress
— Improve the online tree map to engage citizens
— Promote existing City programs
— Educate local businesses about dangers of pest outbreaks
— Partnership outreach

OUTREACH

FOREST RESILIENCY

CANOPY VALUATION

NEXT STEPS

CORE CONCEPTS

To maintain, plan, build, and sustain a healthy, connective, and resilient urban forest at a time when the urban forest is more important than ever before.

FOREST RESILIENCY
Analysis of City's current street tree list

Underwire trees

Latin Name	Common Name
Acer campestre	Hedge Maple
Acer griseum	Paperbark Maple
Amelanchier sp.	Serviceberry
Cercis canadensis	Eastern Redbud
Maackia amurensis	Amur maackia
Prunus 'Accolade'	Accolade cherry
Prunus sargentii	Sargent cherry
Prunus serrulata 'Kwanzan'	Kwanzan cherry
Prunus serrulata 'Snowgoose'	Snowgoose cherry
Prunus subhirtella 'Autumnalis'	Autumun cherry
Prunus x yedoensis 'Akebono'	Akebono cherry
Prunus x incarn 'Okame'	Okame cherry
Malus sp.	Crabapple sp.
Syringa reticulata	Japanese Lilac Tree

Trees with low condition ratings
Trees that exceed diversity target
Trees that have high susceptibility to climate risks

Canopy trees

Latin Name	Common Name
Acer x fremanii	Armstrong Red Maple
Acer rubrum	Red Maple
Betula nigra	River Birch
Carpinus caroliniana	Hornbeam
Celtis occidentalis	Hackberry
Cercidiphyllum japonicum	Katsuratree
Ginkgo biloba	Ginkgo
Gleditsia triacanthos	Honeylocust
Gymnocladus dioicus	Kentucky Coffeetree
Koelreuteria paniculata	Golden Raintree
Liriodendron tulipifera	Tuliptree
Liquidambar styraciflua	Sweetgum
Metasequoia glyptostroboides	Dawn Redwood
Nyssa sylvatica	Black Tupelo
Platanus x acerifolia	London Planetree
Pyrus sp.	Pear spp.
Quercus bicolor	Swamp White Oak
Quercus palustris	Pin Oak
Quercus rubra	Red Oak
Quercus velutina	Black Oak
Sophora japonica	Sophora
Tilia cordata	Littleleaf Linden
Tilia tomentosa	Silver Linden
Ulmus americana	American Elm
Ulmus sp.	Elm cultivars
Zelkova serrata	Zelkova

FOREST RESILIENCY
Snapshot of CUFMP tree database

NAME			CLIMATE RESILIENCY SCORE					ORIGIN		SIZE				TYPOLOGIES	
Genus	Species	Comm_Name	Flood score	Drought Score	Pest Score	Total score	RUST (Relative Urban Stress Tolerance)	Native	Non-native	Typical Range of Mature Crown Width	Small (Mature height less than 35 ft tall)	Medium (Mature height greater than 35 ft but less than 50 ft tall)	Large (Mature height greater than 50 ft tall)	CANOPY STREET TREES	UNDERWIRE STREET TREES
Abies	concolor	Fir-White	1	2	2	5.5			Yes	15-20'		X			
Acer	negundo	Boxelder	3	3	1	4.5	1.40	Yes		40-50'		X		X	
Acer	ginnala	Maple-Amur	1	2	1	6.5			Yes	15-25'	X				
Acer	nigrum	Maple-Black	1	2	1	6.5			Yes	40-50'			X		
Acer	platanoides	Maple-Crimson King No	1	3	1	5.5			Yes	30-45'			X		
Acer	x freemanii	Maple-Freeman	2	2	1	6			Yes	35-40'			X		
Acer	campestre	Maple-Hedge	1	3	1	5.5	4.14		Yes	25-35'	X				X
Acer	palmatum	Maple-Japanese	1	2	1	6.5			Yes	10-25'	X				
Acer	griseum	Maple-Paperbark	1	2	1	6.5			Yes	15-25'	X				
Acer	rubrum	Maple-Red	3	1	1	6.5	1.4	Yes		20-35'			X	X	
Acer	saccharinum	Maple-Silver	3	2	1	5.5	1.73	Yes		40-60'			X	X	
Acer	saccharum	Maple-Sugar	2	1	1	7	-0.72	Yes		30-50'			X		
Acer	tataricum	Maple-Tatarian	1	3	1	5.5			Yes	15-20'	X				
Acer	buergeranum	Maple-Trident	1	2	1	6.5	2.18		Yes	20-30'	X				X
Aesculus	glabra	Buckeye-Ohio	2	1	1	7	1.68		Yes	40-50'			X	X	
Aesculus	hippocastanum	Horsechestnut	2	2	1	6			Yes	40-50'			X		
Aesculus	x carnea	Horsechestnut-Red	2	2	1	6	0		Yes	30-40'		X			
Albizia	julibrissin	Mimosa	1	2	1	6.5			Yes	25-35'		X			
Alnus	glutinosa	Alder-Common	2	2	2	5	1.21		Yes	15-20'			X	X	
Amelanchier	x grandiflora	Serviceberry-Apple	2	2	3	4			Yes	15-25'	X				
Amelanchier	arborea	Serviceberry-Downy	2	1	3	5	0.72	Yes		10-20'	X				
Betula	pendula	Birch-European White	1	1	1	7.5			Yes	15-30'		X			
Betula	populifolia	Birch-Gray	1	1	1	7.5	1.43	Yes		10-20'		X		X	
Betula	papyrifera	Birch-Paper	2	1	1	7	2.95	Yes		25-50'			X	X	
Betula	nigra	Birch-River	2	2	1	6	3.03	Yes		40-60'			X	X	
Carpinus	caroliniana	Hornbeam-American	2	1	1	7	1.82	Yes		15-30'		X		X	
Carpinus	betulus	Hornbeam-European	2	3	3	3	0.12		Yes	35-40'		X			
Carya	tomentosa	Hickory-Mockernut	1	3	2	4.5	1.72	Yes		50-75'			X	X	

FOREST RESILIENCY
Species selection evaluation criteria

— Climate Resiliency Score

-pest/disease resiliency	1 = low 2 = moderate 3 = high
-drought tolerance	1 = low 2 = moderate 3= high
-flood tolerance	0.5 = low 1 = moderate 1.5= high
	Overall score ranges from 2.5 to 7.5

— Relative Urban Stress Tolerance (RUST) Score

-urban stress agents assessed: pH, hardiness, sun, insect/diseases, physiological/environmental, moisture, salt, texture, compaction

-the higher the score, the better the species is as a street tree

FOREST RESILIENCY
Database Sorting Criteria:

— Size
— Planting location
— Sun exposure
— Flooding tolerance
— Native or nonnative
— Soil type

FOREST RESILIENCY
Are there benefits to planting native vs. nonnative species in the city?

"Most published research demonstrates that the native status of trees and shrubs has little influence on biodiversity."[1]

—Linda Chalker-Scott, Ph.D., Extension Horticulturist and Associate Professor, Washington State University

"The dynamic nature of interactions among people, plants, and animals in today's world are producing novel ecological associations with unpredictable consequences for all parties concerned."[2]

—Peter Del Tredici, Ph.D., Senior Research Scientist Emeritus, Arnold Arboretum

1. Chalker-Scott, L. 2018. "Are Native Trees And Shrubs Better Choices For Wildlife In Home Landscapes?" Washington State University Extension Fact Sheet.
2. Del Tredici, P. 2007. The role of horticulture in a changing world. In: M. Conan and W. J. Kress (eds.), Botanical Progress, Horticultural Innovation, and Cultural Changes, pp. 259–264. Dumbarton Oaks, Washington DC.
See also: Chalker-Scott, L., "Nonnative, Noninvasive Woody Species Can Enhance Urban Landscape Biodiversity," Arboriculture & Urban Forestry 2015. 41(4): 173–186.

FOREST RESILIENCY
Are there benefits of planting native vs. nonnative species in the city?

— Certain genera support more wild life than others but there is little significant difference between native and non-native species

— Species diversity is important for a healthy, resilient forest.

— We should plant species proven to be well adapted to the urban environment

FOREST RESILIENCY
Species Diversity Criteria

No more than...

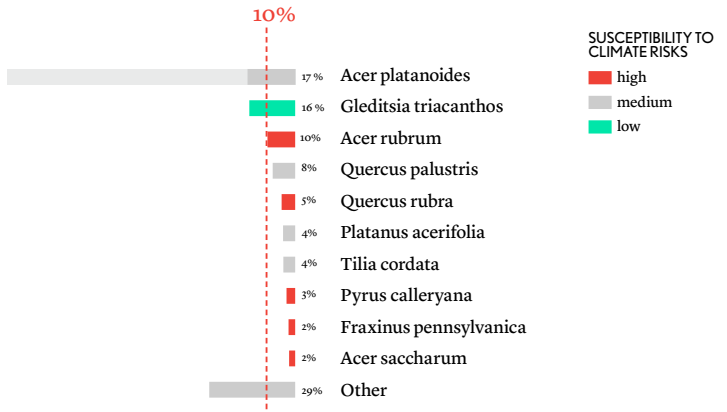
10% SPECIES

20% GENUS

Santamour, 1990: Urban foresters and municipal arborists should use the following guidelines for tree diversity within their areas of jurisdiction:
(1) plant no more than 10% of any species,
(2) no more than 20 % of any genus,
(3) no more than 30 % of any family.

Melbourne Urban Forest Diversity Guidelines, 2011: The urban Forest Diversity Guidelines recommend that by 2040
(1) no more than 5 percent of the forest is to be of any single species,
(2) no more than 10 percent is to be of any genus,
(3) no more than 20 percent is to be of any one Family.

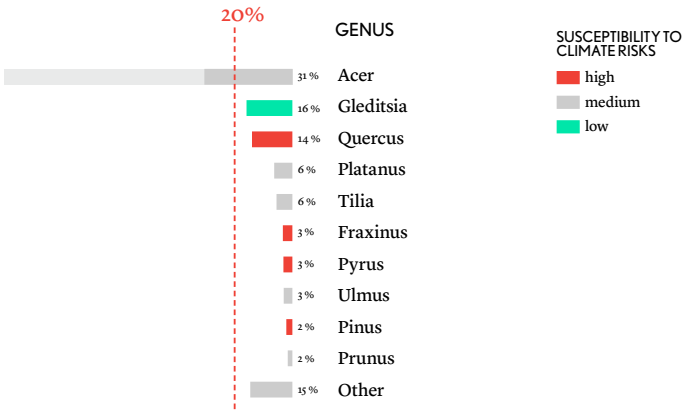
FOREST RESILIENCY
Existing species makeup of the urban forest is susceptible to climate risks of increased pests/diseases, drought and flooding



Source: 2018 CUFMP canopy analysis

FOREST RESILIENCY

Existing genus makeup of the urban forest is susceptible to climate risks of increased pests/diseases, drought and flooding



Source: 2018 CUFMP canopy analysis

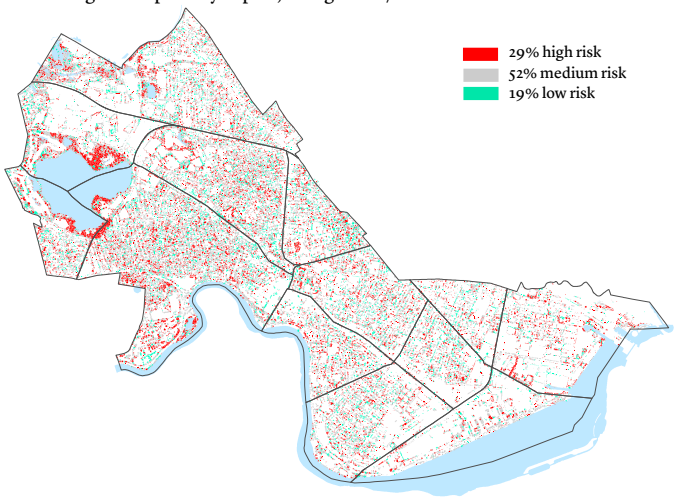
FOREST RESILIENCY

Most climate resilient species

Latin Name	Common Name	Climate Score	% species	% genus
Juniperus virginiana	Eastern Redcedar	7		
Carpinus betulus	European Hornbeam	7		
Cotinus coggygria	Common Smoketree	7		
Sophora japonica	Japanese Pagodatree	7		
Sassafras albidum	Sassafras	6.5	less than 1%	
Eucommia ulmoides	Hardy Rubber Tree	6.5		
Parrotia persica	Persian Parrotia	6.5		
Ptelea trifoliata	Wafer Ash	6.5		
Ginkgo biloba	Ginkgo	6.5	1%	1%

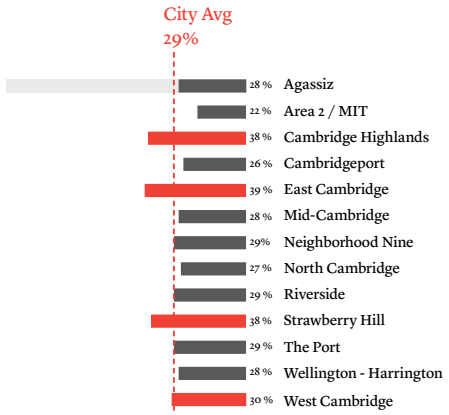
FOREST RESILIENCY

29% percent of the forest has high susceptibility to pest, drought and/or flood factors



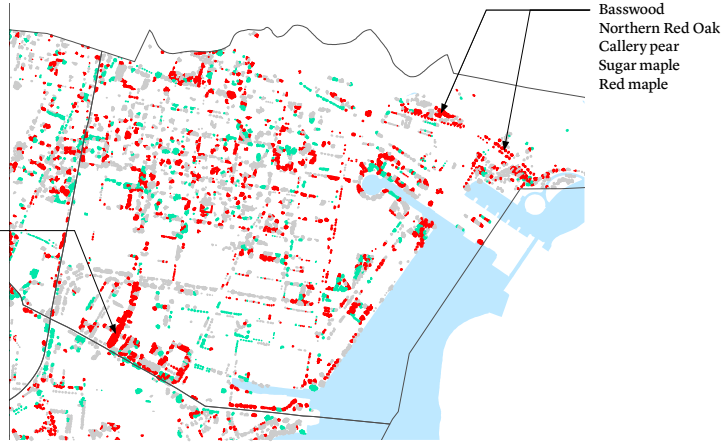
FOREST RESILIENCY

High risk species are generally spread evenly throughout Cambridge.



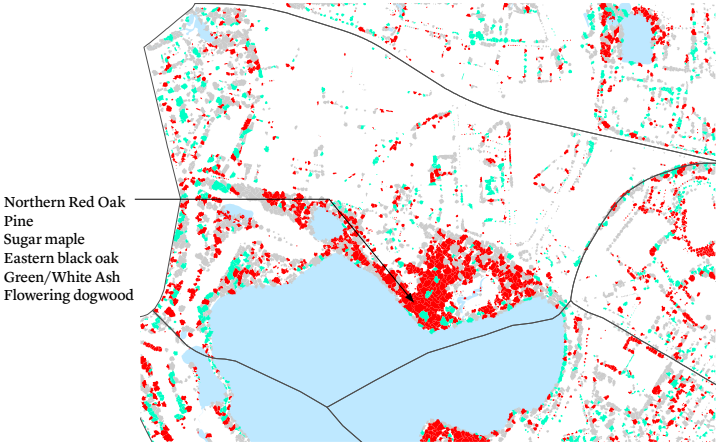
Source: 2018 CUFMP canopy analysis

FOREST RESILIENCY
East Cambridge



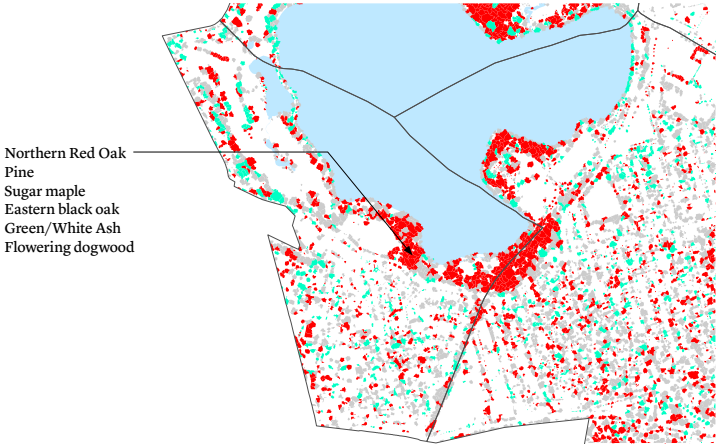
Source: 2018 CUFMP canopy analysis

FOREST RESILIENCY
Cambridge Highlands



Source: 2018 CUFMP canopy analysis

FOREST RESILIENCY
Strawberry Hill/West Cambridge



Source: 2018 CUFMP canopy analysis

FOREST RESILIENCY
Given the susceptibility of the current forest, we should:

—Plant well-adapted species with a higher climate resiliency score

—Plant fewer species that already have met their proportion limits

—Diversify forest to the extent possible

FOREST RESILIENCY
Reduced existing species list

Underwire trees

Latin Name	Common Name
Acer campestre	Hedge Maple
Acer griseum	Paperbark Maple
Amelanchier sp.	Serviceberry
Cercis canadensis	Eastern Redbud
Maackia amurensis	Amur maackia
Syringa reticulata	Japanese Lilac Tree

Trees that exceed diversity target

Canopy trees

Latin Name	Common Name
Acer x fremanii	Armstrong Red Maple
Betula nigra	River Birch
Carpinus caroliniana	Hornbeam
Celtis occidentalis	Hackberry
Cercidiphyllum japonicum	Katsuratree
Ginkgo biloba	Ginkgo
Gleditsia triacanthos	Honeylocust
Gymnocladus dioicus	Kentucky Coffeetree
Koelreuteria paniculata	Golden Raintree
Liriodendron tulipifera	Tuliptree
Liquidambar styraciflua	Sweetgum
Metasequoia glptostroboides	Dawn Redwood
Nyssa sylvatica	Black Tupelo
Platanus x acerifolia	London Planetree
Quercus bicolor	Swamp White Oak
Quercus palustris	Pin Oak
Sophora japonica	Sophora
Tilia cordata	Littleleaf Linden
Tilia tomentosa	Silver Linden
Ulmus americana	American Elm
Ulmus sp.	Elm cultivars
Zelkova serrata	Zelkova

FOREST RESILIENCY
New recommended species

Underwire trees

Latin Name	Common Name
Ostrya virginiana	American Hop Hornbeam
Chionanthus retusus	Chinese Fringetree
Syringa pekinensis	Peking Lilac
Cornus x	Hybrid Dogwoods
Parrotia persica	Persian Parrotia

Canopy trees

Latin Name	Common Name
*Aesculus hippocastanum	Horsechestnut
*Aesculus flava	Yellow Buckeye
*Carya glabra	Pignut Hickory
*Carya ovata	Shagbark Hickory
Eucommia ulmoides	Hardy Rubber Tree
Taxodium distichum	Bald Cypress
Taxodium distichum var. imbricatum	Pond Cypress
Cryptomeria japonica 'Yoshino'	Yoshino Cryptomeria
Quercus acutissima	Sawtooth Oak
Quercus dentata	Daimyo Oak
Quercus imbricaria	Shingle Oak
Quercus macrocarpa	Bur Oak
Quercus shumardii	Shumard Oak
Quercus texana	Nuttall Oak

*trees that drop nuts

FOREST RESILIENCY
New recommended species

Existing street trees list	26 GENERA	40 SPECIES
New street trees list	32 GENERA	46 SPECIES

FOREST RESILIENCY
Comparison with other cities' lists

Philadelpia street trees list	41 GENERA	70 SPECIES
New York street trees list	38 GENERA	75 SPECIES

OUTREACH

FOREST RESILIENCY

CANOPY VALUATION

NEXT STEPS

CORE CONCEPTS

Value the forest as a public resource

The urban forest is a public resource and has **measurable value and impacts** everyone. It provides shade to cool our environment, gives scale and character to our streets, provides habitat for diverse species, improves our air quality, reduces stormwater impacts, and improves our health and well-being.

To shift the trend from increasing loss to sustainable growth, we must manage the urban forest as **urban infrastructure** (like water, sewer, power) investing for the long term, managing resources collectively, and understanding the value (ie., ecosystem services) of the canopy.

To balance the value of the forest with the complex needs of the city, we should focus on the performance of the **forest as a system** over the specific value of individual trees.

CANOPY VALUATION

Urban Forest Benefits: Ecological, cultural and economic values

Table 5
Urban tree benefits reported in the 115 research papers on urban trees examined in this study.

Benefits	Discussed	Demonstrated
Social benefits	7	5
Making urban environment more pleasant to live, work and spend leisure time	3	2
Providing significant outdoor leisure/recreation opportunities	3	2
Providing nature in the city	1	1
Enhancing quality of urban life	5	3
Promoting environmental responsibility and ethics	1	–
Building stronger sense of community	1	–
Enhancing community's sense of social identity and self-esteem	1	–
Providing settings for significant emotional and spiritual experiences	1	–
Providing opportunities for inner city children to experience nature	1	–
Economic benefits	28	27
Saving substantially on fuel expenditure	1	–
Increasing land value	3	3
Increasing property value	13	12
Increasing rental price	1	1
Increasing neighbouring property value	2	1
Reducing 'time on market' for selling property	1	1
Increasing property taxes	1	–
Increasing tourism revenue	1	–
Increasing business activity	1	–
Contributing to the economic vitality of the city	1	–
Providing annual returns on municipal investments	2	1
Alleviating the hardships of inner city living for low – income groups	1	–
Reducing expenditure on air pollution removal	7	6
Reducing expenditure on storm water infrastructure	4	3
Saving annual heating and cooling costs	2	2
Savings on electricity costs	1	1
Avoiding investment in new power supplies	3	2
Providing potential for future carbon offsetting trade	2	2

Ecosystem services	Discussed	Demonstrated
Carbon related ecosystem services	30	27
Storing/sequestering carbon	30	27
Air quality related ecosystem services	38	34
Producing oxygen	2	2
Filtering air	11	9
Removing ozone	18	16
Removing carbon monoxide	12	10
Removing sulphur dioxide	17	15
Removing nitrogen dioxide	15	14
Removing airborne particle matters/suspended particles	22	20
Removing dust	1	1
Reducing smog	3	3
Reducing carbon dioxide emissions	9	8
Storm water related ecosystem services	10	9
Reducing rate of storm water runoff	10	9
Reducing volume of storm water runoff	8	7
Reducing flooding damage	4	3
Reducing water quality problems	3	2
Recharging ground water	1	1
Energy related ecosystem services	20	18
Reducing annual energy use	14	11
Reducing summer time energy use	5	5
Reducing seasonal cooling energy	4	4
Reducing carbon dioxide emission from power plants	3	2
Habitat related ecosystem services	7	5
Providing habitat for wildlife	7	5
Enhancing biodiversity	1	–
Providing stability to urban ecosystems	1	–
Noise related ecosystem services	8	5
Reducing noise	8	5
Reducing apparent loudness	2	1
Micro climate related ecosystem services	25	25
Providing shade	16	16
Reducing solar radiation	4	4
Modifying microclimate	9	
Reducing relative humidity	1	1
Reducing air temperature	15	15
Reducing heat island effect	10	10
Reduction of glare/reflection	3	3
Controlling wind	6	6

Benefits	Discussed	Demonstrated
Health benefits	5	2
Fewer complications and faster recovery at hospital having windows with tree view	2	–
Reducing stress	3	–
Improving physical health	2	–
Creating relaxed psychological states	3	1
Averting premature death	1	1
Averting respiratory hospital admissions	1	1
Visual and aesthetic benefits	6	5
Providing a sense of place & identity	2	1
Creating seasonal interest by highlighting seasonal changes	1	1
Improving scenic quality	6	5
Providing privacy	2	2

Roy et al A systematic quantatitive review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban Forestry & Urban Greening 11 (202 p. 351-0363).

CANOPY VALUATION

Demonstrated tree benefits

Quantifiable economic benefit through iTree

Economic benefit:

- Increased property value
- Reduced expenditure on air pollution removal
- Reduced expenditure on stormwater infrastructure
- Saved investment in new power supplies
- Reduced heating and cooling costs
- Reduced time on housing market

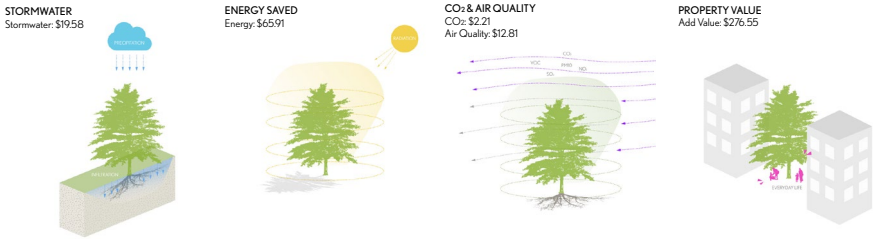
Social benefit:

- Increased quality of life (stress relief- survey study)
- Health benefit – averting respiratory hospital admissions and premature death
- Improved scenic quality
- Providing a sense of place and identity
- Creating seasonal interest
- Providing privacy

Ecosystem services

- Carbon storage and sequestration
- Air quality improvement
- Stormwater attenuation (reducing rate and volume of stormwater runoff, improving water quality, recharging groundwater, minimizing flooding damage)
- Energy conservation
- Habitat preservation
- Noise reduction
- Microclimate amelioration (reducing heat island, glare and reflection)

CANOPY VALUATION
Infrastructure Performance



Ecosystem services for an average Pin Oak in Cambridge
Source: i-Tree Streets - Annual Savings for Average Pin Oak in Cambridge

CANOPY VALUATION
Several methods for valuing tree benefits

Methods for measuring benefit:

— top down aerial based approach (remote sensing, aerial photography) - iTree Canopy

— bottom up ground based assessment (individual trees, GIS based) - iTree Eco, CITYgreen

— specific areas of benefit (mathematical models) - iTree Hydro, Kleinfelder's Port modeling

Methods for measuring economic value:

— market prices, surrogate market approach, production function apporach, state preference approach, cost based valuation, cost benefit analysis

CANOPY VALUATION
iTree Eco analysis using Bartlett's 5% survey

— uses field data along with local hourly air pollution and meteorological data to quantify forest structure, environmental effects, and values

— benefits depend on tree structure and physiology (e.g. tree size, trunk diameter at breast height, leaf area, leaf biomass, evergreen vs. deciduous)

— inputs: dbh, species, condition, street tree/non street tree, land use

CANOPY VALUATION
iTree Eco Output

annual values ($)	one time value ($)
air pollution removal	carbon storage
avoided runoff (interception)	structural value
carbon sequestration	
energy savings (only for residential areas)	

CANOPY VALUATION
Air Pollution Removal

Pollutants:

- ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, particulate matter 2.5 microns

Benefit Estimate (removal rate)

-hourly tree-canopy resistances for O3, SO2 and NO2 based on canopy deposition models

-removal of CO and PM2.5 based on average measured values from literature, adjusted depending on leaf phenology and leaf area

Value Estimate ($)

-local change in pollution concentration with health effects (US EPA Benefits Mapping and Analysis Program)

Nowak, D.J. 1995. Trees pollute? A "TREE" explains it all. In: Proceedings of the 7th National Urban Forestry Conference. Washington, DC: American Forests: 28-30.

CANOPY VALUATION
iTree ECO: Avoided Runoff

Benefit estimate (Avoided runoff through interception):

- based on rainfall interception by vegetation

-only preciptation by leaves is accounted for in this analysis

Value Estimate ($)

-$0.07 per ft^3

CANOPY VALUATION
iTree ECO: Building Energy Use Reduction

Benefit Estimate: Distance and direction of trees was not field collected so assumptions were made to determine this calculation:

Using the average tree in Cambridge (Norway Maple at 9.7 dbh) in fair condition in partial sun, southeast of a house, saves $11 in energy cost per year. 40% of the canopy in Cambridge falls on residential property, so if we assume the 9.7 dbh trees has a canopy spread of 25' diameter and 40% of the canopy provides benefits to homes, this would be $413,138 in energy savings per year.

Value Estimate ($): $149.48 per MWH and $15.64 MBTU saved

CANOPY VALUATION
iTree ECO: Carbon Sequestration

Benefit estimate (Carbon removal)

— Estimated by average diameter growth for the appropriate genera, diameter class and tree condition

— Value Estimate ($): $171 per ton

CANOPY VALUATION
iTree Eco Output - one time values

Carbon Storage

— Benefit estimate: estimates above-ground and below-ground parts of woody vegetation. Biomass for each tree calculated using literature/measured tree data

— Value Estimate ($): $171 per ton

Structural value

— value of the physical resource itself/replacement cost of a similar tree

— valuation from Council of Tree and Landscape Appraisers (1992) and includes loss of property value

CANOPY VALUATION

Using Bartlett's 5% survey to obtain a snapshot of the forest, the total value of the urban forest in 2018 is $136 million

ANNUAL VALUE	x20	x34.65**	AVERAGE	BENEFIT
POLLUTION REMOVAL	$704 K	$1.22 M	$962 K	36,500 LB/YR
CARBON SEQUESTRATION	$133 K	$230 K	$181.2 K	1050 TONS/YR
AVOIDED RUNOFF	$60K	$104 K	$83 K	1.22 MILLION CU FT/YR
ENERGY	$413 K	$413 K	$413 K	
TOTAL BENEFIT	$1.3 M	$1.97 M	$1.64 M	
BENEFIT PER ACRE			$1551	

ONE TIME VALUE	x20	x34.65**		BENEFIT
CARBON STORAGE	$4.9 M	$8.5M	$6.7M	105 TONS/YR
STRUCTURAL VALUE	$93.4 M	$161.8 M	$127.6 M	
TOTAL BENEFIT	$98.3 M	$170.3 M	$134.3 M	
BENEFIT PER ACRE			$127.2 M	

OVERALL VALUE	$136 M

*per iTree ECO for air quality, stormwater, energy, carbon sequestration benefits

** Based on canopy ares: Bartlett's 5% survey stated that canopy covered 30.47, which when extrapolated to 100% underestimates current canopy cover. If we were to consider that the 5% survey was actually representative of the canopy area, we would multiply the iTree results by 34.66 to arrive to the 1056 acres today

CANOPY VALUATION
Relative Tree Effects

Carbon storage equivalent to:

— amount of carbon emitted in Cambridge in 10 days (estimated 1.4 mil tons/yr)

— annual CO_2 emissions from 20,400 cars

— emissions from 8,360 single-family homes

Nitrogen dioxide removal equivalent to:

— annual NO_2 removal from 500 cars

— 220 single family houses

Sulfur dioxide removal equivalent to:

— annual SO_2 emissions from 2,060 cars

*refer to Appendix I of itree Eco output for assumptions

CANOPY VALUATION
Demonstrated tree benefits

Non-quantifiable benefit per iTree

Economic benefit:
- Increased property value
- Reduced expenditure on air pollution removal
- Reduced expenditure on stormwater infrastructure
- Saved investment in new power supplies
- Reduced heating and cooling costs
- Reduced time on housing market

Social benefit:
- Increased quality of life (stress relief- survey study)
- Health benefit – averting respiratory hospital admissions and premature death
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Ecosystem services
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- Energy conservation
- Habitat preservation
- Noise reduction
- Microclimate amelioration (reducing heat island, glare and reflection)

CANOPY VALUATION
Physical Health and Mental Wellbeing

— Reduces urban heat island

— Improved air quality

— Lower risk of diseases and mortality rate

— Lower stress levels

— Better cognitive function in students

— Improved attention among children

— Enhanced performance in the workplace

— Lower risk of mental health disorders

Source: Wolf, K.L., S. Krueger, and M.A. Rozance. 2014. Stress, Wellness & Physiology - A Literature Review.
In: Green Cities: Good Health (www.greenhealth.washington.edu). College of the Environment, University of Washington.

CANOPY VALUATION
Physical Health and Mental Wellbeing Studies

— More parks within 500m of a home, the lower the children's BMI at age 18.[1]

— Researchers from Aarhus University in Denmark found that growing up near vegetation is associated with an up to 55 percent lower risk of mental health disorders in adulthood.[2]

1. Wolch, J., et al., Childhood obesity and proximity to urban parks and recreational resources: A longitudinal cohort study. Health & Place, 2011. 17: p. 207-214.
2. (Engemann, et al., Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. PNAS, 2019 116 (11) p. 5188-5193.

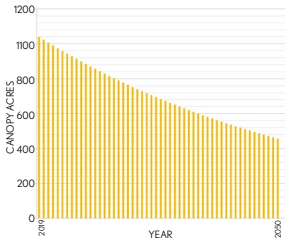
CANOPY VALUATION
Heat Island reduction

— Urban trees reduce air temperatures on summer days by 2-4F and cooling effect can be larger*

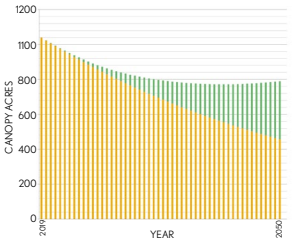
— Kleinfelder found 1% canopy increase results in 0.1 degree difference in ambient air temperature in a study for the Port neighborhood in Cambridge

*McDonald, R.I., et al., Planting Healthy Air: A global analysis of the role of urban trees in addressing particulate matter pollution and extreme heat. 2016, The Nature Conservancy: Arlington, VA.

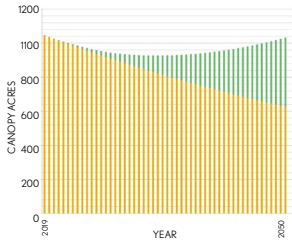
CANOPY VALUATION
Curbing Loss/Growing Canopy



Existing trend with current 400 tree planting rate

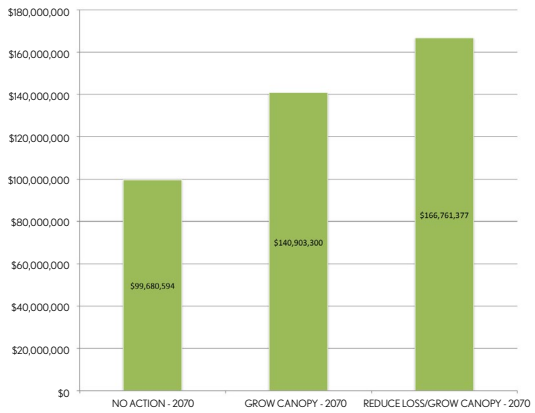


Plant 1,200 additional trees per year



Reduce Loss and Plant 1,200 additional trees per year

CANOPY VALUATION
Cumulative value of the forest under different canopy scenarios



*per iTree ECO for air quality, stormwater, energy, carbon sequestration, carbon storage and structural avlue

OUTREACH

FOREST RESILIENCY

CANOPY VALUATION

NEXT STEPS

Cambridge Urban Forest
Strategy Matrix

ACTION	In response to ...	Policy 1	Policy 2	Policy 3	Planning/Design 4	Planning/Design 5	Planning/Design 6	Planning/Design 7	Planning/Design 8	Practices 9	Practices 10	Practices 11	Practices 12	Outreach/Other 13	Outreach/Other 14	Outreach/Other 15
		Enhance Current Tree Protection Ordinance	Formalize City Practices	Integrate Canopy Value into Planning and Zoning	Leverage Envision Cambridge and Other Initiatives to Restrict Street Tree Planting to Only Suitable Areas	Create New Typologies for Underutilized Spaces	Implement City-Wide Planning Plan to Focus Efforts	Plan for Tree-Scape Spaces Strategically		Improve City Planting Practices	Improve City Maintenance and Care Practices	Improve Soil Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
Grow canopy	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	
	Shading and cooling / pedestrian thermal comfort	•	•	•	•		•	•	•	•	•	•	•		•	
	Environmental quality / wellbeing and public health	•	•	•	•		•	•	•	•	•	•	•		•	•
	Ecological connectivity	•		•	•		•	•	•	•	•	•	•			•
	Diversity of forest composition						•	•		•			•			
	Disaster response preparedness				•			•		•			•	•	•	•

PUBLIC COMMENT

www.cambridgema.gov/ufmp

TASK FORCE MEETING SCHEDULE

JUNE 12	Introduction
JUNE 28	RESEARCH: Regulation and Management
JULY 26	RESEARCH: Goal Setting
AUGUST 30	RESEARCH: Ongoing Analysis + Climate Modeling
SEPTEMBER 27	RESEARCH: Summary of Findings
OCTOBER 25	Cancelled
NOVEMBER 29	TESTING: Baseline Change Model
DECEMBER 20	DRAFT: Policy
JANUARY 31	DRAFT: Policy
FEBRUARY 28	DRAFT: Planning and Practice
MARCH 28	DRAFT: Outreach, Cost / Benefit
APRIL 25	DRAFT: Prioritization

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CANOPY LOSS INVESTIGATIONS

SCENARIO TESTING

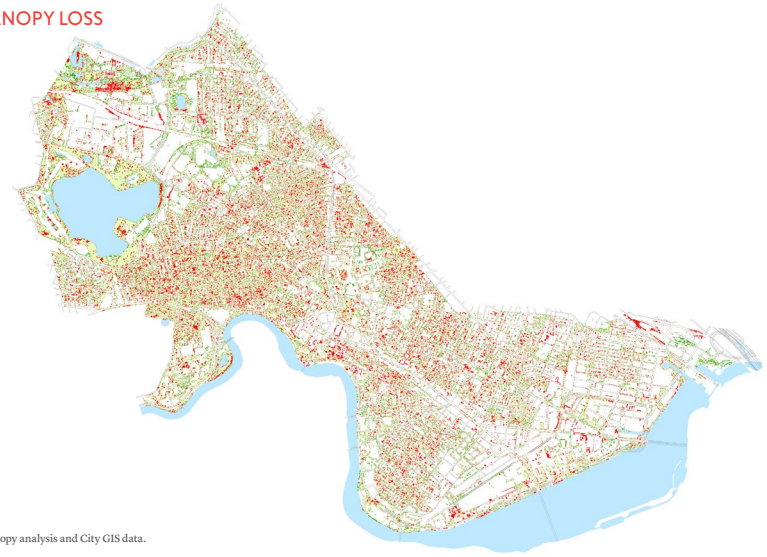
TASK FORCE TAKEAWAYS

CANOPY LOSS INVESTIGATIONS

SCENARIO TESTING

TASK FORCE TAKEAWAYS

CITY-WIDE CANOPY LOSS
2009-2018



Source: CUFMP 2018 canopy analysis and City GIS data.

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN TASK FORCE MEETING 11 | APRIL 25, 2019 4

Data in this study has been modified using an updated analysis of the loss rate between 2009 and 2018 rather than 2014 and 2018.

Ongoing research by University of Vermont will provide a final analysis of 2018 canopy.

Today, Cambridge has **26%** of its land area covered by canopy.

Between 2009 and 2018, Cambridge's canopy declined on average by 16.4 acres* every year.

At this rate, canopy cover would be **21.6% in 2030**.

*Source: CUFMP 2018 canopy analysis

CANOPY LOSS INVESTIGATIONS

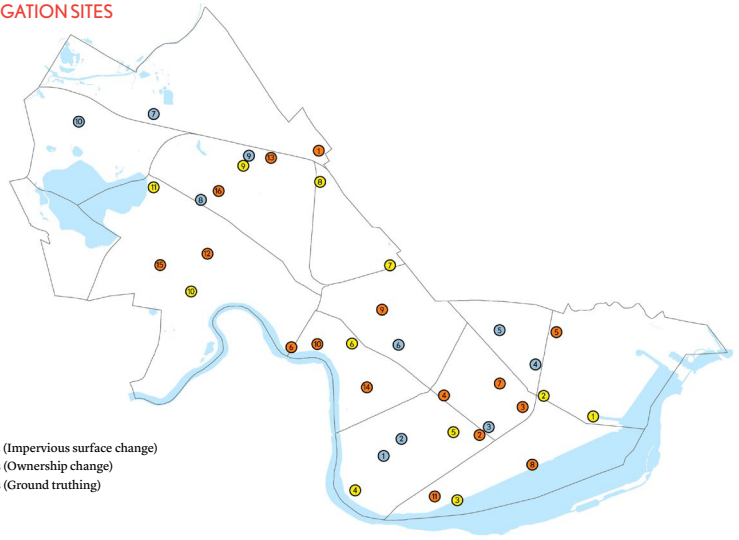
To assess potential causes of tree removals in Cambridge between 2009-2018, we asked three questions:

1. Is loss associated with an **increase in impervious area**?
   Compare impervious cover (2010-2018) and canopy change (2009-2018)

2. Is loss associated with **property sales**?
   Compare 2015-2017 parcel sales and canopy change (2014-2018)

3. What **other causes** are there for canopy loss?
   Undertake field investigation by visiting sites of loss.

LOSS INVESTIGATION SITES



IMPERVIOUS AREA CHANGE
Methodology

Using the aerial mapping

overlay

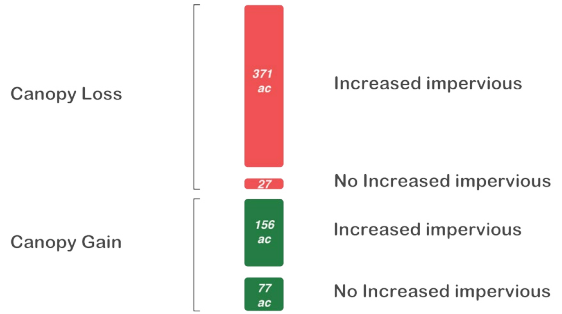
change in **impervious cover** between 2010 and 2018

and

change in **canopy cover** between 2009 and 2018 to

assess correlation

IMPERVIOUS AREA CHANGE – PRELIMINARY FINDINGS
Increased impervious area is correlated with significant canopy loss



OWNERSHIP CHANGE
Methodology

Using the aerial mapping and city records

overlay

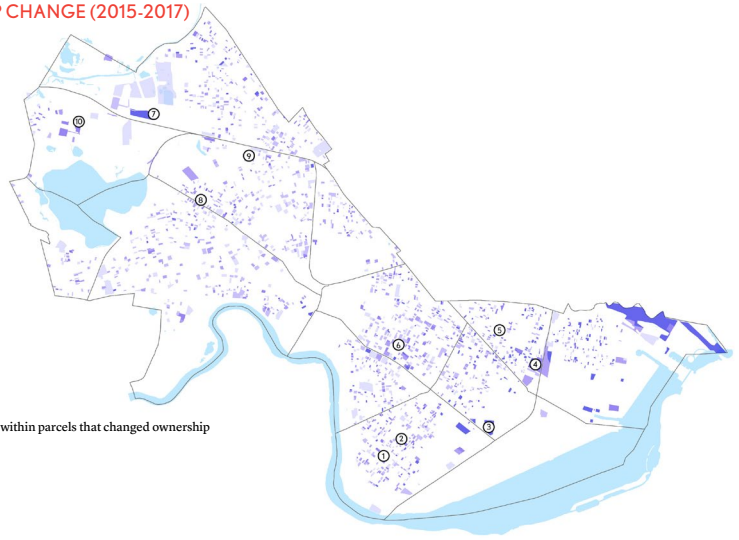
property sales from 2015 to 2017

and

change in **canopy cover** between 2014 and 2018 to

assess correlation

OWNERSHIP CHANGE (2015-2017)
Selected sites



OWNERSHIP CHANGE – FINDINGS

18% of total canopy loss is associated with land sold from 2015 to 2017

2,945 parcel sales took place from January 1, 2015 to December 31, 2017 in Cambridge

22.3 acres of canopy loss (of 330 total gross loss) was on land sold during that time.

10.5 acres (almost half) of 22.3 acre loss was associated with just 179 parcels.

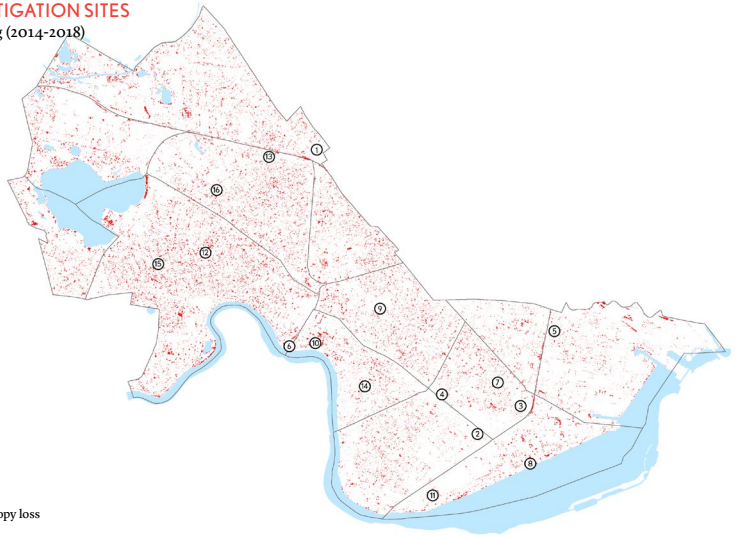
1,100 parcels showed only minor losses.

29 parcels contributed 2.9 acres of new canopy.

313 parcels contributed 4.1 acres of new canopy.

FIELD INVESTIGATION SITES

Ground truthing (2014-2018)



2014-2018 Canopy loss

SUMMARY OF FINDINGS

These studies suggest an association between four conditions and canopy loss.

— New construction

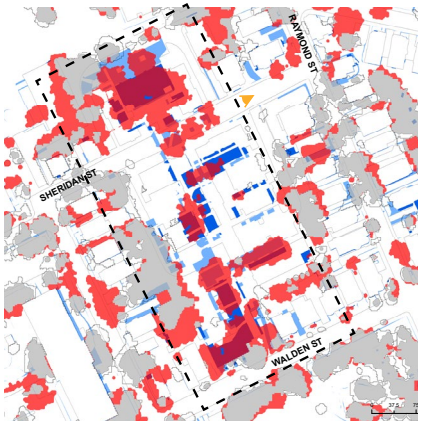
— Renovation & Site Improvements

— Mortality (declining health)

— Miscellaneous decisions by individual owners

NEW CONSTRUCTION

Tree removal is associated with a new development.
New structures and eliminating pervious surfaces affected the tree canopy.

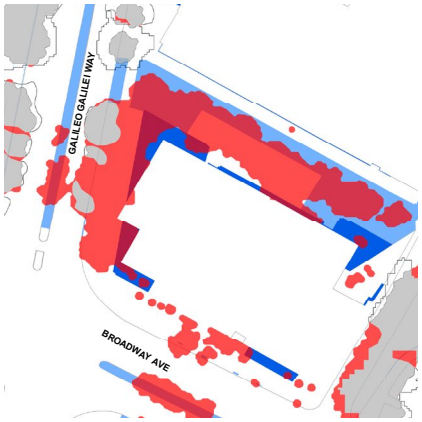


2009-2018 Canopy loss
Canopy gain
No canopy change
New structure
New pavement
Study area
Viewpoint

Project type: Residential

NEW CONSTRUCTION

Tree removal is associated with construction of a new commercial building on Broadway Ave. Street design change also impacted trees in the median.

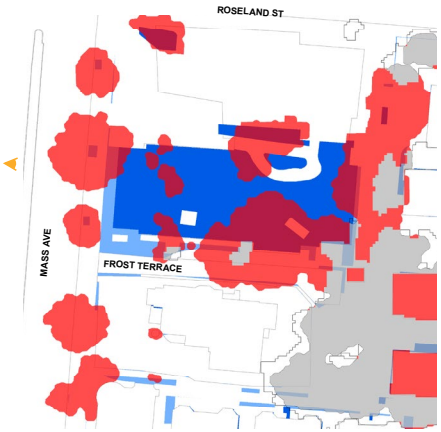


2009-2018 Canopy loss
Canopy gain
No canopy change
New structure
New pavement

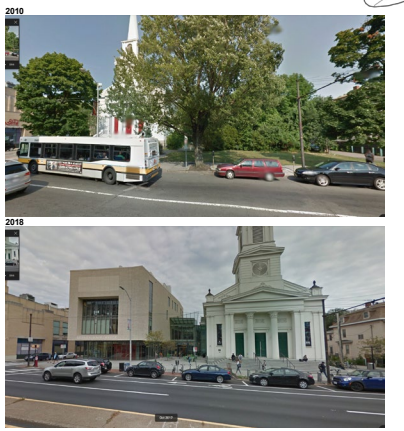
Project type: Commercial

NEW CONSTRUCTION

Tree removal from the green space on Mass Ave is associated with relocating the church



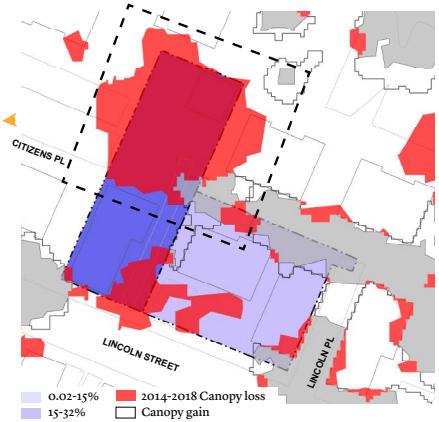
2009-2018 Canopy loss
Canopy gain
No canopy change
New structure
New pavement



Project type: Institutional, Lesley University

NEW CONSTRUCTION

Tree removal on Lincoln Street is associated with a new residential building.

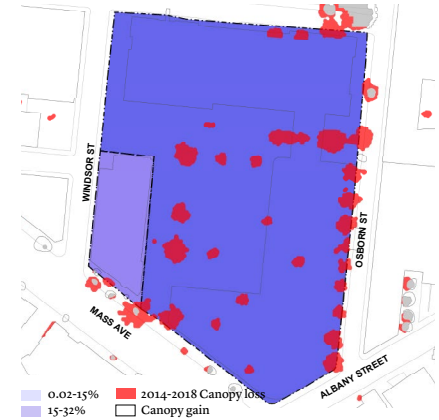


0.02-15%
15-32%
32-53%
53-79%
79-100%
2014-2018 Canopy loss
Canopy gain
No canopy change
Study area
Property line of sold parcels

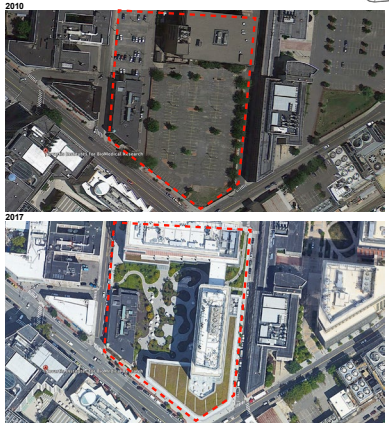
Project type: Residential

NEW CONSTRUCTION

Novartis replaced the parking lot and trees, however the project provides an open space with new trees and a green roof



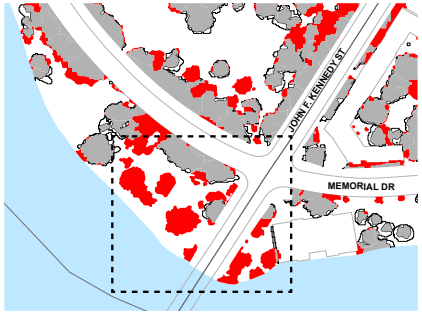
0.02-15%
15-32%
32-53%
53-79%
79-100%
2014-2018 Canopy loss
Canopy gain
No canopy change
Study area
Property line of sold parcels



Project type: Commercial

NEW CONSTRUCTION

During the restoration of Anderson Memorial Bridge, most of the trees along the river were removed.

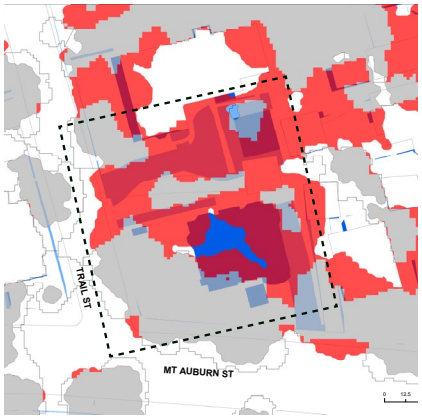


2014-2018 Canopy loss
Canopy gain
No canopy change
Study area

Project type: State (DCR + Mass DOT)

RENOVATION

Tree removal is associated with a yard renovation and new construction near Mt Auburn St.

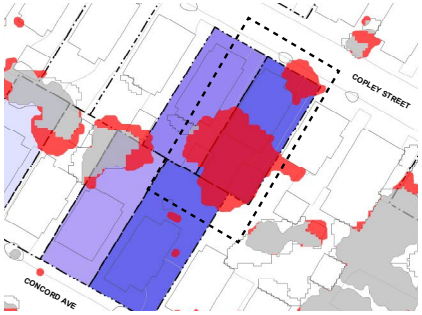


2009-2018 Canopy loss
Canopy gain
No canopy change
New structure
New pavement
Study area

Project type: Residential

RENOVATION

Trees removal associated with a backyard renovation on Copley Street after ownership change.



0.02-15%
15-32%
32-53%
53-79%
79-100%
2014-2018 Canopy loss
Canopy gain
No canopy change
Study area
Property line of sold parcels

Project type: Residential

RENOVATION

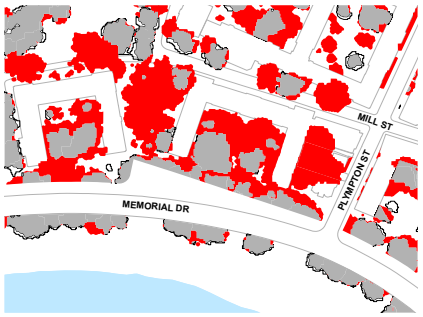
Tree removal is asociated with the MIT Westgate complex renovation.

2009-2018 Canopy loss
Canopy gain
No canopy change

Project type: Institutional

RENOVATION

Tree removal is associated with the Harvard Winthrop House renovation.

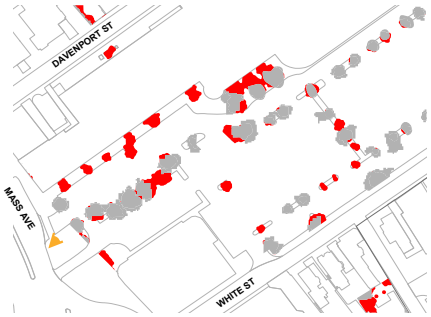


2014-2018 Canopy loss
Canopy gain
No canopy change

Project type: Institutional

MORTALITY

Trees at the Porter Square parking lot were replaced by new small trees.

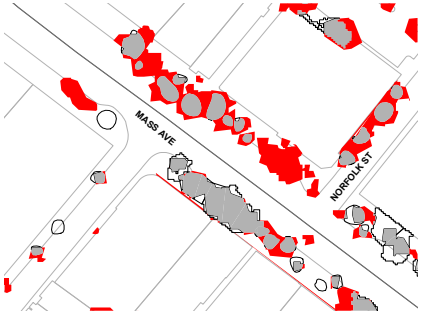


2014-2018 Canopy loss
Canopy gain
No canopy change

Project type: Commercial

UNCATEGORIZED

Trees on Mass Ave were removed due to infrastructure renovation and lost to mortality

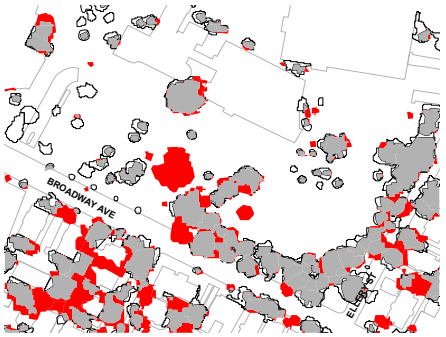


2014-2018 Canopy loss
Canopy gain
No canopy change

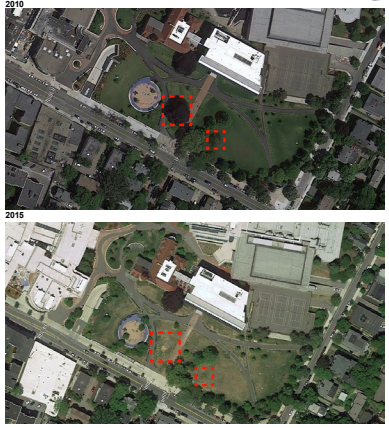
Project type: Public ROW

UNCATEGORIZED

Two trees at the Cambridge Public Library died due to construction activity and transplanting



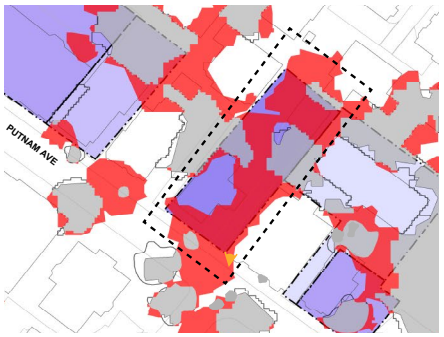
2014-2018 Canopy loss
Canopy gain
No canopy change



Project type: Public

UNCATEGORIZED

Two large trees on Putnam Ave were removed after ownership change



Project type: Residential

SUMMARY OF FINDINGS

These studies suggest an association between four conditions and canopy loss.

— New construction

— Renovation & Site Improvements

— Mortality (declining health)

— Miscellaneous decisions by individual owners

CANOPY LOSS INVESTIGATIONS

SCENARIO MODELING

TASK FORCE TAKEAWAYS

MODEL GOALS

What might canopy cover look like in 2030 & 2070 given the threats of climate change?

What is the potential for canopy to mitigate the urban heat island?

CANOPY CHANGE MODEL
Methodology updates

— Rename the "climate model" to "**canopy change model**"

— Model loss using **canopy area** rather than individual trees
(*benefit: loss rate can be calibrated to observed loss rate rather than using literature-based removal rate)*

— Define a baseline **net loss rate** (1.55% of canopy per year)
(*accounts for growth and prevailing planting rate*)

— Project a **conservative** and an **accelerated** loss rate for the scenarios
conservative loss: model impact of hardiness zone shift and loss of ash trees on private properties due to EAB
accelerated loss: double the impact of pest and diseases on each species

CANOPY CHANGE MODEL
Conclusions

The **species composition** of the future forest is influenced by suceptibility of individual species to climate risks, particularly pest and diseases.

Flooding was found to have a potentially **minimal impact** on the canopy.

Drought was found to have a potentially **moderate impact** on the existing tree canopy.

CANOPY CHANGE MODEL
Conclusions

The findings from this simulation will inform city-wide tree **species recommendations*** and include location-specific selection criteria, for example:

Plant only **flood tolerant species** in flood-prone areas and **drought tolerant species** near impervious surfaces.

*Refer to Forest Resiliency section of Task Force 10 presentation

CANOPY CHANGE MODEL
Scenarios

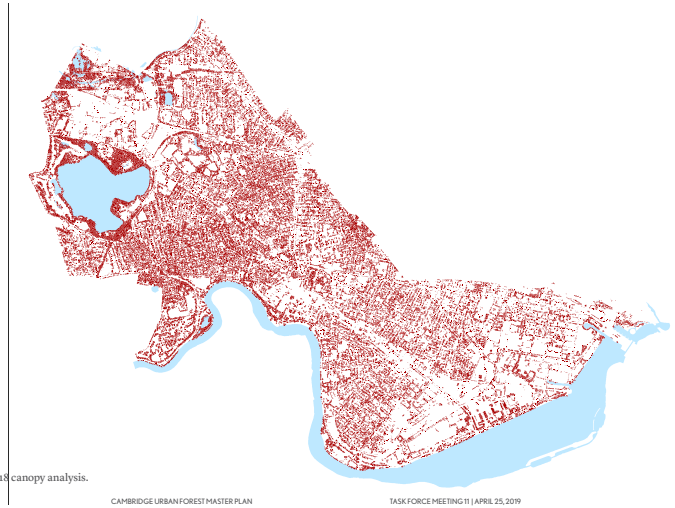
— 2030, 2050 and 2070 Baseline
  — existing and potential pests and diseases
  — temperature change and hardiness zone shift
  — uses existing replanting and growth rates

— 2030 Flooding
  — areas experiencing standing water > 24 hrs in a simulated 100 yr flood event

— 2050 Drought
  — a moderate drought event is projected to occur once every 30 years within the 2035 to 2064 timeframe (Hayhoe et al 2006)

2018 CANOPY COVER

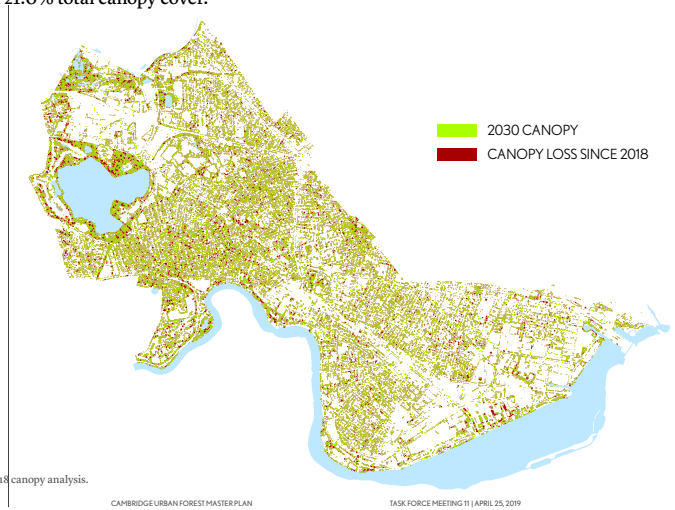
26% canopy cover



Source: CUFMP 2018 canopy analysis.

2030 CONSERVATIVE LOSS SCENARIO

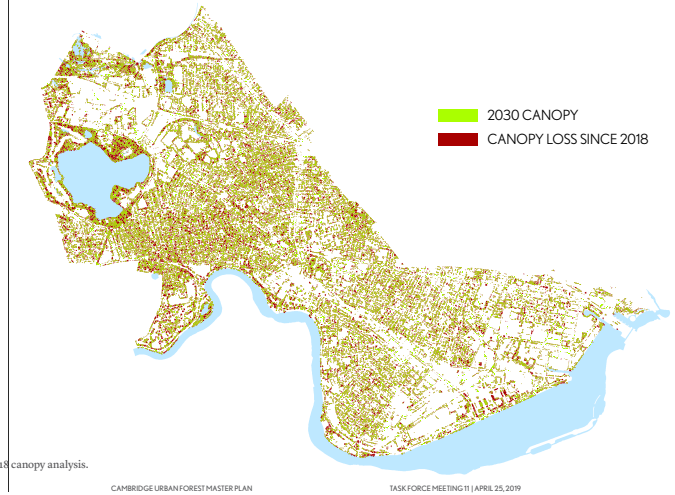
Considering temperature shifts/EAB threat the loss rate of 1.55% increases to 1.8%, resulting in 21.0% total canopy cover.



Source: CUFMP 2018 canopy analysis.

2030 ACCELERATED LOSS SCENARIO

Doubling the impact of pests/diseases on each species the total annual loss rate increases to 3.2%, resulting in 17.6% total canopy cover.



Source: CUFMP 2018 canopy analysis.

BASELINE SCENARIO IMPACT

Which species thrive and which do not?
Honeylocust becomes the most dominant species.

Most Common Species
Cambridge 2030

	Common thornless honeylocust
↓	Norway maple
	Pin Oak
↓	Red Maple
↓	Northern Red Oak
	London Planetree
	Littleleaf Linden
	Sycamore
↓	Sugar Maple
↓	Callery Pear

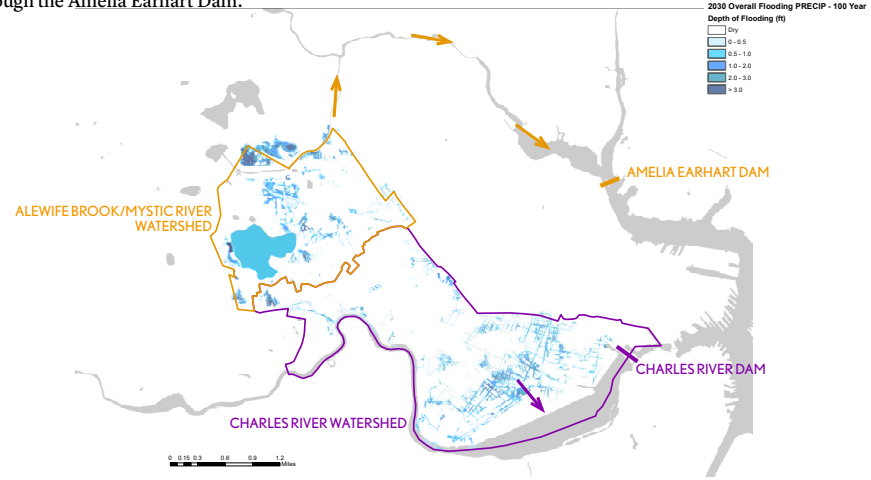
Best Performers
Cambridge 2030

Dawn Redwood
Northern Catalpa
Black Locust
Kentucky Coffeetree
Amur Maackia
Serviceberry
Amur Corktree
Magnolia
Japanese Snowbell
Ginkgo
Japanese Lilac Tree
Zelkova

* range represents conservative and accelerated loss scenarios

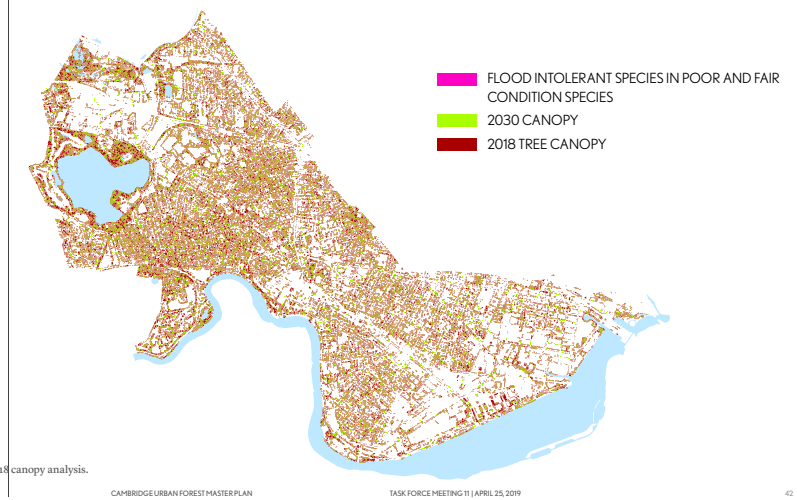
CLIMATE EVENT: FLOODING

One-third of Cambridge is with the Alewife Brook watershed and discharges through the Amelia Earhart Dam.



CLIMATE EVENT: FLOODING

The flooding event resulted in 0.2% additional mortality (~0.7 acres of loss) from the 2030 baseline scenario— resulting in **minimal reduction of canopy** in 2030.



Source: CUFMP 2018 canopy analysis.

CLIMATE EVENT: FLOODING

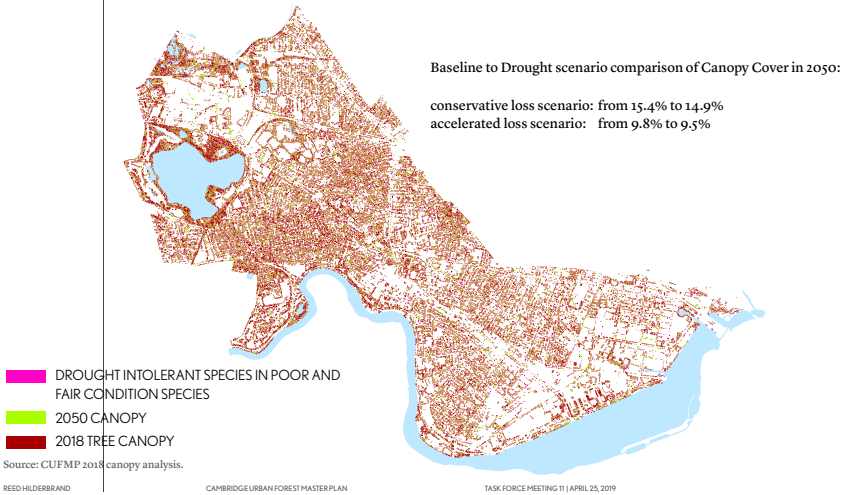
Impacted species

	additional mortality from 2030 baseline*
Flowering Dogwood	0 to -3%
Austrian Pine	-1.4% to -1.7%
Hedge Maple	-0.9 to -1.2%
Eastern White Pine	-0.8 to -1%
Callery Pear	-0.3%
Basswood	-0.3 to 0.4%
Norway Maple	-0.3%
Cherry	-0.3%
Ginkgo	-0.2%
White Oak	-0.2 to -0.3%
Japanese Maple	-0.2%
Japanese Lilac Tree	-0.1%
Northern Red Oak	-0.1%

* range represents conservative and accelerated loss scenarios

CLIMATE EVENT : DROUGHT

The moderate drought event resulted in 3.2% additional mortality, or a loss of 14 to 20 acres of canopy from the 2050 baseline scenario



Source: CUFMP 2018 canopy analysis.

CLIMATE EVENT IMPACTS : 2050 BASELINE + MODERATE DROUGHT

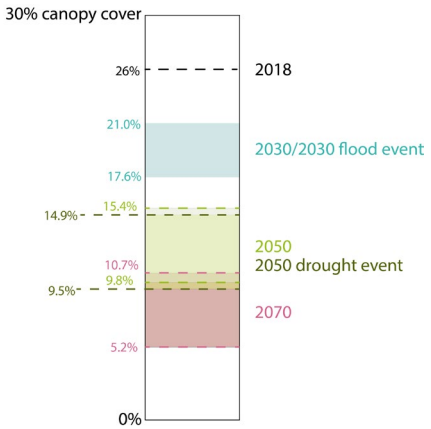
Impacted Species

	additional mortality from 2050 baseline*
Canadian Hemlock	92.4%
Red Maple	26.2%
Eastern White Pine	24.0%
American Hornbeam	23.1%
White Ash	22.6%
Basswood	22.3%
Downy Serviceberry	20.7%
Hornbeam	20.6%
Magnolia	15.0%
Serviceberry	9.5%
Sugar Maple	9.2%
Tree of Heaven	9.0%
Eastern Black Oak	8.9%
Eastern Arborvitae	8.4%
Flowering Dogwood	7.8%
Northern Red Oak	5.0%
White Oak	2.7%

*represents conservative loss scenarios

CANOPY CHANGE MODEL SUMMARY

Annual net loss rate ranges from 1.8% to 3.2%.



*ranges within each event indicate the conservative/accelerate loss rates

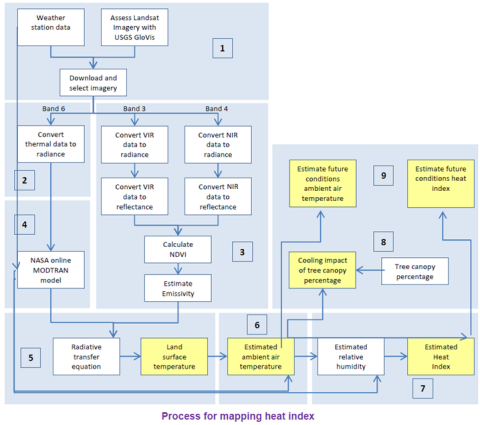
HEAT ISLAND MODELING – 2018 CANOPY

How much can tree planting mitigate heat island?

What strategies move the needle?

HEAT ISLAND MODELING - METHODOLOGY

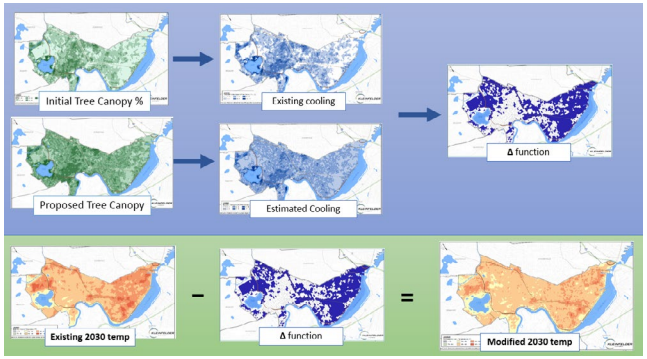
Estimating Urban Heat Island (UHI) from Land Surface Temperature Data



Source: Appendix D Urban Heat Island Protocol for mapping Temperature Projections, Kleinfelder for the City of Cambridge, November 2015

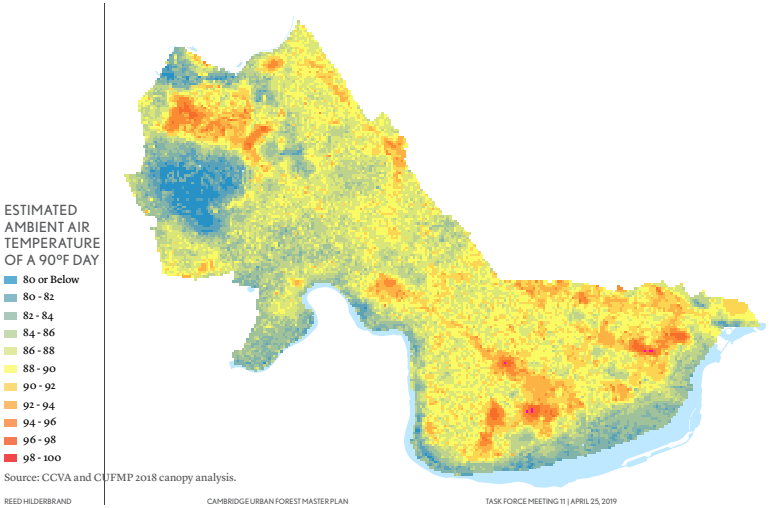
HEAT ISLAND MODELING - METHODOLOGY

Impact of Expanding Urban Forest Canopy in UHI Model



Source: Appendix B Green Infrastructure Analysis and Urban Heat Island Modeling – DRAFT, Kleinfelder for the City of Cambridge, August 2017

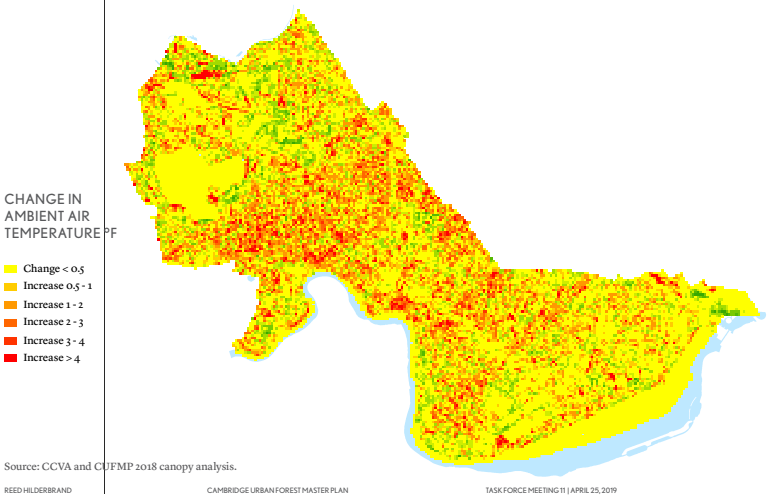
HEAT ISLAND MODELING – 2018 CANOPY



Source: CCVA and CUFMP 2018 canopy analysis.

HEAT ISLAND MODELING – 2018 CANOPY

39% of the city experienced an increase in temperature (> 0.5 °F) since 2009
19% experienced cooling (> 0.5 °F).



Source: CCVA and CUFMP 2018 canopy analysis.

HEAT ISLAND MODELING

What if....

What happens to ambient temperature if ...

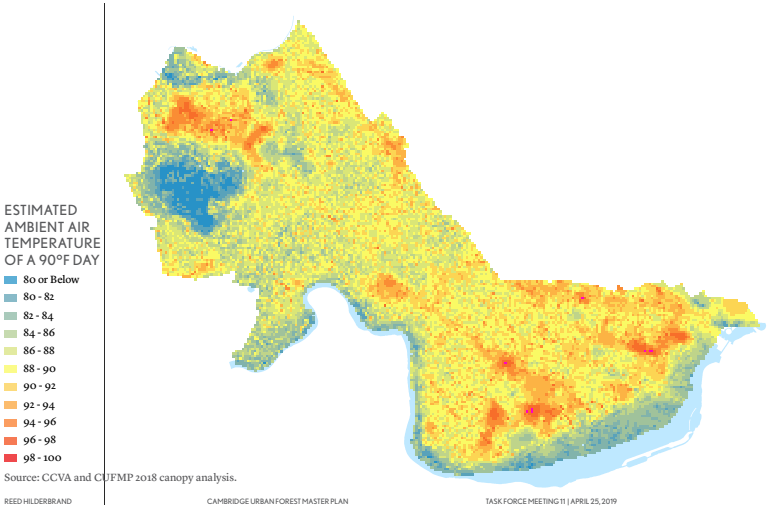
we do not stem loss or grow canopy and climate change accerlerates loss?

we are able to maximize planting in the right of way?

we implement strategies and incentives to increase canopy? (East Cambridge + Mid Cambridge case studies)

HEAT ISLAND MODELING – 2030 CANOPY

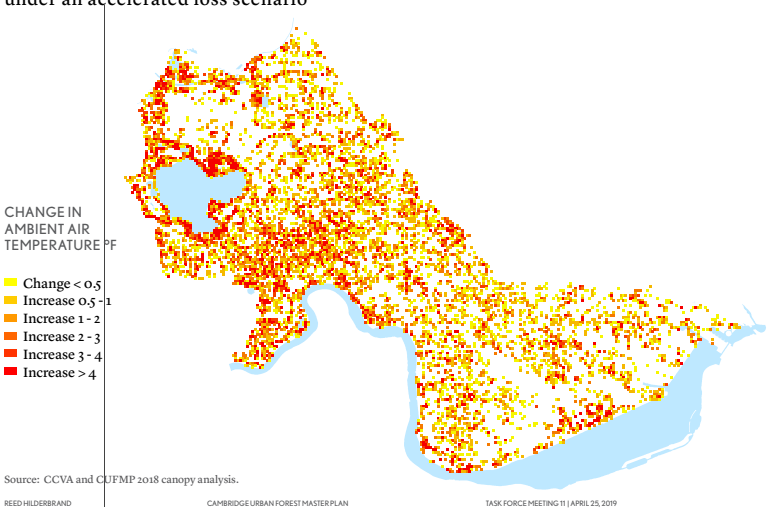
Accelerated loss scenario (17.8% canopy cover)



Source: CCVA and CUFMP 2018 canopy analysis.

HEAT ISLAND MODELING – 2030 CANOPY

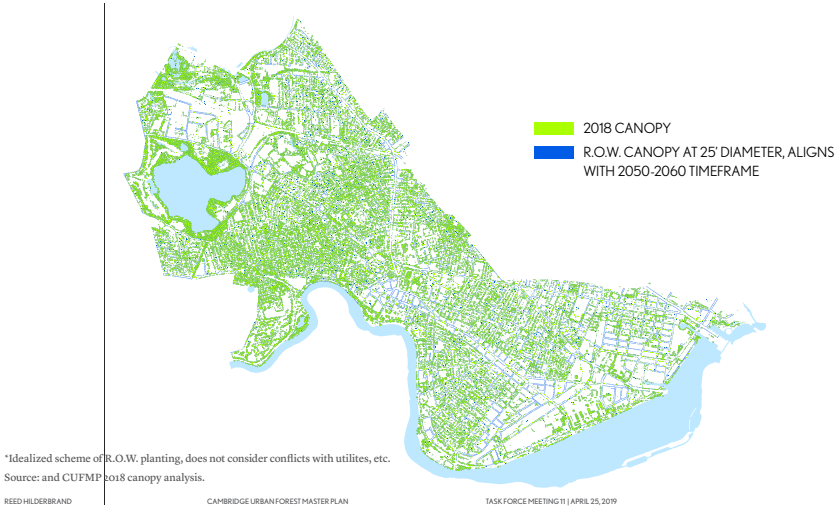
38% of the city experienced an increase in temperature (> 0.5 °F) since 2009 under an accelerated loss scenario



Source: CCVA and CUFMP 2018 canopy analysis.

MAXIMIZE RIGHT OF WAY PLANTING

12,000 new Right of Way trees at maturity increase canopy cover from 26% to 29.4%*

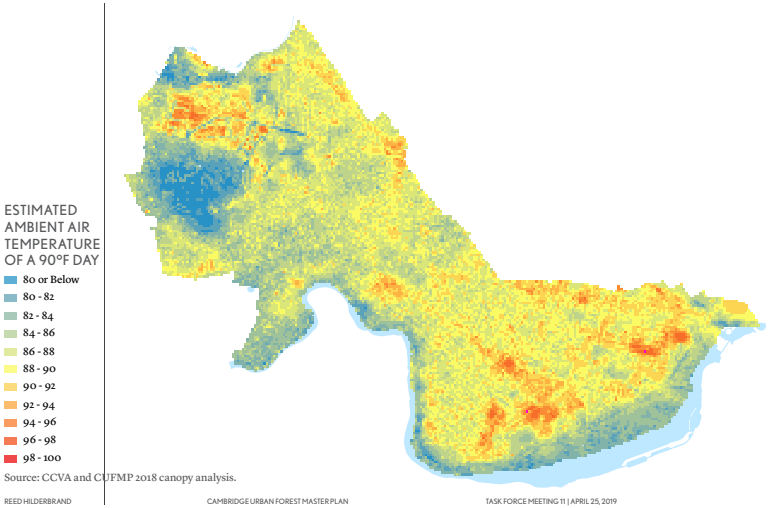


*Idealized scheme of R.O.W. planting, does not consider conflicts with utilites, etc.

Source: and CUFMP 2018 canopy analysis.

MAXIMIZE RIGHT OF WAY PLANTING

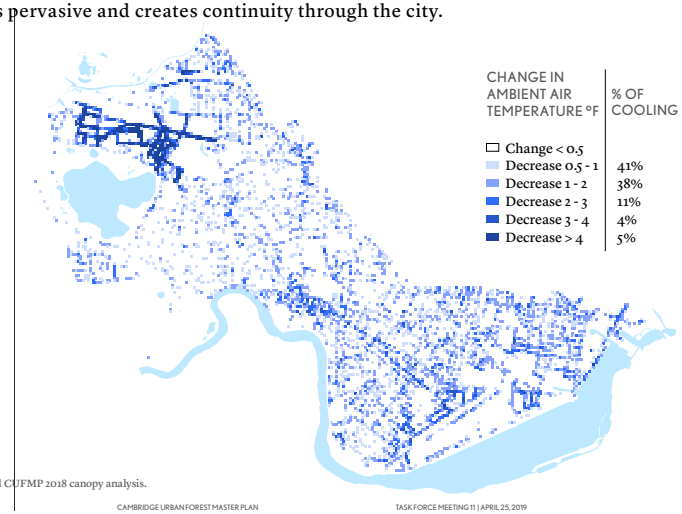
2018 canopy plus 12,000 new Right of Way trees at maturity



Source: CCVA and CUFMP 2018 canopy analysis.

MAXIMIZE RIGHT OF WAY PLANTING

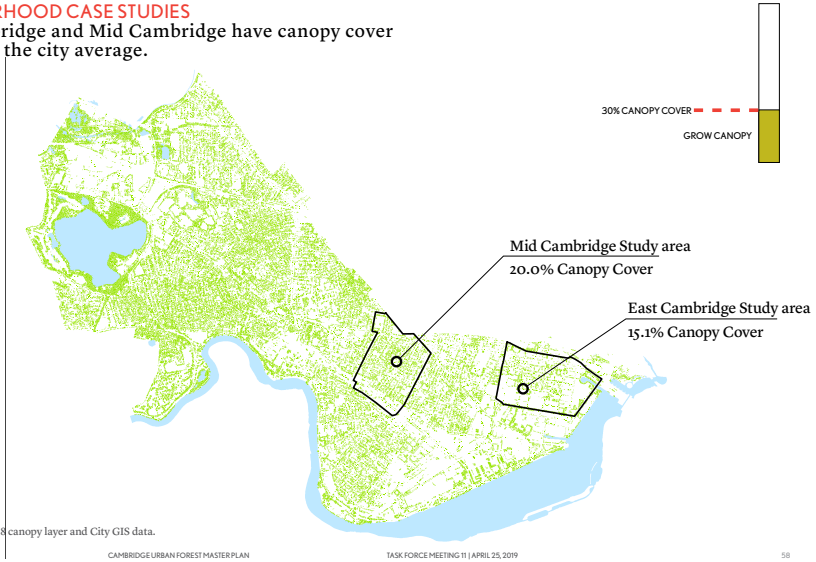
25% of the city experienced a decrease in temperature (> 0.5 °F) since 2009
Cooling is pervasive and creates continuity through the city.



Source: CCVA and CUFMP 2018 canopy analysis.

NEIGHBORHOOD CASE STUDIES

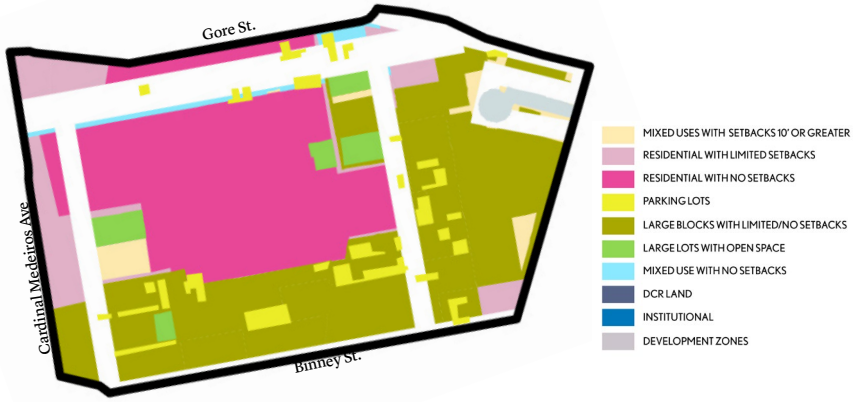
East Cambridge and Mid Cambridge have canopy cover lower than the city average.



Source: CUFMP 2018 canopy layer and City GIS data.

EAST CAMBRIDGE CASE STUDY

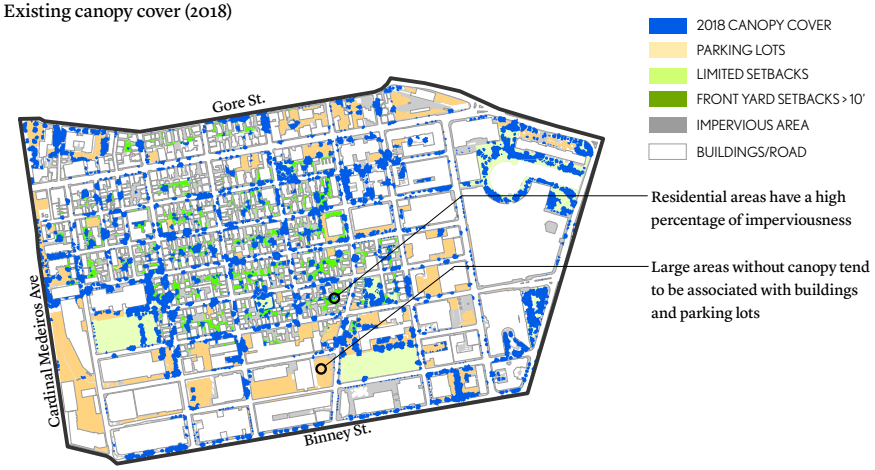
Properties are primarily residences with no front yard setbacks and large blocks with limited setbacks.



Source: CUFMP 2018 canopy analysis and City GIS data.

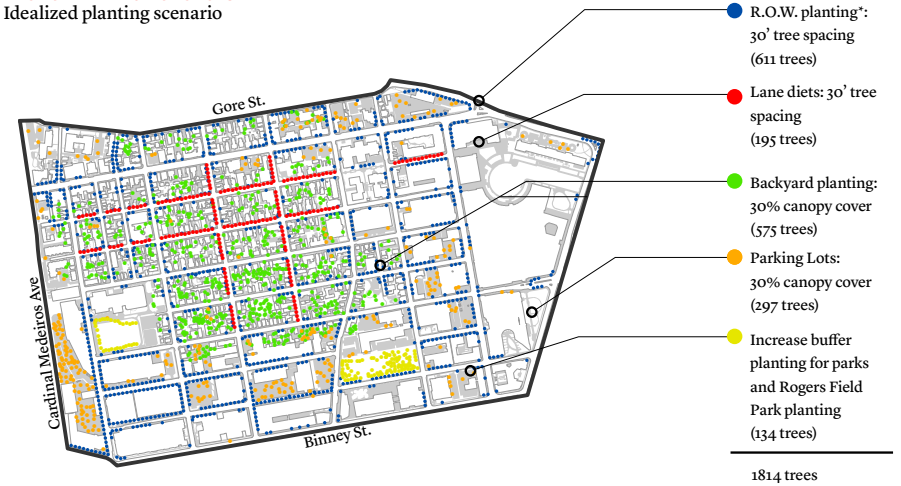
EAST CAMBRIDGE CASE STUDY

Existing canopy cover (2018)



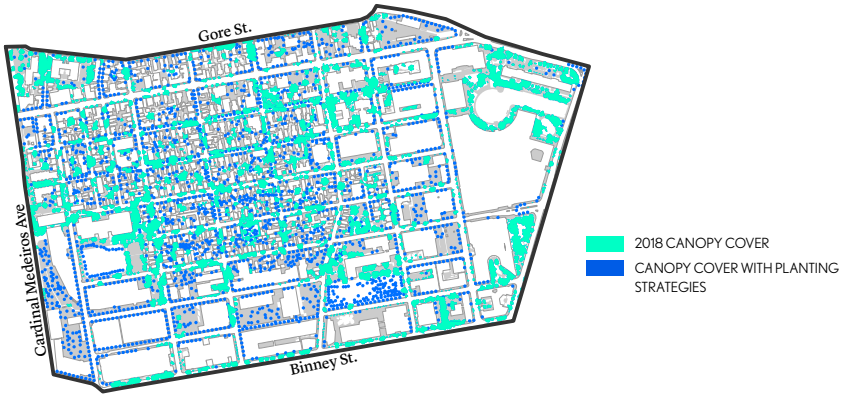
EAST CAMBRIDGE CASE STUDY
Planting opportunities are primarily on streets, in backyards, and parking lots.

EAST CAMBRIDGE CASE STUDY
Idealized planting scenario

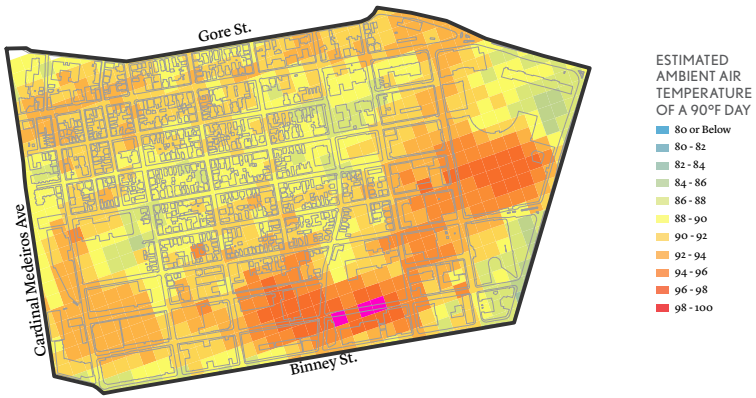


*Idealized scheme of R.O.W. planting, does not consider conflicts with utilites, etc.

EAST CAMBRIDGE CASE STUDY
In an idealized scenario, by 2050 canopy increases from 15.1% to 25.4%

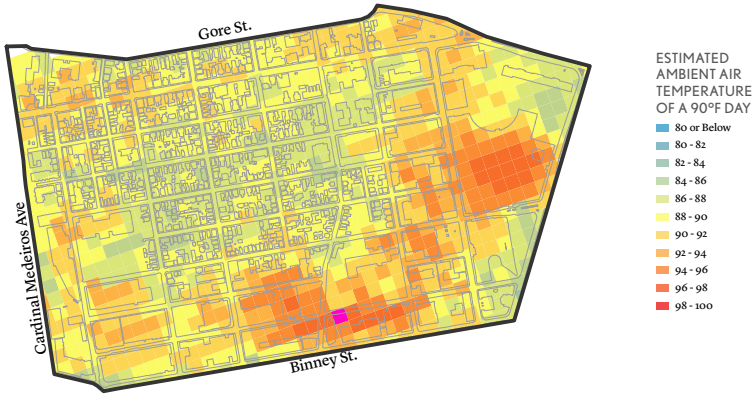


EAST CAMBRIDGE CASE STUDY
2018 Canopy



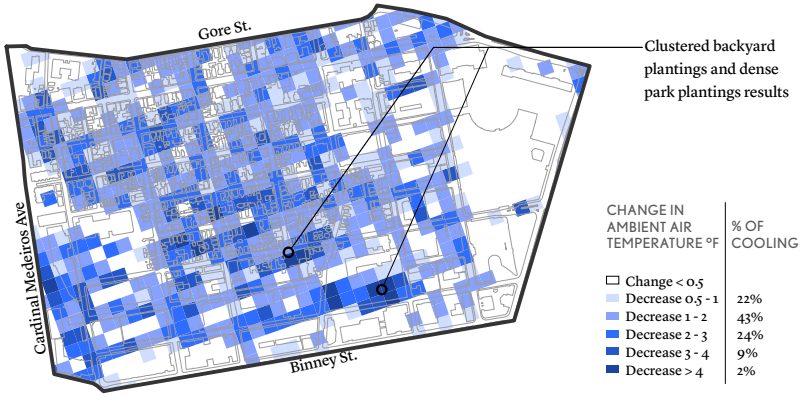
EAST CAMBRIDGE CASE STUDY

Heat island modeling results of idealized planting scenario



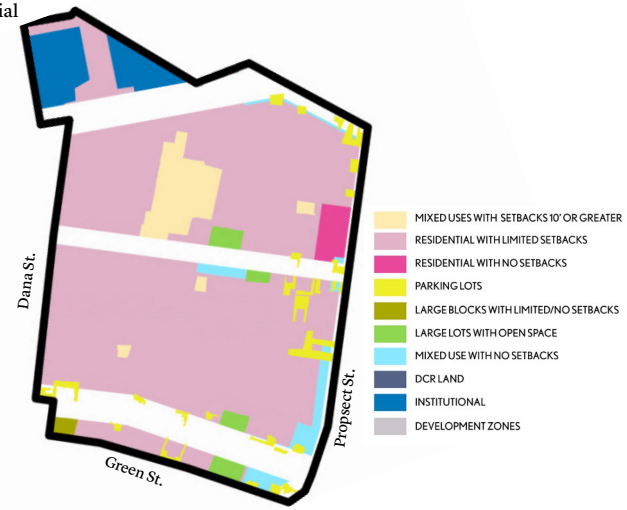
EAST CAMBRIDGE CASE STUDY

62% of East Cambridge experiences cooling of 0.5 degrees or more



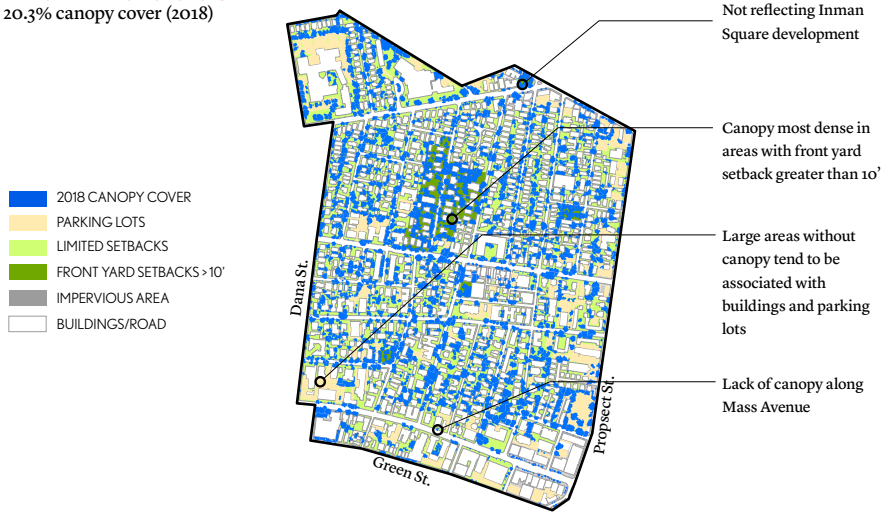
MID CAMBRIDGE CASE STUDY

Properties are primarily residential with limited setbacks with some mixed uses.



MID CAMBRIDGE CASE STUDY

20.3% canopy cover (2018)



MID CAMBRIDGE CASE STUDY

Planting opportunities are along streets, in front yards, and in parking lots

Increase R.O.W. planting*

Increase canopy cover on parking lots (19% cover)

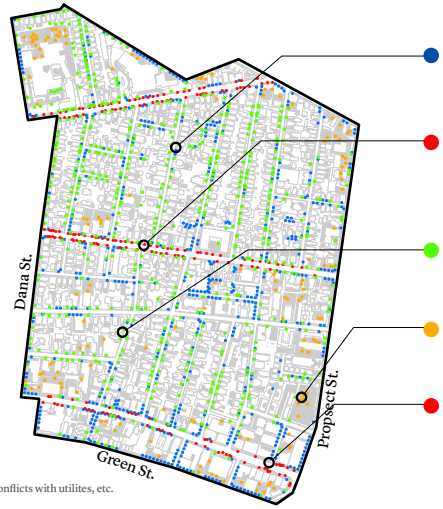
Encourage front yard plantings

For major streets, diversify, stagger and introduce subcanopy trees

*Idealized scheme of R.O.W. planting, does not consider conflicts with utilites, etc.

MID CAMBRIDGE CASE STUDY

Idealized planting scenario



Increase R.O.W. planting* (985 trees)

For major streets with limited sidewalk width introduce subcanopy trees (145 trees)

Increase front yard plantings (596 trees)

Target 30% canopy cover (148 trees)

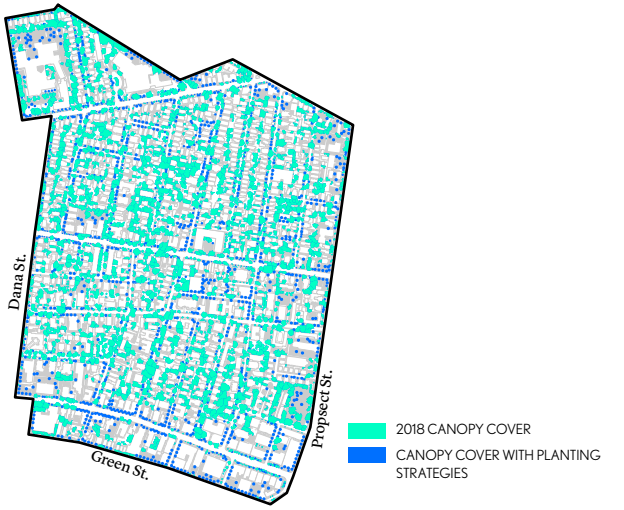
For major streets with generous sidewalk width diversify and stagger trees (145 trees)

2019 trees

*Idealized scheme of R.O.W. planting, does not consider conflicts with utilites, etc.

MID CAMBRIDGE CASE STUDY

In the idealized scenario, canopy increases from 20 to 27%

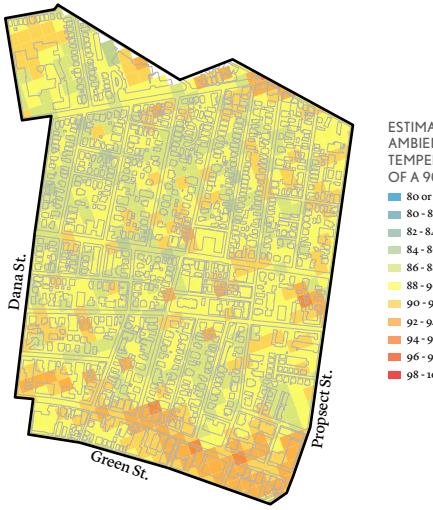


2018 CANOPY COVER

CANOPY COVER WITH PLANTING STRATEGIES

MID CAMBRIDGE CASE STUDY

2018 canopy cover

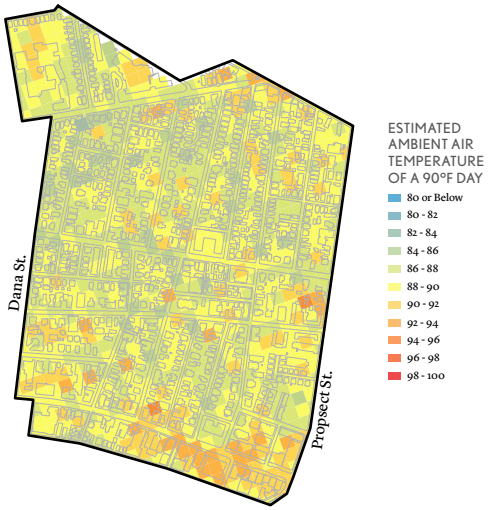


ESTIMATED AMBIENT AIR TEMPERATURE OF A 90°F DAY

- 80 or Below
- 80 - 82
- 82 - 84
- 84 - 86
- 86 - 88
- 88 - 90
- 90 - 92
- 92 - 94
- 94 - 96
- 96 - 98
- 98 - 100

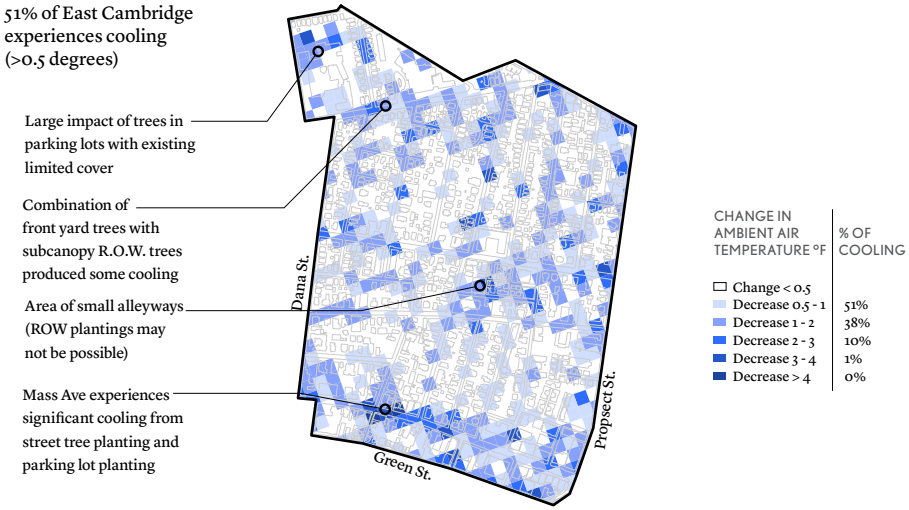
MID CAMBRIDGE CASE STUDY

Heat island modeling results of idealized planting scenario



MID CAMBRIDGE CASE STUDY

51% of East Cambridge experiences cooling (>0.5 degrees)



URBAN HEAT ISLAND MODELING

Other considerations

— Research shows a nonlinear impact of canopy on urban heat island (more net benefit from 20% to 30% canopy than 10% to 20% canopy)

— Grouping trees at the city block scale is potentially more impactful (Ziter et al, 2019)

— It is cooler under a tree on turf than it is under a tree in pavement. Removing impervious surfaces and creating cool roofs, green roofs are other strategies that can also reduce UHI.

— 100' x 100' grid size of model is coarse does not pick up full impact of individual tree planting

SCENARIO TESTING

Summary and conclusions

— Tree planting is shown to have an impactful effect on urban heat island mitigation, particluarly within the public realm.

— The scenarios are based on idealized circumstances and planting opportunities may be fewer than presented.

— Planting form (i.e. grouping trees) and large areas of high canopy cover (i.e. Fresh Pond area) have a disspportionate impact and large areas of existing planting should be a high priority to protect.

CANOPY LOSS INVESTIGATIONS

SCENARIO TESTING

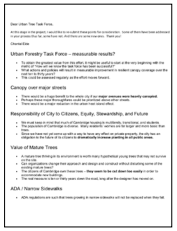
TASK FORCE TAKEAWAYS

ACTIVE PUBLIC PROCESS

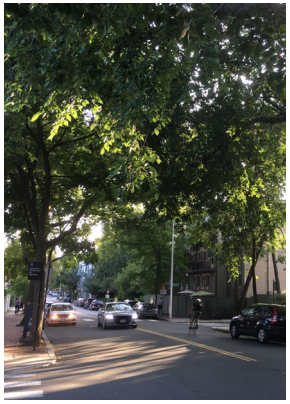
Public engagement with the UFMP process has helped to highlight challenges and opportunities

DE-ICING SALTS

COMPACTION - VEHICULAR



ASPIRATIONS



MAGAZINE STREET, CAMBRIDGE

SAN FRANCISCO

BARCELONA

TAKEAWAYS

What is the most impactful thing
you've learned during this process?

What is the most important thing for us
to study and develop during the next phase?

PUBLIC COMMENT

www.cambridgema.gov/ufmp

SEE YOU IN SEPTEMBER!

www.cambridgema.gov/ufmp

APPENDIX U: TASK FORCE MEETING NOTES

ISSUE DATE
June 20, 2018

MEETING DATE
June 12. 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Management Plan
2953

RE
Task Force Meeting 1

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Kleinfelder
Reed Hilderbrand

Break out session feedback

Advocacy

Engagement ideas:

- Where kids go, people follow. Get people doing something "hands on" and engage as families. Educate the people
- Connect forest issues to social issues, as this will engage the next generation. Social justice issues motivate broad populations
- Take a more holistic approach, consider paying low income residents to manage their forest
- This study should include public health issues and how they relate to the canopy
- Engage corporations and consider how they get employees involved in engagement and social responsibility
- Provide talking points for the city when engaging the corporations on how they support with the city efforts
- Need large public trees and show we value them to get others to do so.
- Consider how this process engages older residents as connectors and advocates
- Utilize engaged residents, Green Cambridge members to conduct visual tree pit assessments (99% of tree pits are in the City's GIS data); develop into long term relationships, stewardship to foster "resident science".
- How does the Task Force communicate within itself in order to feed information back from other resources?

Questions to consider:

- How do you get beyond preaching to people in the people in the choir?
- How do you engage the transient population of renters?
- How can this be understood in regional terms and not just ending at our boundaries as a city?
- How do you get the private land owners to be stewards? Young people, especially. Ground stewardship in reality and the place we live

Analytics

Potential data sources:

- Request tree impact studies from Planning Board that were conducted by

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MEETING NOTES

new development projects (Kendall Sq, at privately owned public spaces (POPS) in the City, elsewhere)

- Is it possible to get tree maintenance records from private companies, e.g. maintenance of Grand Junction; BrightView's work for Boston Properties
- Utilize MIT's Treepedia data to understand tree count and condition from bottom up as opposed to top down
- Include gas leak data in planning

Research ideas:

- Phenology research: -non-natives leafing out faster than natives in urban areas, include this research in decision-making for final tree species list
  - connect with BU's phenology study
  - consider planting trees that are viable under warmer climates, such as those native to the mid-Atlantic region, etc.
- Overhead wires: review regulations governing tree pruning around wires
- Research possibility of insurance cos. reimbursing City for trees damaged/killed in car accidents, similar to developing a "compensatory tree" replacement program.
- Get additional information re: older (older than 3 years) tree plantings in structural soil. Get structural soil specifications not just from City trees, but also from trees planted by universities, such as MIT, Harvard and Lesley.
- Possibility of conducting 'autopsy' on dead tree when it is replaced
- Get information on DCR's latest resource management plan to determine inventory of DCR's current and planned trees on the Cambridge side.
- Cross-reference areas of canopy loss with jumps in assessed property value to see if loss associated with renovations (assessor GIS layer + canopy loss layer)
- Review permit requirements related to cutting down trees.

Practice

- Big question: how do we plant and how do we compel to plant?
- Floodplain trees can survive inundation but do not do well in SBSS
- Challenge of planting along narrow sidewalks – perhaps reprioritization of streets and encourage planting on residential lots
- How do you build in an ability to check the soil?
- Can we manage the need for mycorrhizal fungi citywide?
- Challenges to residential planting: the worry that existing old infrastructure may be impacted by tree roots
- How do you get residents to plant trees and the right ones?

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REED
HILDER
BRAND

Public Comment Period:

Public Comment 1: The speaker is excited and encouraged by this project.

Public Comment 2: The speaker expressed concern of the current rate of tree removal. The speaker encourages everyone to support policy orders to slow down tree loss.

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ISSUE DATE
July 25, 2018

MEETING DATE
June 28. 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Management Plan 2953

RE
Task Force Meeting 2

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Conversation Law Foundation
F2
Reed Hilderbrand

1. Opening Remarks
Owen O'Riordan's introductory remarks:

- Task Force's (TF) focus is on the Urban Forest (trees) and not about green spaces
- Unclear if TF falls within/under Open Meeting law. Will review with Law Dept.
- Letters and documents will be posted on website.
- During presentations the consultants will present their research with opportunities for TF members to comment. The public will be invited to comment at the end of the meeting.

2. Introduction
Reed Hilderbrand (RH) discussed the project statement, how the project is organized, and the project team. Project team and task Force members introduced themselves.

TF: Expressed desire for the Task Force to jointly craft a statement of purpose for the master plan (example of Fresh Pond MP process)
TF: How will the UFMP be taking into account connectivity?
Response: Ecological connectivity, and how people move through the city will be considered.
TF: Will we be considering the spiritual impact of trees upon a community?
Response: There is currently no reliable way to quantify that.

3. Practice
RH presented what the team has learned so far about the City's tree and soil practices, areas where there are further investigation, and best management practices. Summary of the presentation and task force comments follows:

City Tree budget
Per Tree City USA application, Cambridge spends $18 per capita in 2016 and $19.75 per capita in 2017. This budget includes salaries, pruning and planting contracts, EAB, equipment, travel/training, and tree board/volunteer time. Compared with $7.30 average per capita spending for Tree Cities in MA in 2016, this is more than double the average. However, communities count different elements in their Tree City USA

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MEETING NOTES

application, so it is not exactly an "apples to apples" comparison. Cartegraph is a geospatial database system that enables city to track a tree history or tree status from a spatial or mapping perspective. The City currently tracks trees in parks, cemeteries and in the public right of way. Cartegraph can be a powerful tool for not only tracking current status of the urban canopy but to conduct comparative analytics that can help evaluate and inform city practices.

ABOVE GROUND
Species selection
City currently recommends ornamental species under overhead wires and shade trees. Questions to consider are:

-How regularly should the lists be updated, should there be additional categories of recommendations (home owners/developers) and should it be more specifics in terms of planting condition (urban vs. residential).
-How and should the city have more regulatory control over what is planted? Can they tell developers what to plant?
-Generally: how and can we get the right tree species in the right place on private and developer property?

Pruning
Proactive component: City is on a 6 year rotation for Street trees, parks and cemetery on 8 year. All the trees see some treatment on rotation. The City has a pruning contract for all city street trees in Cambridge.
Reactive component: response to service requests and emergency response or storm related services.
Eversource pruning required by state law. Eversource submits their veg plan (circuit pruning plans) yearly to City arborist. City arborist and Eversource will meet to discuss work and have an informal agreement regarding clearance (3' window rather than 10').

Tree removals
Cities response for tree removal is reactive. Managed through SeeClickFix and is integrated with Cartegraph. No private trees removed are tracked.

Pests/Diseases
City currently treats Elms and Ash with trunk injections for EAB application and Dutch Elm Disease. No monitoring for any other pests. At Fresh Pond,

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they seem to be more proactive on treatments, like for Hemlock Wooly Adelgid, Dormant Oil for pests, BT for winter moth. Areas of investigation: what is the appropriate city response to catastrophic vs. nuisance pests.

BELOW GROUND

Planting Details

The City currently replants trees back into its current condition in a tree pit with horticultural soil. For new plantings, the City will use sand based structural soil (SBSS) to expand the soil volume that will allow tree roots to access adjacent condition. Soil volume per tree is much higher in the cases where SBSS is used. A minimum sidewalk width of 6' means tree pit of 2' wide because a 4' sidewalk must be maintained for accessibility. City will not prune roots if sidewalk lift occurs and will use flexipave or asphalt instead of concrete or will shave down concrete.

TF: Underwire trees are categorized according to height, how about tree well pit size and soil volume?
Response: It would be good to include recommendations by tree hardiness.
TF: What is the management over time like with flexipave?
Response: Flushing out of flexipave will remove the silt that has built up in the flexipave.

TF: Is there a cycle to change the size of the tree grate in time?
Response: There isn't a regular cycle but the City will go out and remove tree grates when they see the need.

TF: Are the trees in SSBS doing better?
Response: This is an area where Cartegraph can be very informative. The City might be able to track how trees within SBSS and trees not in SBSS are doing and conduct a comparative analysis. This layer of data needs to be added.

Irrigation:

For new City owned trees, City waters for 5 years. City requires contractors and developers to water trees within public ROW for 2 years. Trees are under warranty for 2 years. Sometimes the City will ask developers to prepare the site for planting and they will pay into the tree fund and the City will plant and maintain. City uses gator bags around young trees (not useful for mature trees). After 2 year period, City employs summer interns through the Water by Bike program to water trees for 3 to 5 years, and for trees that

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MEETING NOTES

are not accessible by fire hydrant, forestry folks

TF: When there is a drought, how do you water the trees?
Response: If the trees are out of the 5 year watering period, the City relies on residents to do it themselves.

Mulch

No standard program for street trees. Parks use natural hemlock mulch and tend to have an issue with over-mulching. Areas of investigation: Adding specificity to the formal specification.

Soil details/specs/systems

City has one specification for replantings and one specification for new tree locations with sand based structural soil. Area of investigation: We know that some trees fare differently in sandy soil- so what kind of flexibility can there be to provide the right soil type for the right species?

TF: Can Cartegraph become a public tool or become a tool for landscape architects to know which trees are existing / can be used when there is a new development?
Response: Right now Cartegraph is internal facing, but the City makes its tree inventory public though the Open Data Portal.

BEST PRACTICES

Several BMPs that currently aren't documented by the City and are being investigated by the team include supplemental support, lightning protection, addressing root defects, pest management, and risk management. Different strategies work for different situations- SBSS, CU-soil, and suspended pavement are all systems that seek to limit compaction and can be considered. Pervious pavement systems have an added stormwater benefit, but it's also very important to consider aeration and drainage. Soils are dynamic, living systems, and even under pavement, research has shown that there is biological activity and they form horizons over time.

Soil Management

F2 presented on the importance of soil biology and best management case studies for soil management. In Battery Park City, a leaf composting program was established in a small footprint. Harvard Yard has an active compost-tea program

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In Battery Park City, soil testing was done after Hurricane Sandy and found that sandy soils had much lower salt content than soils with more loam. Similar conditions are seen with soils exposed to a lot of winter salts. When amending soils for salts (for example gypsum amendments), must also consider the biological component and may have to also add compost. Growth medium

TF: How can the leaves be left on the streets?
Response: Taking the leaves, composting them and putting them back as finished compost.

TF: How can the budget of trees be adjusted?
Response: Through the budget process.

TF: What about the current condition of trees on private property? The average backyard is a significant amount of the city. Is there any effort to analyze that?
Response: Analyzing the entire city using LIDAR so we can understand where the risks are.

4. Advocacy
Conservation Law Foundation presented on the City's current regulations on tree planting, mitigation, funding and best management practices from other cities. Summary of the presentation and task force comments follows:

I. Current State Regulations
<u>M.G.L. Chapter 87 – Shade Trees</u>

- First state in NE to pass this type of legislation. It was enacted in the late 19th century, other NE states followed suit
- Definition of a shade tree
  - All trees within or on the boundaries of a public right of way (within 20 feet with owners consent)
- Protections
  - Protections of the Public Shade Tree Act applies to all public shade trees, shrubs, and vegetative growths within the municipal boundary except (i) those along state highways and (ii) those in public parks under the jurisdiction of the park commissioners unless the park commissioner grants the

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MEETING NOTES

tree warden control in writing

- Planting
  - Cities and towns may appropriate money for planting and maintenance
  - The tree warden, or a private organization acting with written consent of tree warden, may plant shade trees acquired with either private or public funds
- Establishes Tree Warden
  - Guardians of municipal public trees
  - Tree wardens have the power to make regulations for public shade tree care and protection
    - upon approval by the selectmen, those regulations acquire the force and effect of town bylaws
- Cutting down
  - Require a hearing – if there is an objection in writing (at or before hearing) than cannot be cut down or removed without approval by selectman or mayor [In Cambridge this would be the City Manager]
  - Current exception excluding trees of 1.5 inches in diameter measured one foot from the ground from the public shade tree hearing requirement
  - Statutory exceptions to the public shade tree hearing requirements
    - Endanger persons travelling on a highway or hinder travel on highway
    - Purpose of widening a highway
    - "suppression of pests" which has been construed in case law to mean anything that is a risk to public safety so hazardous trees
    - If they obstruct buildings being moved in a public way for public safety reasons
- Utilities
  - Utility may, or the tree warden might require the utility to, submit two documents: (1) an annual vegetation management plan describing the proposed maintenance work to be performed, and (2) an annual hazardous tree removal plan describing hazardous trees to be removed. Approval of these plans exempts the utility from the statutory public hearing requirements. The utility submits the plan no

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later than ninety days before the proposed work begins, and the tree warden notifies the utility within sixty days whether or not the plan has been approved. The tree warden may approve the plan with modifications agreed to by both parties.

- The utility must also comply with tree maintenance standards and specifications
  - The standards must conform with American National Standard Institute A-300; American National Standard Institute Z133; and National Electric Safety Code 218 Tree Trimming and OSHA 29 CFR Part 1910 Line Clearance Tree Trimming Operations, and annually the utility must submit evidence of compliance with these standards.

II. Current City Regulations
Removal Policy: Consistent with state law, the City only removes trees when they are dead, dying, diseased or hazardous. Public shade trees are protected under state law. The City does not remove trees without good reason. They will remove trees that are hazardous i.e. they pose a threat to persons or property and in that context it must meet three criteria: (1) is it sufficiently large enough to cause damage if it falls, (2) It has a target that would be damaged if it fell, and (3) The tree has a condition that would make it likely to fall.
The city will inspect all requests for removal. In some cases, a tree may be developing a condition that would ultimately make it a hazard, but not imminently. The removal of such trees requires a public hearing as prescribed by state law. In some cases, the entire tree may not be hazardous, but some maintenance work is required.

<u>City Tree Protection Ordinance</u>

- Defines Significant trees as trees larger than 8" DBH (diameter of a tree trunk measures in inches at a height of four feet above the ground 'breast height')
- Establishes a tree replacement fund, which is an account administered by the City Treasurer for the sole purpose of buying, planting, and maintaining trees in the city (notably does not say public trees)

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MEETING NOTES

- Establishes and defines "tree protection plan", which is a drawing that depicts existing trees and indicates whether they can save trees on site and if they need to be removed, where on site they can be replaced otherwise the amount of mitigation to be paid into the tree replacement fund. Tree protection plans apply to projects that require a special permit and projects of 25,000 square feet or more
- Defines "replacement trees" a tree or trees to be planted on a lot to replace any significant trees removed from the lot or whose equivalent value is proposed to be paid into the tree replacement fund.
- The "Tree Study" consists of the tree protection plan, a tree survey, and if applicable a mitigation plan (i.e. how they are going to replace or pay into the fund). And a tree survey is a plan showing the location, type, height and DBH of all trees on a lot
- Noteworthy that this section only gives project applicants the option of either (a) planting replacement trees on the same lot or paying the estimated cost into the tree fund
- Also gives the Commissioner of Public Works authority to promulgate regulations to "accomplish the provisions of the chapter"

Zoning Ordinance

- Tree requirements hidden throughout many articles of city zoning – have some mention in 7 different articles. Some of the most noteworthy are:
  - Article 5 which sets development standards for residential and business districts
    - Specifically it applies to the C-2B residential district and to business districts where a lot abuts a residential district
    - For Zone C-2B, the Committee on Public Planting is required to review and approve plans for landscaping and maintenance
    - Some of the requirements that apply to both these districts include set back requirements and calls for proponents to "make an effort to retain best existing trees in setback area"
  - Article 19 is for project review and requires that both applications for special permits and applications for development in a variety of office, business, industrial, and

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residential zones include a tree study as defined in the city's tree protection ordinance

- Article 20 provides requirements for overlay districts
  - Specifically, the parkway overlay district requires that for every 10 "on-grade" (ground level) parking spaces there has to be at least one 3-inch caliper tree located within the area devoted to ground level parking
    - There are also standards for tree protection included here and a requirement that front yards contain at least one three inch caliper tree for every 25 feet of linear feet of street frontage
  - The Prospect Overlay district requires that any new development or redevelopment on a lot, an existing or new tree is required on the lot within 10 feet of the public sidewalk or in the public sidewalk for every 25 feet of frontage along Prospect Street.
- Article 11 requires townhouse development to provide at least one three inch caliper tree for every two ground level parking spaces but that this requirement can be reduced through special permit
- Article 6 also includes requirements for off-street parking facilities including that "every effort" shall be made to retain existing trees and that removal of a tree exceeding 6 inch caliper to accommodate construction is discouraged
  - Also, ground-level parking facilities containing 5 or more parking spaces shall have at least one tree and the facility as a whole shall contain at least one tree for every ten parking spaces
  - Trees must be a minimum of 3 inch caliper at planting

Committee on Public Planting
Established in Chapter 2 of City code of ordinances.
Purpose is to advise the city council, city manager, public works commissioner and others on public planting issues, including the effective maintenance of public plantings already in place; serve as a resource for the city; review planting plans of all proposals for new public work in the city; to support the role of the City arborist or tree warden; to encourage interest in public planting; to conduct other activities as considered appropriate for

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achieve the basic purpose of the committee.
The committee is appointed by the City Manager – members of the public who serve have term limits of three years but can be reappointed.

Tree Ambassador/Water by Bike
Paid program –currently four summer interns. They are responsible for inspecting, weeding, and watering young trees via bicycle and cargo trailer.

Planting Requests

- You can request a replacement tree if a tree in the public right of way was removed from an existing well in front of your property and there is no expense to you.
- You can also request to plant a new tree if there is no tree well on your property but the city will determine whether or not the site is suitable for a tree well and if it is not you can chose to instead participate in the back of sidewalk program

Back of Sidewalk

- The back of sidewalk program is an opt in program where property owners can have a tree planted on their private property within 20 feet of the public right of way at no initial cost to them but the property owner agrees to maintenance of the tree once its planted.

Adopt-a-Tree
Residents can use the City's interactive mapping tool to find city trees near a specific address whether its work, home, wherever, click on a tree and fill out a form to adopt it. In doing so, they agree to water and tend the tree well.

Commemorative Tree
You can opt to have a tree planted in honor of something – a person, significant life event or anything else you want. It costs $200.

II. Challenges and Opportunities
Team is in the process of digesting the information from a meeting with the City but we came away with ideas for things that could be reworked or made more efficient.

Public-private partnerships – What is the interest in public-private partnerships to work toward this goal. Part of our best practice review will be looking at how these have worked in other places. Part of this will be dependent on what we find in other areas in terms of which areas are

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suitable for planting, are in most need of canopy coverage, where the greatest opportunity areas are. For small property owners we will likely get a sense of their level of buy-in through community meetings presenting some of our initial findings and recommendations.

Relationship with the State – one of the things we are doing to be looking into is the City's existing relationship with DCR on this topic area and whether there are any systems in place to coordinate or have a dialogue and if not, why that is and whether there is a way to rectify it if we believe it would be useful or make it easier for the city to achieve its tree canopy goals.

Cross-departmental city coordination – making sure that when there are updates in zoning in so far as those updates would impact tree requirements or introduce new landscaping requirements – what systems are in place to coordinate that. I also mentioned earlier that is currently is not common practice for the City Arborist to go out and assess projects with landscape plans prior to them being issued a certificate of occupancy. Should there be a mechanism to make sure this is being double checked and that properties are in compliance with tree studies.

IV. Feasibility survey/study
The intent of the feasibility survey is to give a baseline knowledge to narrow the world of possibilities to what the team thinks will be feasible here in Cambridge. For this purposes, there are three major research questions we're seeking to answer with the information we collect from the study/survey.
Research questions:

- What is the attitude toward or interest in tree planting?
- Why are current programs for planting and maintenance successful or unsuccessful? Known or unknown?
- How do attitudes, awareness and interests differ by neighborhood and housing tenure (own or rent)

Not being used as a public engagement tool – the goal is not to collect general information from residents. The team is still in the process of confirming these general research questions and the sub-questions with city staff.

V. Best Practices

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Seattle, WA
Tree protection code:

- Similar to the city's tree protection ordinance – except applies more broadly
- Limits the number and the size of trees that can be removed from private property
- There are several detailed provisions of this code but at a high level some of the noteworthy things it requires are:
  - Developed land: no exceptional trees can be removed and no more than 3 non-exceptional trees six inches in diameter or greater may be removed on any lot in any one-year period
  - Undeveloped land: no trees six inches in diameter or greater may be removed unless they are hazardous or where tree removal is proposal as part of development
  - During development: they have to identify all trees with a diameter of over six inches and requirements are based on zoning and building subtypes similar to as in the Cambridge
- Exceptional trees are defined as a tree of group of trees that are unique because of historical, ecological, or aesthetic value. They include trees designated as "heritage trees" which are voluntarily designated or they are exceptional by virtue of size, species, condition, historic important, age, etc. Ultimately designation is determined by the Director of the Department of Planning and Development.
- Heritage trees have to meet some criteria based on specimen, historic value, etc. but they also have to be nominated with a property owners consent and evaluated by the city arborist and a review committee before they are designated.

Update: Seattle is currently revising its ordinance

Green Factor:

- Similar to the Green Area setbacks in Cambridge zoning
- Green factor is a score-based requirement that increases the amount of and improves the quality of landscaping in new development.
- To meet the green factor you have to reach a minimum score and you can choose from a menu – similar to LEED certification. The menu includes a lot of things green roofs, rain gardens, trees, etc.

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- Doesn't apply to everywhere – for example it doesn't apply to single-family zoning districts, which probably makes sense because those are more likely to be smaller lots. New commercial development and large mixed use would really be the target here
- But there are built in incentives for doing certain things – so as it relates to trees, a developer would get more points for a preserved tree than a newly planted tree. They also get added points for layering vegetation so a tree with an understory of shrubs is worth more than just one tree by itself.
- Catch here is that it gives developers more options than just tree canopy when they are meeting the requirements. Which may or may not be a bad thing depending on the situation. Something like this could easily be tweaked to favor trees above all other green landscaping features but it also does provide some mechanism for a developer to comply with onsite features if for whatever reason a tree or many trees is not feasible.

Atlanta, GA

- Whereas the city of Cambridge's tree ordinance is a page or two long, the city of Atlanta's is 32 pages so it's very robust. I'm not going to give you all the intricate details but at a high level some of the things that make it strong are:
  - Slightly lower tree to surface parking space ratio – 1 tree for every 8 space instead of Cambridge's 10.
  - They empower their tree conservation commission to determine when a person has violated the provisions of the ordinance and impose fines – the first violation is no less than $500 and the fine for each subsequent violation is $1000 which is a little more substantial than Cambridge's fines
    - If the commission can't determine the number of trees for which the violation occurred, they assume a density of 60 trees per acre and can impose a fine of $60,000 per acre of land.
  - They also have a tree fund but they have stricter requirements for how much money can be used for what purpose. They also allow some of the funds to be used for educational outreach.
  - In terms of tree removal, they require a permit to remove any tree on public property and to remove a tree with a DBH of six inches or more on private property and if the tree is not

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dead or dying or hazardous they have to meet standards for tree replacement – similar set up where if you can't replace them all on site you contribute into a tree fund
  - Another interest provision is that a certificate of occupancy for a property cannot be issued until the city arborist has inspected the site and confirmed that all replacement trees have been planted

Nashville, TN
Tree protection and replacement ordinance

- Requires a permit before removing any tree that is considered a "protected tree" which means its 6 or more inches in diameter. Does not apply to one and two family residential areas.
- Tree removal permits are not granted unless it meets specific criteria including its disease, poses a threat to safety, structural integrity or utilities, permissible use of the site cannot be undertaken unless the tree is removed or relocated; and others. But generally it doesn't allow for healthy, nonhazardous trees to be removed without special circumstances.
- Has special designation for historic and specimen trees that are designated by the metro beautification and environment commission based on advice from the tree advisory committee and with consent of a property owner. None of these can be removed without a finding from the commission that it's hazardous or it's economically or practically unfeasible to develop the parcel without removing the tree.

Mayor also recently signed an executive order reinforcing tree protections on public property

- Among other things, the EO requires ongoing monitoring of the tree canopy and an update of the city's tree canopy study every five years, regular tracking of tree plantings and removals on public property and public right of ways and track and log replanting opportunities throughout the county.

Arlington, VA

- Arlington, like Cambridge has a tree canopy fund but they use the fund to provide grants to plant trees on private property. Since the program started, 1.213 trees have been planted. When grant

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applications are approved, the tree is planted by a contractor and the property owner is responsible for maintenance. Grant applications are prioritized based on a number of factors including the location and suitability for planting, whether the applicant has training or experience in tree care, whether its submitted by a lone individual or an organized group, whether they are a first time applicant or not but interestingly there doesn't appear to be any ability to pay criteria or prioritization.

Dallas, TX

- The revised ordinance distinguishes between species of trees for imposing fines with heavy fines for "legacy" trees like elms and oaks but no fines for removal of invasive species. Also takes into account the age and size of trees being removed with the intent being to limit very large old trees from being replaced with lots of very small trees that may not survive.
- New version also limits the number of "exempt" trees
- Added credits for transplanted trees, habitat preservation, and sustainable landscape design
- Different types of street topologies, so residential, mixed use, commercial, etc. have different tree canopy cover goals stated. Those percentages are converted to square feet by multiplying the percent and the total square footage of the building site. If the property can't meet the goal they have to mitigate it but there are credits available that can reduce the mitigation requirement.
- Although this was not one of the updates – it was already in the ordinance—they charge $2,000 a day in fines for violations.
- Also allows them some flexibility in how they spend the money in their tree fund including funding an urban forest plan with some of the money

Also noteworthy that there have been some unsuccessful efforts at the state level in Texas to put restrictions on local tree ordinances. A few bills have been introduced over the years to restrict localities ability to prohibit tree removal on private property for trees of a certain size and proposals to cap tree removal fines.

TF: Would like to have notes from this presentation, particularly the advocacy section, available for the task force.

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TF: What does the 19.75 spent per capita. What does this look like in comparison to the per capita budget spent by DPW?

TF: Consider looking into incentivizing microforest. Microforests are considered at the parcel scale and help growth rates of trees.

TF: Conflicts with neighbors regarding their ability to trim trees.

TF: Cambridge is a dense city compared to Dallas, when we use per capita comparison, should be cognizant of comparing similar municipalities.

TF: Why did we settle on 8" dbh on policy?

Public Comment Period:

Public Comment 1: She has praise and thanks to the City arborist for help on replacing tree after it was pruned too heavily by Eversource. A lot is possible on a person to person basis.

Public Comment 2: He expressed concern on the impact of development on tree mortality. He sighted the Holyoke Center renovation as a large development with significant tree removal. There are controversial situations with both public and private tree removals and tree mortality rates connected to that. How can this be handled better? He's interested in learning how we get a better handle on large development- what other solution are there?

Public Comment 3: Beyond the single tree, what kind of analysis can be done on clusters/groupings of trees?

Public Comment 4: There are stark tree health differences between trees south and north of Porter sq. Seems like it might be an equity issues. Are there maintenance differences?

Public Comment 5: Hotel owners put small trees in front of their developments, similar to the trees put in for small homeowners. Example of hotels at Porter Square- this seems an inadequate tree size for larger

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development.

Public Comment 6: Thanks to everyone. She's interested in a comparative per capita numbers for cities that have better policy or have better canopy.

Public Comment 7: He would like to relate spending to environmental services.

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ISSUE DATE
Aug 07, 2018

MEETING DATE
July 26, 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Master Plan
2953

RE
Task Force Meeting 3

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Reed Hilderbrand

1. Introduction
Reed Hilderbrand (RH) gave an overview of the agenda for the evening.
Attendees were reminded to sign in on the provided sign in sheets.
It was noted that there would be a public comment period at the end of the meeting. It was clarified that preliminary analysis is based on UVM Study from 2014 and is spatial and does not include other data like species.

2. Schedule
RH reviewed the project schedule and that the team is at the end of the Research Phase of the schedule. RH noted that three public meetings will be held, starting in the fall.

RH summarized the design team workshop that was held the previous week. The team members discussed the set of research questions that each are investigating, laying out the process going forward and took a tour around Cambridge. They looked at various conditions in the city, park and street trees, and areas that would be representative of larger areas of the city. They also visited the new street tree plantings that were part of the Sewer Separation project in West Cambridge.

Bartlett is conducting a representative tree health survey, which started last week.
The soil sample locations have been shifted to align with tree sample locations and soil analysis will start next month.

3. Initial Spatial Analysis
RH presented what the team has learned so far about the relationship between City's tree canopy cover and the urban heat islands, as well as the land use by breaking down by neighborhoods, according to LiDAR data and City GIS data. Summary of the presentation and task force comments follows:

Urban Heat Island and Tree Canopy Cover
RH noted the maps are based on 2014 LiDAR data and will be redone with 2018 LiDAR when it is available.

28.73% of land area of the City is covered by tree canopy. The canopy cover by neighborhoods range from 13% to 42%. The heat island data from 2070

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CCVA report were overlaid with the canopy cover, to show the areas of the city with higher and lower temperatures.
For clarification, the heat island data uses measurements of ambient air temperature (six feet off the ground), not the temperature of the physical surface. Resolution of the data is 100 feet by 100 feet. [It is important to note that the maps in this presentation show ambient air temperature, while the heat island maps in the CCVA report use heat index temperature which accounts for relative humidity].
The variation of heat island and the relationship with canopy cover can be easily seen from the maps. It is noticeable that hot spots occur in areas with large block sizes and that the river edge and areas around water bodies are cooler.

Task Force (TF) comments:
Lechmere canal upper side has a good canopy and that's a nice place to hang out on a hot day. What is under the red hot spots- Cambridge Mall, large parcels with buildings and garages that take up most of the parcel. Mostly new construction.
Response: Because block size is so big, planting along the edge isn't going to be the solution for increasing canopy cover.

How do you measure ambient air at the building? Roofs will generate heat.
Response: It is measured 6' above the surface, whether it is ground or roof. Green roofs are not a part of this project, but it is important to think about. Different colors create different temperatures. A green roof would have a cooler signature than a white roof which has a cooler signature than a conventional black roof.

Urban Heat Island and Canopy Cover by Neighborhoods:
RH then walked through each neighborhood map which depicted canopy cover and heat island and invited the task force to comment on the maps.

Area 2/MIT:
Neighborhood has sports fields and pockets of hot spots along the edges of the neighborhood, which is usually commercial area.
TF: Does the canopy coverage include the water?
Response: It does not include the water.

Cambridgeport:
The neighborhood's hot spots are light industrial area and used to be filled

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with auto body shops, so demand was not high for trees. These historical remnants are now being developed with biotech or new housing. It's an opportunity for new canopy.
TF: What about Mass Ave? There are trees on the avenue but is a large hot spot.
Response: Even if you have trees, they might be unhealthy, not creating shade. On Mass Ave, some of the commercial areas are continuous with no yards, thus creating hot spots. Adjacent streets to Mass Ave also don't have many trees.
TF: What is a healthy city's canopy coverage? What is a target canopy?
Response: We don't think we are ready to set numbers. We need to understand the context first and need to be realistic. We are giving the context now and will get to our mission statement.

The Port:
22% canopy cover. Hot spots are along the edges.

Wellington Harrington:
19% canopy cover. Hot spots are along arterials.

Mid-Cambridge:
Canopy cover is 29% with Harvard yard. Campus spaces have more canopy.
TF: Harvard Museum of Natural History area is very green.

Riverside:
Canopy cover is 27%. River edge is cooler.

Agassiz:
Canopy cover is 33%. Left edge is Mass Ave. Green area is Academy of Arts and Sciences.

Neighborhood Nine:
Canopy cover is 33%. Density and continuity of canopy with Danehy Park. Pattern of trees in Danehy delineate the sports fields.

West Cambridge:
West Cambridge has a good amount of canopy, 42%, but it still has red spots, so it is not only about number but the distribution.

North Cambridge:

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Canopy cover is 26%. The neighborhood has large open areas and Alewife corridor, which will see big changes.

Cambridge Highlands:
28% of canopy cover, but this number is misleading as almost all of which is at Fresh Pond.

Strawberry Hill:
37% of canopy coverage, not many hot spots because of Fresh Pond.

Land use and Tree Canopy Cover
The next set of maps and diagrams relate canopy to land use type in three different neighborhoods of Cambridge (East Cambridge with low canopy, Mid Cambridge with medium canopy, and West Cambridge with high canopy). The legend shows the proportion of canopy by land use. For instance, in Mid-Cambridge residential yards have most of the canopy, but because of land use percentage the overall pattern is a rather even distribution of canopy. With these maps we're looking to identify opportunities and challenges/limitations for more trees by land use. Owner occupied vs renter occupied will also be evaluated at a later time.

TF: Would like to see heat island over land use to see where more trees could be planted.

TF: We cannot have impact on heat island in commercial areas like Binney St because of big footprint of buildings but can do so on residential. What can we do with street trees?

TF: Pedestrian comfort is important. What can and cannot be done?

Response: There will be different strategies based on land use types. There can be processes to encourage developers to plant more trees. We are just showing heat island map right now because it's the data we have available, but it's important to keep in mind it's not our only goal.

Tree Canopy Cover Change
The figure shows the UVM report's percent change of canopy cover over five years (2009-2014) by census block.

TF: What are the gains in tree canopy cover?

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Public Comment: Green part may be Danehy Park where existing canopy became bigger- maturation of existing trees.
Public Comment: Even though trees were planted, there is loss corresponding to sewer separation.
John Bolduc: West Cambridge- some aging out of trees. Irene and Sandy happened between 2009-2014, storm damage have affected some trees.
RH: The Earthwatch Institute report, "Scientific Analysis of Current Trends in Growth and Survival of Cambridge's Street Trees and Management Recommendations" is specific about species mortality but not about causes.

TF: No mention about people and income levels who live in these neighborhoods.
Response: Vulnerable populations is something we are looking into as mentioned in our first presentation. There are differences between owner or renter occupied, and will run analysis when we have the data.

4. Project Goals
The mission statement was part of the RH proposal. We are interested in what this means at the practical scale, what our goals are and how we can set practical targets.

Some cities have set planting goals, such as million trees. Is this a good metric? We are conscious of setting targets that don't mean anything. It matters which species you select, how long they survive, and where you put them. Achieving a canopy cover percent may be more useful than specifying a number of trees to be planted, but we're still looking at what that percent should be.

TF: Our own city council looked into 1000 trees a year.
Response: It is easy to set number targets but it is hard to achieve them. 40% coverage was a goal set by American Forests in 1997 but they no longer recommend this target and instead say the goal should be contextualized to the culture and climate of the city.

The real question is what we are trying to achieve and how we get there. Envision may help us narrow our goals to make more targeted decisions. Equity, stormwater, transportation and connectivity are some of the things that help us focus our goal.

In the CCPR Report, "cool corridors" is a strategy about to design the

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spaces people move through. Imperviousness, soil volume, planting strategy, green infrastructure- these should feed into decision making.

Our goals should be talking about individual trees, people and forest as a system. Within "People," a forest that contributes to the well-being of the people. Within trees, a healthy forest whose trees live longer and thrive during predicted changing climate conditions. Within forest, a forest that supports a resilient, connected ecosystem.

Decision Support Framework
RH talked through the draft project goals in the decision support framework.
The goals in the framework are not listed in ranked order and it is a draft document.

People:
- Reducing urban heat island effects
- Enhancing citywide stormwater management
- Increasing equity in distribution of canopy cover
- Air quality: How to measure air quality, pollutants in the air or abstract to leaf surface area?
- Creating aesthetically pleasing streetscapes: How to measure aesthetically pleasing streets?
- Enhancing pedestrian outdoor thermal comfort
- Increasing carbon sequestration

Trees:
- Improving soils health: How to evaluate health?
- Improving tree health: A baseline that can be assessed over time
- Improving street tree lifespan: Street tree is limited

Forest:
- Enhancing habitat, connectivity
- Diversifying forest composition
- Planning for disaster response (noreaster, drought)

Discussion

TF: Under people for stormwater, include water quality and thermal pollution?

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Wind buffering, some trees buffer wind?

TF: Suggestions for measuring air quality, such as moss. Nitrogen analysis on leaf for air pollution. Is it possible to set target for air quality?
Response: Maybe leaf area defined through species.

TF: Social Aspects of trees; canopy connectivity- trees are social. Are there ways to increase proximity of trees with each other? They share soil and water. Soil connectivity is the key here. Grove plantings, clumping trees. For example, on Mass Ave, clumping six trees would protect each other and can supply shade and can be watered easily.

TF: Bird observations: Bird populations might be a criteria to measure habitat connectivity. Getting in touch with birders in Cambridge for bird surveys. It's hard to find a baseline for new species. Mass Audubon's mission is all about climate change and would be a great partner.

TF: Public health information: Respiratory illnesses tied to the air quality. Maybe look into ambulance calls during heat waves

TF: Measuring human stress levels on different streets, in public spaces, as a measure of aesthetically pleasing streetscapes.

TF: Upland Road -anecdotal- small planting areas can make huge differences.

TF: Tree health: what additional supports can be made to increase tree lifespan? Rethinking how we are planting along denser, busier streets. Is there a way to assess how we are doing now? How can we give the agencies responsible more tools- how can we use data to buttress that effort? Maintenance issues: Mass Ave trees take a beating – very difficult to get a tree to grow in that environment – DPW/City needs more resources. Design and planning issue – put trees more likely to thrive.
Response: We aren't in a place for making recommendation right now but hope to set the stage.

TF: Can we quantify economic value of ecosystem services?
Response: We have a cost estimator on the team, and we will assess the costs of planting and maintenance programs against the value of benefits to the City, including ecosystem services that can be reliably quantified.

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TF: What about unnatural causes of tree death such as damage from trucks which impacts tree mortality?
Response: We need to talk about all the reasons why tree die. There are many different factors for reasons of mortality. In some neighborhoods they are aging, in others it might be drought etc.

TF: Property value is not necessarily a good metric for aesthetics. Keep an eye on social equity with property value.
Response: We need to find metrics to respond to the overall experiential quality of trees.

TF: Street Design: Not only planting trees but we need to improve conditions. Restrictive sidewalk widths will limit street planting. How can the urban form change? If mature trees die, they would not be replanted because sidewalks are too narrow to accommodate ADA and trees. Some changes in parking requirement and traffic patterns? Some ideas: asymmetrical streets, front yard trees.

TF: Goals under people, there should be something for engagement and awareness because we are looking for partners. Must be a way to measure engagement. Measuring programs like BOS program.

TF: "What can we do for trees?" We are not doing enough as residents and as a city. Add "residents that contribute to the forest well-being" to People Goals. More of awareness in Cambridge of the value of trees.

TF: Salt as a subcomponent of soils

TF: What is the Shannon Index?
Response: In order to evaluate diversity, look at ratio of species and number of species. We should figure out a number for an urban context – Shannon Index used for forestry. Management tool and we have to figure out how to use it.
D Lefcourt: have used a metric that says there should be no more than 10% of genus. Currently, Honey locust and Maples are more than 10%.
Response: What percentage of the canopy under risk? We need to start to adjust for future planting, catastrophic events

TF: Break out Public ROW street trees from other trees

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TF: Concerns about using 2014 data
Response: Once we have the full data, we will run the models. AES gathered and is processing the 2018 LiDAR, Bartlett and T are also gathering data. These numbers from 2014 will change. In August we will have the current conditions.

TF: How detailed is the Bartlett survey?
Response: Their categories of assessment are genus, species, DBH, condition class, age class, native-invasive species to Massachusetts, pests/diseases, location info, size of planting bed/tree pit, material of the surface, private/public/commercial.

Question to the TF: Is there a hierarchy to the goals- how would you prioritize the values and goals?
TF: Some of the goals seem unnecessary, like air quality. It is a residual effect of having trees. It's worth measuring but not at the top of the list.

TF: Loved the phrase "Cool corridors". Cool corridors have multiple benefits and they are very desirable as goal or strategy.

TF: Neighborhood differentiation in character: The framework is too general, neighborhoods have different characters and goals and strategies need to be prioritized by neighborhood. How do you take these metrics and apply them to the neighborhoods? The goals of neighborhoods may require certain things to increase or decrease. In an urban environment, you might want to have pedestrian connectivity, pleasant streets, active programming etc. How does this get overlaid on that matrix?

TF: Neighborhoods are often divided by major corridor, transportation corridors.

TF: Education about private trees. How can we influence/protect private trees (majority of trees)?
Response: Recommendations, some of these will be about soils, about policy and about education. We don't know yet what the most effective place is to spend money on.

5. Public Comment Period:

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Speaker 1: She believes naming trees create connection and allows residents to also report issues. She's lived here for 25 years. She has seen a job posting for Superintendent of Urban Forestry on City website- is it part of this effort? We should have a relation, an interactive thing with trees. Trees should not be anonymous. Cambridge citizens should be able to have call in number to phone a problem. A Pin Oak in East Cambridge was devastated by EverSource, which was an old, enormous and beautiful tree – need to consider policies below ground and advocate for trees.

Speaker 2: Importance of equity, habitat and joy of trees. Would like to see equity moved over to Macro definition to "well being in equitable fashion". Seeing many things quantified on the list but not everything can be quantified, would like to see inclusion of joy and pleasure. Birds and critters of all kind and tree habitat should be an important component. Additional suggestion for metrics- When does it makes sense to cut down existing trees? Maintenance schedule for existing city trees?

Speaker 3: Expand Adopt-a-tree program. A tree was removed from Gore St. in East Cambridge, and it was a traumatic experience for the neighborhood. People wrote letters and put flowers on the stump. East Cambridge has a spiritual relationship to trees, especially on Gore St. He doesn't see development on the list- not the same if replacing large trees with small ones. Developers need to take into count value of trees. He has a handout for a Adopt-a-Tree Partners Program Incentive program and Catherine will put it up on the website. The handout proposes to make Adopt-a-Tree program more attractive by providing public recognition such as tree tags, certificate of adoption, business window sticker, listing on City website, and media kit. Maybe developers would like to adopt a whole street of trees.

Speaker 4: Runoff/carbon sequestration/beauty/cool corridors.
She remarks this has been a great discussion. City manager has responded to council order asking for more frequent LiDAR studies. They are willing to do more frequent LiDAR studies because also benefits for other things. Her four top rankings for value of trees are: stormwater, carbon, cool corridors and beauty/aesthetic factors.

Speaker 5: SeeClickFix doesn't have entry for trees in distress. Many trees being cut down in the past year. He doesn't see anything about why trees being proactively cut down in our study. He thinks there is a big hole in the

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Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

data. Barcelona has big program on green corridors. SeeClickFix used to report tree issues- should have option to help out a tree.

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Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

ISSUE DATE
Sep 17, 2018

MEETING DATE
Aug 30, 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Master Plan
2953

RE
Task Force Meeting 4

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Reed Hilderbrand

1. Introduction
Opening remarks from Owen O'Riordan introducing Andrew Putnam as the new director of Urban Forestry, who will be working with David Lefcourt to help manage the population of trees.

2. Schedule
RH reviewed the project schedule and that the team is wrapping up the data gathering and research phase. The team is setting up parameters for the climate modeling. Tree inventory is completed and soil sampling is in the process of analyzing results.

3. Design Team Presentation
RH presented what the team has learned so far about the composition and health of the citywide tree canopy cover according to Bartlett's 5% inventory data and AES' classification data based on imagery and LiDAR. Climate modeling assumptions (KLF&RH) and the new Urban Forest Survey (CLF) are also overviewed.

Summary of the presentation and task force comments follows:

Draft Analysis of City-wide Classification Data (RH)

Looking at the draft classification data, trees in the city are identified down to genus and species, classified through 2018 LIDAR data and aerial imagery. This gives us species breakdown of the City. Seven species make up roughly 60% of the urban forest. Norway maple and honey locust are the highest in number. We've been asked whether we would remove some Norway maples but we would not because of their large canopy that provide shade.

TF: What is "Other" on the chart?
Response: Other includes trees that are less than 1.63% of the forest and the unidentified trees that are growing under large canopy trees. We will have canopy loss and canopy cover by neighborhood and land use for the next meeting.

TF: Private vs public tree separation?
Response: This includes all the canopy cover in city both public and private.

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MEETING NOTES

We will be breaking it down according to the City's GIS land use layer.

TF: Is this new data?
Response: It is new data. It is still a draft but the numbers will not change drastically.

TF: Is this a representative canopy cover?
Response: This is not tree counts, it show the species as a percentage of the overall canopy.

TF: What do you mean by public?
Response: DCR land is also public but we don't have control over that, so it will be considered public-other. Private institutions will be considered separately. We have opportunities to form partnerships with universities.

TF: What is the canopy loss?
Response: There is a small loss. We will be looking at comparison of 2014 and 2018. Cities on a whole across the nation are losing canopy.

TF: There was a pixelated map that shows the canopy cover from the GIS (page 7 from previous Task Force presentation), can we get higher resolution images?
City response: It depends on the GIS, we can check.
KLF: Canopy maps are pixelated because they are raster images within the presentation itself. The LiDAR data has more precise information because the survey produces fine-grained data.

Initial Analysis of Tree Inventory Data (RH)

Survey summary:
Tree survey map shows all the trees that were surveyed (5% of all trees in the city) and are color-coded. Green means in good condition, yellow – fair, orange – poor, red – dead, with 95% confidence interval. The numbers of the trees are separated according to location, material etc. New plantings have a low sample rate but there is a good distribution of young, semi-mature and mature trees. 88% of trees are in good or fair condition.

TF: What does over mature mean?
Response: Trees have expected life spans, over mature means beyond its

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peak age when the tree is expected to start declining.

Tree Condition Graphs:
City trees have lower percentage of trees in good condition, not unusual that this lags behind other categories.

TF: What are the ages of commercial trees? Is it possible that commercial trees are in good condition because they are younger?
Response: Yes, your question gets at the fact that there are many additional analyses to look into.

TF: What is a commercial property, as an example?
Response: Commercial buildings at Alewife, parking lots at Porter square.

Overmature trees are in good condition.

TF: What is "overmature"?
Response: A tree that is at the end of its expected lifespan and is assumed to be beginning to decline.

Trees by Material:
We have experienced in our practice over time that using tree grates is not the best practice. Even if it is low sample size, we are not surprised that they are not doing well.
Why is turf condition so low? We looked at the turf breakdown: 62% of the turf is lawn, including the Fresh Pond, where there is a high percentage of buckthorn. It is an invasive and isn't doing well, which skews the results.

TF: Competition for space with turf going up to the tree- is there a classification for mulch?
Response: That would be planting bed.

TF: Raised planters are deadly. Does that fall under planting bed?
Response: Might be planting bed but we need to check in with Bartlett.
[Update: Raised planters built around trees in tree pits would have been counted as "Tree Pits."]

TF: Is the golf course included in the survey?
Response: We don't believe the sampling fell on the golf course.
[Correction: four sample plots included portions of the golf course.]

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MEETING NOTES

TF: Why include the areas with buckthorn?
Response: We didn't know it was there. It's a random plot selection in order to create the 5% representative inventory.

The locations of the survey plots are intentionally random. Removing buckthorn is already in Fresh Pond's management strategy. As we get into this, we will get more precise in the questions we are asking of the data- so will evaluate whether it makes sense to remove buckthorn from the inventory data when we're creating these analysis graphs.

Conditions of Trees in all Age Classes:

A question of whether mature trees are declining: should we be worried? The data shows us the mature trees are fairing as well as the average. The arc of mature/young is in a good percentage. However in specific areas some trees skew the data in some way, such as buckthorn at Fresh Pond or London Plane trees on Memorial Drive.

Trees by Genus:

The chart shows the 20 or more occurrences of each genus. Interesting things to come out: Acer is at 61% of good condition, Norway is dragging the average down a bit (57% in good condition). We thought the maples were doing better in the city. We need to consider what trees are not planted any more, we have to understand that level.

Prunus (Cherries) and Malus (Crabapple) are lower in the graph, doing less well – also doing far down on the Earthwatch report. Common trees to plant underwires- so if both are not doing well, then we need to take a look at what is growing underwire.

TF: Both are also short-lived trees (where maybe doing well when first planted), maybe look at age class.
Response: Yes, this goes back to the question re: whether commercial trees are younger. Some of these graphs provoke further questions that need additional analyses.

Fraxinus (Ash trees) only 35% is in good condition. This is before EAB comes in, so this tells us the ash is very susceptible to EAB.

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EAB:
11 suspected occurrences found in the survey. Ash trees make up 5% of the total canopy of the city from AES layer.

David Lefcourt on EAB:
As a member of the Municipal Society of Arborists, the EAB has been a hot topic starting around 2002 especially because ash is a high percentage of the population. The initial thought was to cut down ash, but researchers realized it was cost effective to treat rather than remove. In 2012 EAB was identified in Dalton, MA, so shortly after he put together a plan to treat. He surveyed all 800 ash trees in Cambridge and 50 were in poor condition and were removed. Then broke it up that every year half the population is treated. It's difficult to use chemicals in urban environments so Cambridge is using an organic treatment. Each tree has 2 doses. 2 weeks ago they found a beetle in a trap in Raymond Park. Green traps at 14 locations in the City. Started monitoring 3 years ago, but now switching to tracking mode. As they see the population grow, will shift to treating ash every year. Somerville also identified around the same time. Boston found EAB 4 years ago. 20 years ago, there was a huge decline in ash population. No one knew what it really was. When they decline they become very brittle and falls apart. A lot of arborists don't like ash because they are very problematic.

EAB goes after all ash. Blue ash is the most resistant but we don't have any in Cambridge.

Public comment: Are homeowners aware? Is it useful to get the word out through contractors?
Response: City will pursue this option.

Pests:
2% of trees had pests/diseases. Overall forest is healthy in terms of pests/diseases. We did not break out lethal vs. nuisance.

Climate Modeling

We are in the first phase of the climate modeling. We aim to understand what is the current condition of the canopy in Cambridge and what will happen with climate change. First, we need to understand the composition of the forest and the mortality rate.

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In the modeling diagram that shows the process, the inputs of the model are on the left, such as citywide tree layer and pest occurrences and the outputs are on the right. We looked at the literature to see how tree species will react to these events.

We'll use the model to establish the baseline for the effects of climate change on the forest assuming no preventative measures. Then we'll evaluate management options to find effective strategies to address challenges shown in model.

TF: Are these the only inputs? How about the wind?
Response: Wind will affect the selection of tree species.

TF: Establishing baseline, what does that mean?
Response: If we did nothing, how would the urban forest look like?

To determine the mortality rate, the trees in urban conditions have a problematic environment. According to Earthwatch study the survival rates are 96.7% for young trees and 90.8% for old trees.

TF: The mortality rate is low given the years a mature tree live. The annual survival rate is high, I am surprised.

Q: Is Earthwatch report about Cambridge?
Response: Yes.

We tried to find what criteria affects the mortality rate. Differentiating the age and tree condition and also street and residential trees.

In 2012 City of Cambridge started working on CCVA, and in 2014 on CCPR about how to mitigate extreme heat and flooding. In 2012-2013 Army Corps of Engineers studied urban forest in relation to flooding but the climate modeling was not yet complete for Cambridge.

Temperature Projections:
We want to be consistent with CCVA. Recap of the temperature projections from expert judgments, specifically designed for the city. Gradual increase, as the new normal. In our projections, more extreme events such as heat waves are expected. Temperature increases – mean annual temperature by

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9°F by 2070. Heat wave defined as three consecutive days greater than 90 degrees. Calendar graphic: nighttime lows not being low enough, second day becomes worst.

The increase and severity of temperatures affect the pests. Bartlett's experts have assessed what is likely and when that would happen. In terms of temperature increase, we need to look at the hardiness zones for the species to evaluate whether species will decline. For example, Aspen have pretty low range.

There is a difference between trying to model pests and diseases than assessing the tree conditions. For these we are working with a probabilistic model rather than a spatial model.

Extreme event - Precipitation Flooding:
City will experience more frequent and heavier storms and more precipitation in the future. We want some spatial correlation where the highest flooding is. Design storms – used to evaluate what types of storm infrastructure should be used. 10 year storm has a 10% chance of occurring. From the CCVA work, we know where the flood-prone areas are and can evaluate the species in that area.

Addressed frequency in this way:
25 year storm of today will be the 10 year storm by 2070
100 yr storm of today is more like 25 yr storm of 2070

Owen: There are maps in CCVA that indicates some locations are more vulnerable to flooding.

TF: Length of time for trees- some can survive a certain length of time. Problem with modeling 24 hr storm event?
Response: We will look at drawn down time for flooding.

TF: Any historical record of what trees were in the Great Swamp before that might potentially suggest species that would do well in the flood-prone Alewife areas?
Response: We're not aware of what species were there historically but will look to see if there were any surveys made.

TF: These graphics seem fatalistic- what can we do?

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MEETING NOTES

Response: We need to look at worst case to see how we can prepare.

TF: What does the probabilistic model mean for us?
Response: It tells us what percent of a species is likely to be present in 2030, 2070.

Extreme event - Storm Surge Flooding:
Flooding in the east side of Cambridge is not overland but rather through pipes, through the infrastructure. The flooding in Alewife is coming from the projected overtopping of the Earhart dam. As this is a regional issue of concern, we may decide that it would be addressed by 2070. If we decide the flooding from dam will not be taken into account- will need to make decision.

Extreme event – Drought:
There are a lot of uncertainties of how drought can impact Northeast and impact on certain species. We're drawing from the best available resources.

What about other climate risks? In the case of an ice storm, there are some species that will be more susceptible. Trees on shallow groundwater are more susceptible to hurricanes. Species suggestion in terms of material strength.

TF: Thinking about seasonal events, such as ice storm after flowering or before the leaves drop in fall?
Response: There are some expected catastrophic events, so part of the plan should be emergency plans.

Owen: One of the interesting challenges is Alewife. Fresh Pond water table is artificially elevated to avoid contact with groundwater. Something to bear in mind, as the elevated water table means adjacent areas are at risk.

TF: In relationship to mortality, how do you correlate the lifespan when you think about these events? You need to think about gradual change, there will be a new world. That relationship of lifespan and canopy loss is complex.

TF: Adaptive management is necessary- what you recommend for 2030 might be different for 2070.

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Owen: CCPR – appendix B shows the ambient temperature on a street in 2070, speaks to existing street that has 15-20% canopy. 30% canopy has 3.6 degrees decrease.

TF: Mt Auburn has been doing phenology studies – more mature trees and microclimates.

We're looking to identify what are the big risk factors? Then from there we will develop planning strategies. These will also be evaluated according to their cost/benefit.

Urban Forest Survey

Deanna from Conservation Law Foundation: We have been working on the survey with the city in recent months. We are finalizing it and we will post it next week on website, as well as asking help from organizations. We encourage the Task Force to help spread the word. It will be translated in 7 different languages. 5 to 10 minutes for people to fill out. Will be asking for people to send out the survey, it can be done on phone, iPad etc.

TF(Suggestions for the survey): Can be done at the Danehy Park Day
Use E-line Cambridge newsletter
Schools newsletters
First in person survey – senior citizen center

TF: Is it limited to residents?
Response: No, but has to have an interest in Cambridge.

Public: Goal for the number of recipients?
Response: 1000 responses, anyone can take it

We will send an e-mail to the task force. Next Thursday (Sept 6th) it will be online.

TF: What is the purpose?
Response: Purpose of the survey is to know how the people are thinking about the urban forest to make recommendations. It is like market research. Survey will give us context to refine the set of national best practices.

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Public: The answers will be informed by the level of knowledge
Response: Yes, we will get a sense of whether people know about trees by asking them about the benefits of tree. We will be able to pick up attitudes on trees.

TF: Is it for a certain age?
Response: It is for everyone.

TF: Can they add input on the questions?
Response: Already vetted and ready to distribute.

Met with Community Learning Center with people not native speakers to help refine the language and questions.

TF: Installation at the library? Places where people gather.

TF: Some little flyer?
We are thinking to run the survey until the end of December.

TF: How to deal with the pixelated nature of Urban Heat Island map? One pixel can be a habitat, it is not very specific. Inherent limitations of urban heat island model- not very accurate (hard to predict ambient air)- based on land surface temperature (Landsat) – inherent limitation to resolution – 30'x30'. Scale differences between heat island and scale of tree (microclimate). Extreme vs. gradual.
Response: There are some limitations of UHI model, it isn't very accurate, based on landsat data, its resolution is 30'.

TF: Relationship between density and canopy- but also so much to do with air flow. Harder to understand in denser urban areas.
Urban microclimate and urban heat island have a huge difference. The denser neighborhoods tend to be hotter neighborhoods. It is also about how the air moves, the relationship about where you stand, where you move.
You don't see the microclimate. But it does impact how cool or hot it feels.
It is going to be hard to work with dense neighborhoods.
Response: We will consider the human scale in our proposals. The proposal phase will involve making recommendations at various scales, from city-wide planting strategy to street level.

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4. Public Comment Period:

Speaker 1: Wants to have ability to not answer a question on the survey. Would like to include a question about concern on loss of tree. Character of development of commercial and residential development – should be included in the impact on mortality – maybe provide alternative approaches to zoning. It didn't seem like development and zoning is part of the climate.
A: We are looking at development patterns- not part of the climate modeling. CCPR will be looking into zoning (not part of this effort).

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Cambridge, MA 02139

ISSUE DATE
November 29, 2018

MEETING DATE
Sept 27, 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Master Plan
2953

RE
Task Force Meeting 5

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Reed Hilderbrand

Introduction
Opening remarks from Owen O'Riordan, noting that the format would be a discussion around four topics: Canopy Cover, Species Diversity, Canopy Equity, and Human Experience followed as a public comment period.

2. Design Team Presentation
Reed Hilderbrand (RH) informed the Task Force of the design team's Parking Day activities publicizing the Urban Forest Master Plan process.

Preliminary canopy loss findings:
Average net loss of 31 acres each year since 2009.
Showed data from UVM 2009-2014 canopy loss study
Showed preliminary 2014-2018 loss data

RH introduced three topics around canopy loss for discussion:
1. What are the primary causes of canopy loss?
2. What will it take to reverse the trend?
3. Where are the most opportune places to act?

RH noted canopy loss by land use and highlighted greatest loss was in residential areas.

RH reviewed several areas of large loss to note likely causes:
-City wetland project in Alewife. RH pointed out that loss of trees likely offset by benefits of improved stormwater function. Example of compromises required when urban space is limited.
-North Point development
-West Cambridge residential neighborhood
-Central Square area

RH noted tree ages in inventory roughly evenly divided between Young, Semi-mature, and Mature. Over 60% of City trees in Good condition and over 25% in Fair condition.

TF question: How often do LiDAR flyovers?
Owen: Anticipate doing flyovers every 3 years.

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MEETING NOTES

TF question: Where is loss map by Land Use?
RH: Map is not legible at the City scale. Will revisit at neighborhood scales.

RH noted other cities' canopy goals for comparison.

RH noted that 4,300 3" caliper trees would, after 20 years, equal 31 acres of canopy

RH noted that 5,633 3" caliper trees would, after 20 years, equal 1% canopy increase for the City

RH reviewed potential plantable area by land use for each neighborhood.

Task Force comments on discussion topics [preceding number indicates topic being referred to]:
1. Possibly due to maturing trees in residential areas, referring to UVM study findings.
1. Likely multiple causes of loss. Re: wetland construction in Alewife: what was the % canopy loss created by this project? Maybe remove that as a cause because it's an outlier.
1.Is there a relationship between new house sales/building permits and canopy loss? Should be investigated.
1. Zoom in to one area and look at human scale – go door to door? Google Earth shows canopy history.
1. Overlay other data to determine causality? Front yard vs. backyard? What are the data points? Post storm, downed power lines, power company pruning areas (anecdotal information)
1. Compare gain/loss maps with 2009-2014 information
2. How often would LIDAR be taken? Shorter increments may yield more information
1. How to visualize land use/canopy? Very difficult to be legible
2. How do you engage landowners?
1. Data covers the drought in 2015 which would have had an indiscernible pattern
2. Focus on existing trees
-3. What are the variables in the model that determine tree health... tree canopy
-3. Parking spaces in the street?
-3. Collaboration with DCR
-3. Brainstorm about gains-
-3. How does plantable areas correspond to equity/heat island areas?
-3. Is there a way we could correlate health with canopy cover percentage?

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Equity question
-3. Plantable area per neighborhood/total plantable area calculation
-3. Could the top species the hardiest/toughest survivors?
-3. Could we assess canopy growth by species using AES layer?

RH noted potential species diversity targets and what species are above those metrics.

Species diversity topics for discussion:
1. What diversity targets should Cambridge set?
2. And how can the city best achieve that goal?

2. Could species recommendations be provided in special permits
1. Could have unintended consequences for canopy by diverting from common species such as oaks
1. Could we be more broad in our species recommendations – Robinia, Catalpa
1. Southern species – sweetgums
2. Species diversity limited by nursery availability so takes a lot of planning in advance. Contract growing? City work with nurseries?
2. Species recommendations may differ amongst neighborhoods (East Cambridge vs. Alewife)
1. Clumping trees and different forms that provide canopy cover beyond typical street tree
2. Understory trees under shade trees
1. 80 species from state (TF member may be able to share)
1.NYC tree list – compare with their list. What lessons to be learned?

RH discussed vulnerable populations generally living in denser neighborhoods that tend to have less canopy

Equity topic for discussion:
1. What can Cambridge do to reverse the canopy deficit in vulnerable communities?

-Urban heat island studies that look at extent of cooling from parks
-Creation of parks?
-Incentive open space area ratios?
-Would like to look at owner/renter and canopy cover ratios
-Difficulties in zoning changes – real estate values
-Incentives for connecting areas

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MEETING NOTES

-Traffic calming and canopy cover synergies
-Human scale – looking at City mapped public trees

RH pointed out heat island areas and CCPR cool corridor strategy as one starting point to address these areas.

Planting strategy topics for discussion:
1. Where should the city focus resources in order to most effectively enhance human comfort?
2. Where street trees can't be planted in ideal conditions, are there alternative strategies?

1. Overlay bike routes with heat island map
1. Mass Ave is a unique environment – relationship between commercial businesses, lack of residents to care for trees, conversation with the businesses? True opportunity requiring investment. Sponsorship/signage of trees. What would it take to create a plan?
1. Corporation strategy
2. Utility constraints on many of the major streets
1. Above ground plantings?
1. Tree in a median on Mass Ave (like Broadway)? Competing uses for that space
1. Binney St – looking to remove median, place bike path and place row of trees
1. Placing spigots on Mass Ave? Availability of water

RH showed updated draft decision support framework and asked Task Force members to provide any feedback on this guiding framework.

4. Public Comment Period:

Attendee: Largest cause of loss is removals in my observation. You're not addressing this.
Owen: We can certainly look at that.

Attendee: loss on slide 13 due to microburst in 2017.

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ISSUE DATE
Dec 19, 2018

MEETING DATE
Nov 29, 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT
Urban Forest Master Plan 2953

RE
Task Force Meeting 6

ATTENDEES
City of Cambridge Task Force
Reed Hilderbrand

Opening remarks by Owen O'Riordan
Owen noted that the reason for the cancellation of the last meeting was that the LiDAR data set that the consultants are basing their canopy analysis on needed to be reviewed for accuracy. The Urban Forest consultant team are the first ones to use it in the city, and we wanted to be sure that we're proceeding with correct data. The City is now satisfied with the data set.
In addition, each analyst has their own approach to creating a canopy layer, and the City wants to have a consistent methodology for the canopy change data. Consequently the City has asked UVM to produce a 2014-2018 canopy change analysis which will complement their 2009-14 analysis. The City expects a conclusion from UVM in late January or early February.
However, UVM's analysis won't change the overall finding that, from the perspective of land use, the recent canopy loss is mostly in residential areas.

RH reviewed the project schedule:
In the overall project timeline, we are done with the research phase, and climate modeling has just ended. We have some broad recommendations to review with you tonight.
We have been doing a lot of fieldwork such as collecting the soils, lab analysis, etc. which we will share with you tonight. We have also been coordinating with CCPR and Envision.

Design Team presentation outline:
- Soils analysis
- Climate model
- Response strategies
- Planning synergies

Soil Sampling

RH presented the results from soil condition analysis. Sites that were sampled were all public sites: street tree pits and several parks. Overall, the soil conditions for street trees are fair to poor in the sampled sites, with high levels of compaction, low nutrient cycling, and poor drainage characteristics. The team expected below optimal results as public plantings endure significant foot traffic.
These soil conditions can limit tree vitality.

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MEETING NOTES

TF: What steps can be taken to improve the soils?
Some limiting factors can be remediated through management practices.

The sites are scattered around, to distribute them around the city. The black circles show the sample sites, we labeled them going from west to east.
We will not go through all the sites, but rather will review a few sites that are examples of the challenges faced. We will make all the test results available online.

Danehy Park soils tend to be poor, because it is artificial, a capped land fill, and not a natural soil profile.
Fresh Pond was the best site, a forest floor where the soil was very healthy.
Cambridge Common was compacted, because of the foot traffic. Along the public path, relatively sandy and dry.

Initial Analysis Result:
16 of the 20 sites have severe compaction. 12 sites had low nutrient levels and little to no available nitrogen. 7 sites showed poor drainage. Generally, there was an inconsistency in the texture, with presence of construction debris.

Possible remediation measures for limiting factors:
Compaction - Aeration can loosen compacted soils. The addition of compost over time can also loosen soils.
Low nutrient levels - Compost aids nutrient cycling.
Poor drainage – Best to address prior to planting but augering dry wells can help post-planting.
Texture - Difficult to address post-planting.

TF: How does aerating work?
Response: Compressed air introduces air pockets.

Sampling Sites:
One of the sites was in Alewife. The soils sampling sites were selected to align with the tree inventory sampling sites to correlate tree health with soils conditions. They took 5 samples from each site and combined the topsoil to create a representative sample of the area.
In this case, tree was planted high and it had burlap still on it from the nursery.
This slide [11] shows an example of the soils consultant summary page and

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the soils report pages.

Second site was a street in residential area of West Cambridge and is an example of poor drainage. Heavy wet clay was found 24”-36” down in the tree pits.

Third site was on Mass Ave, between Harvard and Porter Squares. Large and small trees and an empty tree pit were sampled. The soils were all very dry and compacted, no moisture at all. The samples were taken in August.

TF: We had lots of rain early this year. How about the salt levels?
Response: Only one site showed high salt levels. However, testing again in the spring would be good as the road salts may have washed out of the soils by August

TF: Is there a history of soil remediation of street trees?
Response: Our soils consultant has experience in a wide range of soils management.

Climate Model
The base assumptions behind the climate model were reviewed in previous meetings. We separated it out to two:
1- Baseline: Evaluating the threats of pests and disease along with increasing temperatures
2- Extreme event scenarios: a 100 year flood in 2030 and a moderate drought event that would reduce the urban canopy.

The increased threat of pests and diseases associated with a warming environment was found to have a significant impact on tree mortality. Drought was found to have a potentially moderate impact on the existing tree canopy.

The findings from this simulation will inform city-wide tree species recommendations and include location-specific selection criteria. We will see what species are doing well in specific locations, such as flood tolerant species in flood prone areas.

Baseline Scenarios:
The climate scenarios look only at gross loss, meaning we’re not accounting for replanting as part of the model. We are starting with the canopy today

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and projecting out to 2030 and 2070. With a small mortality annual rate, you still get a great loss in 2070. With 3% annual canopy loss, you have about 20% of the canopy remaining in 2070; with 4.5% and 6% annual loss, you have less than 10% canopy remaining. When you add the climate change effects, we see even higher losses.

Pests and Diseases:
For each species, we assigned either below average, average, or high threat according to the vulnerability to existing pests and diseases and those projected to move here as the climate warms.

Temperature Increase: Each species’ hardiness zone is used to understand how the temperature change will effect the trees. In 2030, any species outside of zone 6b, will be removed from the model. This includes Black Ash, Bigtooth Aspen, Pin Cherry, Balsam Fir, Red Pine, and Tamarack. Only Red Pine has significant numbers in Cambridge (4.2 acres).
In 2070, any species that are outside of the 7a range, (11 species) will be removed.

We’re not anticipating adding any southern species to the proposed species list, because extreme cold events are still expected to happen at least in the near-term future.
We are just looking how the current canopy changes with the current conditions here.

This slide [21] shows a part of the pests and diseases spreadsheet. We looked at the average lifespan of species, hardiness zone, flood and drought tolerance. Pests and diseases are organized according to their distance to Cambridge (250 miles, 500 miles and 750 miles). The closer ones may appear in the city by 2030.

This slide [22] shows the averaged result of the baseline scenario model run, 41.4% (+/-2%) of the 2018 canopy remains (gross loss assuming no replanting). This results in 10.5% total canopy cover in 2030. When compared to the baseline mortality loss (without higher mortality from pests, disease and higher tempratures) of 56% remaining canopy, this is an additional decrease of 26.1%. We don’t want to underestimate the loss the City faces, that is why we want to show these numbers without replanting.

In terms of common street trees, honeylocust and zelkova perform higher

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than average. Best performers are exotic species and small, short lived species.

Extreme Events:
Getting to the extreme events that we modeled, this slide [24] is a map of tree condition created by AES from LIDAR. They classified species conditions by using a leaf reflectivity ratio. For each individual species, we were able to generate the tree health condition correlated against condition ratings provided by Bartlett's 5% tree inventory. Purple is the trees in poor condition, orange shows fair condition and green shows the good condition. Some major avenues are notable for having poor and fair trees.

TF: Street trees are large trees. Does it measure the size of trees?
Response: No, just the conditions.

Moderate drought event is not a likely event, it happens once in 30 years within the 2035-2064 timeframe. But we don't know how the frequency of these events will change after 2030. Droughts are defined as deficits of 10% or more in monthly soil moisture relative to the climatological mean. Moderate drought duration is approximately 3-6 months. We actually experienced a moderate drought event recently in 2016. During a drought event, in the lower bound (less severe) scenrio, drought-intolerant trees in poor condition will experience mortality. In the upper bound (more severe) scenario, drought-intolerant trees in poor and fair condition and moderate drought tolerant trees in poor condition will experience mortality.

In our lower bound map [26], we would see additional 1.9% reduction in canopy from the 2030 baseline scenario. It is reflecting 2018 tree canopy, drought tolerant map. It is not a spatially explicit event.

In the upper bound map [27], there is 9% additional mortality from the 2030 baseline scenario, which is pretty bad. How do we adjust to the drought scenario?

In the table [28], we are representing the worst performers (species) in lower bound and upper bound. Pin Oak and Littleleaf Linden are common species in Cambridge. In both cases Hemlock does poorly. Red maple, Crabapple, Cherry are notable for higher losses in the more severe (upper bound) event.

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TF: What is the difference between American hornbeam and hornbeam?
Response: We need to check that, it might be a question of genus vs species. Trees in the data set that can't be classified down to the species level are listed by their genus.

TF: This is applied on to the baseline scenario. We see the impact of pests and diseases plus the drought?
Response: Yes, we're looking at what is the potential large scale impacts of these stressors.

We are not presenting the results for the flooding this month as we're still finalizing the conclusions. We're modeling a 100 year 24 hour event in 2030, and this map shows flood depths for the event. As you can see, one third of Cambridge is in Mystic River watershed, and other two thirds is in Charles River watershed. Flood intolerant trees will be removed from the lower bound scenario. Flooding impacts will be spatial (location specific) unlike the pest, disease, and drought impacts.

We have been told for 25 years that the canopy is declining in the Northern Forest, they have been measuring it and this is not a prediction. This is 'do nothing' scenario. These are what we intuitively knew. Think about how many cities in northern are not doing anything. This defines the leadership problem for us.

Response Strategies

This slide [31] is just the summary of where we left off in September. Today, Cambridge has 25.3% of its land area covered by canopy. Cambridge has had an average net loss of 31 acres of canopy cover every year. At this rate, canopy cover will be 16.2% in 2030. Factoring in climate change, it may be 10.5% in 2030 but with a moderate drought, it could be 9.5%.

How do we respond to this?
Stem the loss of existing trees and **Grow the canopy** by planting new trees. These are the two choices for how to spend our time and energy.

To put the decline that we've been looking at in a larger context, here's a graph [33] of forest cover and population change in New England which shows us that there is a dip in mid 1800s as the clearing of forest for farmland peaks. There's a secondary forest decline after the 1950s as the

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suburbs spread out into wooded areas.

We've annotated the next graphic from UVM's 2012 canopy study, we call it the champagne diagram. It shows the percent of existing canopy by property (residential, single family) and when that property was constructed. Properties with homes built around 1920 have unusually high percentage of tree canopy. These trees are now likely reaching maturity. Development tapered off after 1930 so we can surmise that the residential canopy will also begin to taper off as those trees age. Incredible bursts of planting between 1850-1930. The bars at the top represent a hypothetical tree with a hundred year lifespan to help illustrate the canopy decline that results from the tapering off of residential construction.

TF: It's interesting to note the decline of tree planting in relation to the rise of air conditioning.

RH: That's a good point. Another correlation is the rise of residential development with strong tree canopy after 1870 which was the time of the City Beautiful movement and the creation of parks nationwide, arbor day was started in 1872. It is useful to think what is happening now in the culture, social dimension, how we situate our project culturally.

In thinking about growing the City's canopy, we were also intrigued by the parallel with retirement investing. This is about growing canopy, when do you start growing canopy. As starting to invest a small amount earlier accumulates in time, the same is true for tree plantings and canopy growth.

For a mortality rate of 6.5% a year, that is the curve you get. The table shows year over year canopy growth and the remaining canopy from 2018. When you plant 2,500 trees a year, you still are fighting against the time. But if you stem the loss to 3% a year, you overcome the loss. This is not only the city trees, but citywide. If you plant 5,000 annually for the first 5 years, and continue planting 2,500 trees a year, you would get a canopy gain. Maturation of the trees and climate change impact is huge, whether this is realistic or not.

Strategy Matrix:
Here is the decision framework [40] which we've reviewed previously. We are using this framework to structure a matrix of strategies [41]. In the strategy matrix, we have policy, planning, practice and outreach across the

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top. We have a set of goals on the left side and a couple of categories. Within the strategies, we are going to walk you through a couple of these. As we go down, it focuses on specific conditions or areas. We're focusing on planning and design today. Policy and practices will follow.

Neighborhood Case Study:
This is a case study about how you start to act. The Wellington-Harrington neighborhood has overall 16.9% canopy cover and R.O.W. has 29.3% canopy cover. In this study we started to plant new trees on all the streets with sidewalks with 6' width or greater. This allows us to plant 645 trees (with 30' spacing between trees). After 20 years we have 38% canopy cover on R.O.W. but the overall canopy cover of the neighborhood only increases to 20% (assuming new trees have 20' diameter canopy after 20 years). This exercise allows us to see the limitations of relying on City plantings alone.

Looking at where else tree could be planted beyond City- owned property, "plantable areas" are overlaid on to this map [45]. Plantable area does not include buildings and sports fields but parking lots are included. Light green shows the existing canopy and dark green shows the plantable areas.

In terms of land use [46], most of the area is residential. To increase the overall canopy cover more, we need to plant in residential yards, commercial areas etc. If there are opportunities, they may be small opportunities but we are just trying to recognize, if there are limitations on ROW, what are the other ways to plant? Privately developed open spaces can be plantable with policy change but not the densely used areas. Another strategy is to create asymmetrical streets with new plantings.

Where are the plantable areas in the city? Citywide, the opportunities for planting are greatest on residential and open space land use types.

Streetscape Design:

We are trying to catalogue some of the conditions and strategies. City can look into these and decide where to plant.

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Typical narrow commercial streets
Parking or one lane may be taken out from some of the streets.

Major commercial avenues
Asymmetrical streets or boulevard streets. Taking the parking off the street.

Parking lots
There are quite a lot of surface parking lots. Some of these can be planted.

We had an interesting conversation with our ecological consultants, AES, thinking about an ecological approach to planting in cities. This graphic [56] shows the difference in tree coverage in a forest and savanna. In terms of canopy cover and tree spacing, the city is more like a savanna than a forest. But urban trees are generally forest species, used to growing in those conditions. There might be some opportunity here to rethink how we design urban plantings to better align planting conditions with those of a forest, such as grouping trees, not standard spacing, multiple stories of vegetation. These plant groupings might help stem loss and increase the vitality of the individual trees.

Planning Synergies

Where do you plant to enhance shading and cooling? We set up a category to focus on aligning our work with Envision Cambridge and CCPR work.

These are Envision plans [59,60] for an open space network and showing major corridors.

This map [61] show the existing and proposed biking network from the Cambridge City Bike Plan. Senseable City Lab also has the data on most used running, cycling and walking routes in the city [62-64].

We sketched out an initial concept that overlays all these plans to create a network of green corridors that link squares, transportation networks and open spaces. Primary bike routes, bus routes, bus stops, open spaces, primary and secondary set of streets, arteries, along the waterfront participate in this network. This helps us to plan where to prioritize plantings to build off the work of these other planning efforts.

We've also been working with the CCPR team to develop a tree planting

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detail that incorporates stormwater storage.

Owen: Bike lane on western avenue is porous. Overflows to catch basin. The trees are thriving.

New treatment of stormwater that also addresses urban heat island.

TF Comments:
TF: There is a permeable pavement that goes along the street, in Boylston in Boston, trees are doing well.

Not small proposition, a strategy to grow health trees over time.

TF: Alewife area, rapid development, it will be all constructed before we finish our meetings. How can we have an impact?
Response: We can significantly improve it by proposing green infrastructure and canopy build out.
TF: There is no rules or structures for the development to plant trees.

TF: Envision team is looking to Alewife, the goal toward zoning, thinking about shade and open spaces. We can help them with language, what we are advocating.

TF: There is a top down approach in the city, it is about communities, climate change perspective, how can we communicate this with people?

TF: City needs to demonstrate leadership. "We plant well", "we are the model", set the example for what people need to do.

TF: But there's a problem in the City of depending on top-down thinking to solve problems. We should be developing an understanding within communities of the need to combat climate change, a culture of climate care.

TF: We should cultivate ambassadors, identify who in the City are themselves cultivators.

TF: Particular education tools, who do they appeal to? Recommendation to the city, middle school kids need to be learning these etc.

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TF: Pilot project, a stretch of Mass Ave, designed by RH ?
Response: Western Ave recent construction demonstrated new strategies.

TF: All the stormwater, ripping up the sidewalks, what it means for the neighborhood. East Cambridge dense neighborhood, so tiny open space, it is valuable to this effort.

TF: Yards are being infilled, not planted anymore, new condos and housing. Creating plantable space. A lot of asphalt in people's yards, how can we get it planted?
Response: It is about incentive building

TF: The strategy matrix could be simplified, boil it down, reduce loss, increase gain. Some categories or strategies in matrix are repetitive.

Public Comment Period:

Speaker 1: City Councilor who advocated for the creation of the Urban Forest Master Plan. Thank you for the amazing work. I read today about the ongoing biomass loss of insects worldwide. Goals from Envision, urban form didn't include the trees. Setting the context,
I met with a property owner who was proposing to cut down a tree for a new curb cut. He didn't know the 20% loss that we are having. How do we get more people to understand this? A complicated system, it is hard to predict. We need to do "safe to fail" experiments. City has done some great experiments, biochar for instance. If it turns out that it doesn't help the trees, it doesn't kill the tree either.

Speaker 2: Sarah Bell, Russell Aprtements, elderly house on Mass ave, being renovated. The city should use it as an example as a green space. Pilot projects on city property. Blockwide, we need to invest in green spaces. There needs to be a model, businesses with green and trees.
Leading is important, change in the strategy of the city.
How much of the canopy is on ROW?
Response: 20% on ROW, 40-50% on residential

Speaker 3: Question about the number of trees needed to be planted, and

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the loss rate? Previously you had showed that we need to plant 4300 trees just to keep up with loss and then 5600 trees to get 1% new canopy cover, and now you're showing 5000 trees?
Response: Yes, the 3400 and 5600 numbers from the last presentation were an exercise to understand how many trees would be needed to stem loss and create 1% canopy cover but they were not specific proposals.

Speaker 4: Thank you, I learn a lot each time. We're attracting new businesses which in turn requires denser residential development. How do we balance the pressures aligned against creating/reserving space for trees?

Speaker 5: In Alewife we have giant blocks, light industrial with large trucks, flood prone area, not a lot of room for trees. What is the target canopy cover?

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ISSUE DATE
Jan. 28, 2019

MEETING DATE
Dec 20, 2018

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Master Plan 2953

RE
Task Force Meeting 7

ATTENDEES
City of Cambridge Task Force
Reed Hilderbrand

Opening remarks by Owen O'Riordan:
Owen noted that tonight is the first of a couple of conversations about regulations and the Task Force will be given homework about this topic for the coming months. City has given some of the information on regulations to the team that has been gathered so far. Owen wanted to discuss a particular project; 55 Wheeler Street, a 6 acre site in the west of the city, adjacent to Fresh Pond. There was a special permit issue associated with that project in December 2017. Tree Ordinance compliance needed to be revisited specific to the courtyard. The developer visited the site with the City the day before the meeting. City needs more details before issuing an updated letter to the community development department.

RH review of the project schedule:
The team is going to focus on the Policy category tonight. There are also overlaps between the different categories. In the following meetings, we will talk about other categories.

Design Team presentation on policy strategies:
At the last meeting, RH framed the way we think about response in two categories: Stemming the loss of the existing canopy in Cambridge and growing canopy by planting new trees. The matrix developed about strategies and responses were also shown last time. On the left of the matrix, there are actions in response to certain conditions and at the top, there are strategies, which are Policy, Planning/Design, Practice and Outreach/Education.

Policy seems to be top-down in its nature. Even in a policy strategy, we need to be thinking about all of the categories of landowners in City of Cambridge. The graphic on slide 4 shows the amount of plantable area by land use. The plantable area model shows us where there are opportunities to plant new trees. It is a multi-pronged approach, no one party takes the responsibility. We are going to start talking about what the city can do in regulation but that will eventually connect to all these pieces.

We are aware that when we are talking about changing regulations, there are always competing priorities. If we expand the jurisdiction of some of these regulations, we might encourage tree planting. If you increase the penalties, you have to be careful about impacting the vulnerable

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populations. Preserving open space is important. Enhancing enforcement may have impacts on staffing. When we talk about the change of regulations, we need to think about all of the impacts.

Tree Protection Ordinance

Currently the Tree Protection Ordinance applies to development review that happens on businesses, industry, institutions and residents depending on the scale of project. So, when we start to make changes, it has a ripple effect all the way through.

TF: Do we have a copy of what the current ordinances are?
Response: We don't have those to handout but we will talk about those. We will first talk about the base before talking about the changes. Existing ordinances can be found online in the Cambridge municipal codes: Chapter 8.66 Tree Protection.

Today, trees in Cambridge have protection only when they are over 8" dbh (diameter at breast height). Those trees require mitigation if they are being removed as part of new development projects. This applies to certain multifamily, townhouse and other projects requiring a special permit from the Planning Board or development projects of 50,000 square feet or more. Other thresholds apply to different projects and sizes.

Three approaches that strengthen current Tree Protection Ordinance:
- Expand jurisdiction
- Increase deterrence
- Enhance mitigation

Strategies for expanding the jurisdiction:
Redefining the "Significant Trees"
Adding "Exceptional Tree" protections
Adding triggers to expand the application of the Ordinance
Expanding to all properties
Redefining the "Significant Trees" :

The difference between a 6" dbh tree and 8" dbh tree is not huge but when you change the definition of Significant tree to include 6" and over, you would expand the number of trees that are protected by 49% (estimated).

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Adding "Exceptional Tree" protections:
There is also "exceptional trees", which can be a giant tree or a unique species, in a particular location in the city that is important or with a historical significance. If we add this category, the city would have to create a database of where these trees are. In some cities, it is prohibited to remove the exceptional trees. If they need to be removed because of a hazard, a larger fee is associated with that. Or a developer has to prove that it is absolutely unfeasible to protect that tree and still develop the site.

Adding triggers to expand the application of the Ordinance:
There are certain things that trigger the tree protection ordinance. It is tied to the size of the project, number of trees to be removed and the area of new impervious surface. One could lower the project size threshold, but there might be some small size projects that you wouldn't want to overburden.

Expanding to all properties:
Data shows that the majority of canopy loss is not happening on development sites but on private residences. Many cities across the country, and some locally, have expanded their tree protection ordinances to apply to all properties including those that are not currently being developed/redeveloped. There are pros and cons to expanding the jurisdiction to all private properties. There is this question of who you are penalizing, and the question of the cost.
This has been done in a number of different ways and in a number of cities, so there isn't one standard for Cambridge. Many people reference Seattle as a good example, with a strong Tree Protection Ordinance. They passed their Ordinance in 2008. They protect the trees in private property but they also have an undeveloped land category. Their threshold is 6" dbh. They are now asking for a single consolidating permitting system.

TF: About the slide that shows the land use types, specific to Cambridge, there is a category of residents that is a developer, (condo developers) that are temporary residents/owner of that property, who builds a property and sells it off. This person who is not really a resident but just a temporary owner is causing a lot of tree loss. Are there any regulations that address that?
Response: That is related to what we were talking about, mitigation requirements in protection during the development process. In that scenario, Tree Ordinance would kick in as long as that project meets the

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large project threshold. So, it gets to this idea of how you could encompass that kind of project. We need to think how often that happens in smaller properties, what the appropriate size of development should fall under the Tree Ordinance.

TF: I have a hard time with regulating small developers more stringently. Zoning Ordinance in Cambridge for housing is already very restrictive. We can't rebuild the city that we have if houses were burnt down. It creates a lot of problems and the housing is very expensive. Personally, I feel strongly that the small developer should succeed over large developers because small developers create variety in the city. The other thing is, not all trees are created equally. In small residential lots, people need to have a choice about what they want. They can have trees or urban agriculture, there are so many things you can do. I would argue for de-paving and plantings than only trees because the urban forest is combination of things. We can be a little more creative with that kind of small lots to have some variety in the city.
Response: You touched on a couple of topics that we will come back to, such as how you value the trees, trees are not equal, etc. In the Zoning conversation, we will talk about some strategies, how we evaluate not only the trees but other measures as well.

TF: I want to disagree a bit. I think that protection of urban wilds is very important. There are several projects that I can think of. There are big and beautiful trees along property lines, along fences that were left alone.
Response: We will talk about overlay districts and whether there is a way of understanding priority areas for preservation of planting. But it is interesting to think about what category that can be.

TF: On the previous slide, it says the majority of loss is on private property. From my long term observations in the city, there are big developments with no trees.
Response: If we want to curb loss, we need to look into the private property to come up with some strategies as that's where the data shows the loss is. This loss is harder to see as it can happen away from public space.

TF: To back up for a second, why are we trying to keep the canopy, what is that we are trying to achieve?
Response: Because of the ecosystems services they provide: heat island, carbon sequestration, stormwater management, but also experiential

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quality. All of these reasons get at how we value trees.

TF: Regarding your initial slides about plantable area, it is an opportunity to keep the open space and avoid impervious surface to use that space to plant new trees.
Response: That is our second category, growing the canopy, and we'll get to that shortly.

TF: What is the difference between development project and private residential project?
Response: They overlap. Some of the residential developments are not covered by the Tree Protection Ordinance.

Owen: We haven't yet been able to differentiate causes of loss on private property. In the coming months we may be able to get at some causes by looking at building permits, residential sales, and increases in impervious surface.

<u>Mitigation as part of the Tree Protection Ordinance:</u>
To remove a significant tree, a property developer must either replace the tree on site or pay into the Tree Fund. How do we calculate that?
Current cost of mitigation is based on the cost of planting a number of 3" caliper trees, about $1,500 per tree, including the maintenance. There is little incentive for a developer to minimize tree removal or to replant on site.

What happens when you increase the mitigation costs?
One is to develop more stringent requirements for replacing those trees on site and the other one is to develop a more robust valuation process for off-site mitigation.

Currently, if you are replacing your trees, it is measured by caliper inch against diameter. If you remove 40" tree, you have to replace it with eight (8) 5" trees, when you are replacing the total diameter of tree. 5" trees over time will grow in size, but that's a small replacement at planting. There are other models than what we do in Cambridge, one is to replace the tree by area. That would mean sixty-four (64) 5" trees for the same 40" tree. In some properties you can't plant this many trees but there are different ways to handle where mitigation trees are planted.

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TF: How do you value a tree?
Response: Right now the City's valuation is based on the replacement cost for the diameter of tree(s) being removed. I-tree is a program that gives a dollar value for the ecosystem services of a tree. NYC Parks have their own customized valuation which is kind of a mix of these.
We will go through how a typical caliper inch model works. The cost of a 3" caliper tree is $1,568. You figure out the total caliper inches of your tree divided by 3. So, if we have a 36" tree, the value of the tree is $19,182.

In the other model, "weighted trunk area replacement value", we take the typical tree replacement cost ($1,568) and we figure out per square inch what is the cost to replace that tree. $222/sq. inch caliper and our tree has 1057.8 sq. inches. There is also species rating, condition rating and location rating. An arborist would evaluate these in the process. The same 36" Pin Oak tree in good condition and good location comes to $79,197.

TF: This is to pay this fee to the Tree Fund. I suggest another option, planting these trees in other locations in the city.
Response: We'll address this in a moment, yes.

Public: Is there anywhere in that formula that takes into account the age?
Response: It does not, it is an interesting point. But it is also very difficult to evaluate the age of a tree in urban conditions.

TF: There is an Ordinance Committee meeting January 9th. The urgency of the tree canopy right now is critical regarding how much we've lost and how long it would take to replace. I would ask the Tree Task Force to make a recommendation to the City Council in favor of a moratorium on tree removals until the Master Plan process is completed.

Response: If we were to increase restrictions on tree removals, there is currently limited capacity for DPW to have an oversight of that. Contractors are asked to describe the tree protection, the ordinance doesn't actually require any particular practices. We think that there is an opportunity to require increased offset from tree dripline to protect tree roots, also to require periodic site review of conditions to improve tree protection measures during construction, and to require city arborist/city engineer inspection prior to obtaining Certificate of Occupancy.

Owen: In City of Atlanta, they have 4 planners that look into tree

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applications, 6 arborists, 2 technicians and a separate tree planting department. As we look into more involved process here, that is a significantly onerous application. City of Atlanta is 33 square miles, whereas Cambridge is 6 sq. miles.

TF: So we are smaller.

Response: But still there would be probably additional staff required.

TF: I think we will find that there is going to be an interest in expanding what the City spends.

The next category is engaging with private property owners. Aside from the back of sidewalk program, the City doesn't have a way to plant trees on private property. Even within that back of sidewalk program, there are certain constraints. So, is there a way to do grants or some other program that distributes that money to the groups that can do planting on private property?

Owen: City cannot provide funding to private property owners. One could argue that there is a public benefit there but there is a legal question that needs to be answered. We need further clarification of the anti-aid amendment regarding providing public funds to benefit private property.

Seattle has a local non-profit organization that organizes neighborhood planting days with volunteers that are trained to plant trees. It is a very successful program but they found out that if you apply a cost to it, the participation rate decreases. It is important especially for neighborhoods where residents are not willing to pay for a tree but would be interested in having the tree.

TF: The state is currently contracting with private contractors or with municipalities or non-profits to do the planting because the quality of volunteer plantings is not great. State program Greening the Gateway Cities planted 20,000 trees in the last 5 years focusing on low-income areas. The program is state funding from the alternative compliance fund.

<u>Formalizing City Practices:</u>
Can the Committee on Public Planting as an existing entity evolve in ways that are particularly valuable to the Urban Forest Master Plan?

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Providing the resources so that the committee can interpret recommendations, updating analysis based on current research, reviewing pilot projects, reviewing progress toward targets.
There might be additional resources given to the committee. Chicago Region Trees Initiative partnered with a group of organizations such as US Forest Services, The Morton Arboretum etc. who have deep scientific knowledge. It may be possible to build a similar group of technical advisors, and meet with them for example twice a year.

There are also many concurrent planning efforts that have different priorities and we should help identify what the priorities are and how they can be applied to zoning.

Another question is where the trees are planted. Right now trees get planted when people request them, probably in an empty tree pit.

There are two problems with the canopy distribution in city. One is new planting requests which we need to formalize. The other is tied back to Tree Protection Ordinance. There is no system now that requires the developer to spend the money that they put in the Tree Fund to be spent for plantings in that same neighborhood. It creates an unequal distribution when trees are removed by new development and not replaced in the same neighborhood, but instead are planted according to requests. It may have negative impact on vulnerable populations.

One of the examples about how Cambridge might be able to get a planting protocol is the sidewalk replacement study that was done in Boston. They surveyed the condition of sidewalks in the city and they found a significant disparity in low income communities and communities of color where the sidewalks have not been repaired for decades. The system required a call and complaint about the sidewalks, then the city would put you on a list. But if no one called, the sidewalks didn't get repaired. Recognizing the inequity in this system, they changed their protocol. They did an inventory and now they have a priority list according to the sidewalk conditions.

For us, we have an initial tree inventory for the city and know the canopy conditions. So, the City may have a protocol for prioritizing areas. In defining these priority areas, we did a quick overlay. First of all, we looked into the environmentally vulnerable populations (including minority population, low income population, non-English speaking population).

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Other than that, we looked into the heat island hotspots, the transportation corridors (cool corridors) and the social infrastructure including the public schools and hospitals. And when we layer these categories, this becomes our heat map, where the dark reds and oranges are higher priority planting areas.

TF: One of the modules in iTree Landscape has a planting priority tool that uses some additional census data, so you can filter different categories.

Response: Thank you, we will look at that.

We zoomed in on two of our red hotspots to show what that looks like.

TF: Many of these areas are also an urban design problem where there is no space to plant a tree. It is a great intent but it is not that simple.
Response: One option in these areas is making changes to the street cross section, where you know that the current conditions do not allow any trees can make a difference. The prioritization of trees also requires bigger construction projects. That's why this master plan needs to relate to Envision in some ways.

TF: Rethinking street sidewalks and parking is really important. In some neighborhoods, there is plenty of space for cars but not enough space for pedestrians, narrow sidewalks.

Response: There is quite a lot of change in the city, largely around protected bike lanes. We should motivate similar redesign for traffic and trees.

Owen: There are competing needs associated with street space, such as trees, cycling, parking etc. We have a tradition of community process around the design of streets, and it is an extraordinarily challenging conversation.

TF: What about giving the Public Planting Committee a larger role?

TF: It's impressive how the Atlanta tree board is structured. The Public Planting Committee is always wanting new technical presentations.
If the committee had more teeth it would be easier to get people to participate.
Community Development is not always on the same page as Planting

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Committee, should give it the value it deserves.

Owen: The counterargument is that we have many competing interests with 6 square miles, and we can't empower one interest over the many others in the city.

Clarifying Planning and Zoning:
One problem with the Cambridge's Zoning Ordinances is that the tree protection and new planting mandates are scattered through the Ordinance. Another issue is that the requirements are tied to specific site uses (such as construction of a parking garage) and districts (such as the Parkway Overlay District).

From these observations, there is an opportunity to consolidate requirements into a single tree-related zoning article, which could increase compliance and consistency. Other options are to make the existing requirements more stringent such as requiring more trees at the parking lots and at the front yards.

TF: Parking lots have a huge impact on the heat island effect and stormwater management. And there are not many parking lots built at the moment, so the existing parking lots also need to have porous pavement and trees.

TF: The current ordinance is outdated because it does not meet the needs of green infrastructure. Trees could be planted in groups and used with green infrastructure improvements. We could do more if we are going to rewrite the ordinance.

Setbacks and Open Space:
Consolidating and strengthening zoning ordinances relating to trees create an opportunity. We need to define performance characteristics for:
- overlay districts
- canopy cover by land use
- setback/open space by land use
- parking space/tree ratios
- develop a Green Factor evaluation tool

Current zoning requires one tree for every 25 feet of frontage and at least fifty square feet of porous surface around the tree within the Parkway and

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Prospect Street Overlay Districts. Creating an “urban heat” or “urban forest” overlay district and have this standard apply across the city in high priority planting areas can help supporting the urban trees.

Salem, VA has an “urban forest” overlay district to increase the quantity of trees in new development along seven designated corridors. New development is required to have at least one tree per acre and at least one tree per 100 feet of frontage.

NYC requires one new tree for every 25 feet of frontage for all new buildings and enlargements exceeding 20 percent of floor space as a condition of occupancy.

Cambridge needs a feasible system for minimum canopy coverage requirements by land use and open space requirements. Examples of thresholds from other cities such as Providence, RI and Chapel Hill, NC are shown on slide 59. Open space requirement is very flexible, there is no incentive to plant trees.

Using a Green Factor ratio gives more flexibility to the individual property owners about how they can feasibly meet a threshold on their site. There is a chart that shows the landscape components in the cities with the associated multiplier.

TF: Sustainable Sites is a vetted ranking criteria which we could take principles from, especially performance-based criteria.

TF: Are there examples of incentives/programs especially in small residential districts?
Response: There are monetary incentives for private residences, but for developers there are more options available such as density bonuses or permits when there is preservation of trees in the site. Incentives for small-scale residential is a great place for us to focus.

TF: Since most of the land in Cambridge is developed, focusing on the developers instead of homeowners, institutions or the city itself is not as effective in the long run.

TF: I would argue for stricter rules on tree removals. No removals unless it’s a safety hazard.

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TF: You mentioned the urban forest overlay in high priority planting areas but there is also a possibility to create an urban forest overlay area where there is currently canopy coverage as a way to incentivize keeping those trees. There is the smallest and only urban national forest in San Francisco, which is a communal space, attracts people.

TF: As a representative of an institution, I cannot support a moratorium. The recommendation for a moratorium needs more discussion.

Public Comment:

Speaker 1: She suggested to do some survey at the edges of the city, and also to take into account the courtyard close to the Alewife Brook Parkway. She thanked Owen about mentioning the courtyard at 55 Wheeler, which she thinks is a very special site and needs a special permit.

Speaker 2: He mentioned Greening the Gateway Cities model and Advancing Green Infrastructure Program in New Haven, which creates bioswales around the city and also creates opportunities to plant trees. It not only includes volunteers but also help building skill and leadership. He suggested to partner with a department of forestry in one of the many universities around the city.

Speaker 3: The executive director of Green Cambridge, he commended the effort of both sides [Task Force and design team] to address comments and the clarity of the presentations. He thinks that it would have been better if this team started this work years ago because of the climate change emergency today. De-paving some of the city streets and creating shared streets are some of the strategies that can be pursued. Use space differently.

Speaker 4: She brought up the urgency of climate change and that Cambridge has lost lots of trees in the last nine years and she thinks there is no way that we can get that canopy coverage back. She stressed the importance of trees and added that we need to stop cutting down mature trees. Also, she thinks that residential category needs to be redefined as only 15% of city is single family.

Speaker 5: City councilor, he noted that there are an insane number of

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overlay districts already and there's another one coming. Housing versus trees is a false dichotomy. He thinks that we need to have a simpler permit process to remove trees. He supports a moratorium of tree removals. Current ordinance does not protect trees and 55 Wheeler is perfect example. Time to charge what trees are worth.

Speaker 6: She asked if the team knows about what the City is planning in Inman Square. She added that four of the mature trees will be removed from Vellucci Park. Also there was a fire a few years ago at Wellington-Harrington area, she wonders what happened to the canopy there. Also, many schools in Cambridge were built on small parks and the trees were removed.

Speaker 7: He asked if the presentation can be published on the website before the meeting. Noted that Somerville is planning to put the green factor into their zoning. He thinks that people need to be educated about the importance of trees as infrastructure. Trees need help to survive in cities but he needs to pay $2400 for the maintenance of trees that he has on his property. Is there some way for city to help with maintenance?

Speaker 8: She mentioned that instead of replacing trees, we need to focus on saving trees. She was at a public tree removal meeting for 29 Charles Street and she opposed, so the developer needed to go to City Manager. In favor of moratorium.

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ISSUE DATE
Feb 14, 2019

MEETING DATE
Jan 31, 2019

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT NAME/NUMBER
Urban Forest Master Plan 2953

RE
Task Force Meeting 8

ATTENDEES
City of Cambridge Task Force
Reed Hilderbrand

1. Introduction
Owen O'Riordan reminded the meeting attendees that there would be an ordinance hearing on February 14 at 5:30 in the Council Chamber on the proposed change to the Tree Protection Ordinance. Information regarding the proposed ordinance language is on the city's website.

Owen noted that the Task Force is subject to the Open Meeting law. The meetings must to be advertised 48 hours in advance, and more than half of the task force cannot meet and discuss any Task Force related matters.

Lastly, Owen noted that there would be a lot of material to get through and asked that conversation be confined to the Task Force members.

2. Design Team Presentation
Team thanked the public and the Task Force for sending comments and emails related to the project and noted that they would try to respond some of the questions with this presentation.

The meeting will cover the public survey results and how those might inform the thinking of the Task Force for next steps. Then we will talk about policy recommendations. The Policy Options handout has already been given to Task Force and it's also on the website.

Summary of the presentation and task force comments follows:

Survey Results

We ended up getting 1643 respondents, more than anticipated. The target number was around 1,100 (1% of the population) in 3 months. We ran the survey longer than planned to capture as many responses as we could. It's important to note that this was not a random sampling of city residents, but rather a self-selected sample. Because the survey sample is not representative of the residents of Cambridge, the survey results will not be used to justify any specific proposal or strategy. They are useful for guiding the education and outreach portion of the project, which we will talk about.

Some details about the demographics of the survey respondents:
-The survey was offered in eight different languages.

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-Although the people who responded to survey represent a broad cross section of ages, we have an overrepresentation in the Over 45 group compared to the city demographics.
-The majority of respondents were women (overrepresented compared with city demographics).
-The majority of respondents were white (overrepresented compared with city demographics).
-3% of respondents identify as Hispanic (underrepresented compared with city demographics).
-The census only gives median household income data for the city, so we can't show the exact correlation citywide. Median household income is $83,122, but 47% of respondents earn more than $100,000.

How does this survey help us understand the opportunities or constraints around stemming the loss of existing trees or growing canopy by planting new trees?
We found that survey respondents generally understand the value of trees in the urban environment. This was judged by the question: "In your opinion, how do Cambridge's trees contribute to the following items?"
Trees in Cambridge provide shade and cooling
Trees in Cambridge reduce flooding
Trees in Cambridge increase property values
Trees in Cambridge improve residents' quality of life
Trees in Cambridge reduce energy costs
Trees in Cambridge reduce air and noise pollution
Trees in Cambridge add beauty to my surroundings
The majority of respondents said "yes, greatly" to all of these questions. However, on flooding and energy costs, respondents were uncertain about the benefits of trees.

Respondents generally believe that there are not enough trees in their neighborhoods.
"Which of the following characterizes the number of trees in your neighborhood?"
In the bar chart on slide 14, the orange represents the canopy coverage by neighborhood and the dashed line denotes the average canopy cover, 26%. The blue bar shows the percentage of respondents for each of the neighborhoods that said "yes, there are enough trees". Respondents' answers generally correlate with the canopy cover. Only in Area2/MIT, the answer

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and the actual canopy cover is inconsistent. The canopy cover is low, 17%, but a high number of respondents perceived that there are enough trees. This might be due to the small sample number. Or people might include the trees along the river when they think of the city trees.

Respondents generally believe that city trees are not as healthy as they could be. This is compared to the tree health information from LiDAR classification data, which categorizes it as Good, Fair, Poor. Slide 16 is a general characterization for each neighborhood, showing only the percentage of "Good" trees and comparing it to the survey responses that trees are in "very good" and "excellent" condition.

The following slides (17-29) breakdown canopy cover by neighborhood, showing the canopy cover of each neighborhood vs. the perception of respondents who self-identified as living in that neighborhood. For example, East Cambridge's canopy coverage is 13%, and 75% of respondents think that there are too few trees while 5% of respondents think there are too many trees.

Even if the canopy coverage is above the average, about half of respondents still think that there are too few trees.

Regarding where new trees should be planted, a majority of respondents felt it was "Very important" to plant new trees on public sidewalks and streets, large institutional projects, new development projects and parks and public green spaces. However, a majority of respondents felt it was "Somewhat important" to plant new trees on individual private properties.
When asked a follow up question about the single most important location to plant new trees a majority (55%) stated that public sidewalks and streets were the single most important location to plant new trees.
We want to dig into this result because we think it's important. We've identified that a lot of loss has happened on private residential over the years, but the survey responses tell us that trees have the most impact where people can see and experience them. Ideal city-wide canopy cover is one metric to evaluate the city's forest, but this shows us that there is also value in focusing on where people experience the urban canopy.

To follow up on this finding, we did a quick case study to see how the canopy cover changes when maximizing the number of trees in the city Right of Way (ROW). We took the 2018 LiDAR data, extrapolated centroids from the

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canopy shapes, and counted the trees that fell in the right of way. This amounted to 13,000 trees, which is very close to city's assumptions, so we know it's a useful data set. We then categorized the trees according to what type of sidewalk they are located on, such as wider than 6', narrower than 6' and ROW trees in other conditions. The 6' width is important because it's the minimum to have an accessible 4' sidewalk and still have 2' for a tree pit.

TF: So there's the opportunity for 13,000 new trees?
Response: This number is our estimation of existing ROW trees.

We then looked at planting trees along the ROW every 30', but removing trees that are within 25' of an existing tree. This gives us about 12,000 trees but we are aware that this is an overestimation because of different urban conditions that we can't account for at this scale such as hydrants and utilities.
As an experiment, if 1,200 trees planted per year for 10 years, that means a 0.3% increase on citywide canopy cover in 2030. If you continue planting until 2050, it means 1% increase on citywide canopy cover in 2050. This is taking into account a 3% mortality rate.

TF: How about spacing the trees 20' or 25' instead of 30'?
Response: We generally space the trees at 30' because the street lights are often spaced every 60' so this allows for a consistent tree spacing. But we can see if there are areas that allow for tighter spacing.
It's worth noting that this strategy almost doubles the number of trees the city would maintain but only produces a 1% increase in city canopy.
But it does produce over 3% increase on sidewalks.

Continuing with the survey results, regarding tree preservation:
93% of respondents agree (70% strongly agree, 23% agree) that the city should have laws to protect large, healthy trees on public property, and 58% agree (27% strongly agree, 31% agree) that the city should have laws to protect large, healthy trees on private property.

The next question was phrased differently to prevent people from just clicking through the survey. 50% disagree (11% strongly disagree, 39% disagree) with the statement: "private property owners should make decisions about trees on their property without input form the city."

86% of respondents agree that the city should regulate removal of trees

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during construction, and 88% agree that the city should require planting of new trees on site if existing trees cannot be preserved.

81% agree (46% strongly agree, 35% agree) that the city should use more resources to maintain and protect existing trees, but 43% said "I don't know" when asked whether the city should prioritize resources for other services over tree planting and maintenance.

TF: I heard comments from residents that this question was problematic because it didn't list alternatives for other priorities people have, such as affordable housing.
Response: That is a good feedback, but we wanted to put it in a broad perspective, trees vs other resources.

The responses to the next question showed a preference for incentives over restrictions: 67% agree that the city should incentivize, not require, tree planting and maintenance on private property, and 77% agree that the city should provide resources to residents to plant trees on private property.

Respondents are broadly unaware of city tree-related programs, and in cases where they were aware, use of the programs is very limited. The programs listed were Tree replacement, New tree, Back of sidewalk tree, and Commemorative tree.

These slide (42) references two articles that were published about a tree planting program in Detroit. There needs to be education programs theat accompany tree planting efforts, but it is not also only about education. In Detroit, very few people take advantage of these programs, not because they don't understand the value of trees, but it is a burden for individual property owners to maintain and take care of the tree once they planted. There was distrust of the nonprofit and the city.

We'll pause for a moment here to take questions.

TF: Did you model the impact of heat when you did the ROW study?
Response: We didn't but we will as a next step. The grain of the heat island model that Kleinfelder has developed as part of their other resilience studies for the city is large and will not be able to get down to the experiential scale.
TF: We bought a thermometer and walked around Harvard Square to see the differences. It read 86º under the Brattle trees and 12º hotter at the Harvard T

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station.

TF: Are we going to address streets with narrow (<6') sidewalks?
Response: Yes, we will look at design strategies in the next meeting.

TF: ROW trees are the most stressed, and it is important to keep those trees healthy, getting them adequate soil and water.
Response: Yes, that will be in the upcoming Practices section

TF: What about clumping trees vs. a single tree every 30'?
Response: Yes, that will considered as part of design strategies.

TF: Connectivity below grade, including the private property is very important. We need more permeable surfaces.

TF: When you talked about a cool corridor strategy that has stuck in my head.
Response: Yes, shade on public streets is profoundly important.
TF: Yes, there's also equity in focusing on public space.

TF: What is the biggest takeaway from the survey?
Response: We're realigning our thinking away from private trees to focus our energy on the public realm to have the most success.

TF: You said you wouldn't use the survey results to justify decisions, why is that?
Response: Because the respondents were self-selecting, they chose to take the survey, it's not a random sample that accurately reflects a cross-section of the city.

Moving on to Policy, we want your [Task Force's] questions and comments, but we won't dig too deeply.

This slide [45] shows sample cost/benefit pages that we're working on. We want to do a summary and the cost benefit analysis for each of the policy strategies. Benefits of canopy over time, how does it change the curve, what are the ecological benefits, ecosystem services, heat island, social equity etc. If there is an impact area, how does it layout?

TF: Is it going to assess the citywide canopy or only the ROW as you showed?
Response: We're thinking it would be citywide, but we can try to categorize

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ROW benefits as well.

We gave you this outline [slide 46] last time and we will walk through each of these now.

1. Enhance Tree Protection Ordinance
   a. Change the definition of Significant Trees

Today, only trees greater than 8" dbh require mitigation and only when part of new development projects (applies to certain multifamily, townhouse and other projects requiring a special permit from the Planning Board or development projects of 25,000 square feet or more). Many cities currently regulate trees 6" dbh and greater.

To calculate what effect it would have to change the regulation to include trees 6" dbh or greater we created this map [slide 48]. It shows all the parcels under a special permit and also the canopy loss between 2009-2018 on these parcels. In 2009, there was 20.1 acres of canopy that existed on these parcels. According to the 2018 data, 12.9 acres were removed, which is displayed as red on the map. We calculated that those 12. Acres likely contained 162 additional trees that would have been covered by the ordinance if it pertained to 6" dbh or greater. We also calculated how much that would mean for the tree fund:

162 trees at 7" dbh = 1134" dbh to be mitigated
567 total trees at 2" caliper x $1,700 = $963,900 to tree fund (2009-2018 timeframe)

TF: How much is in the tree fund right now?
Response: Over $300,000 currently.

RH: Remember the additional $900k would have been spread out over 9 years.

b. Create an "Exceptional Tree" category

The addition of an "Exceptional Tree" category in the City's Tree Protection Ordinance would allow for a more stringent set of protections than those currently applied to Significant Trees in order to protect the city's most valuable trees.

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TF: What is the definition of Exceptional tree in other cities? Is it based on some criteria unique to each ordinance?
Response: Yes, the language of each ordinance is unique to the city. Portland maps their exceptional trees, other nominate on a case by case basis. We'd have to establish quantitative criteria.
TF: Yes, we'd have to. Otherwise it would just be qualitative.

c. Change mitigation requirements

We looked at alternative ways to calculate replacement value [slide 51]. The current calculation method is on the top, the diameter of the tree to be replaced is divided by 2" and multiplied by the cost of a replacement 2" tree. According to this, a 36.7 inch tree is worth $31,195. The same tree is worth $193,141 when calculated by the Weighted Trunk Area Replacement Value. Area versus diameter increases the value exponentially. This model might be overburden some community members, but it could designed account for residents' means. Having this higher cost could discourage removals.

TF: Could you have a simpler calculation to get a value?
Response: Because then you would calculate different species as the same.

TF: It is interesting to value trees more and create funds for the City to do things. But what I would want is an overall vision for the city that encompasses this and more, cool corridors, support education for residents, etc. It's hard to decide where to go without a holistic vision.

TF: I would want this Task Force to have an attitude of tree protection, not an attitude of how much the city can make by cutting down trees.

TF: This accounts for the maintenance fee of the tree, but how about the ecosystem services? Can we put a dollar value to that?
Response: Yes, we can do that and will be working on that in the coming weeks through iTree.

TF: Does the maintenance fee include watering? I personally question the $1,700 value for a new tree.
Response: That value reflects the cost of watering for the first three years as required under the mitigation.
TF: I'm not sure that watering is actually happening.

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TF: That money could go to groups for education, we can talk about what the priorities should be and where that money is best to spend.

TF: Instead for replacing the area of the trunk, it could be the area of the existing canopy that need to be replaced.
Response: That's an interesting idea, we should look at that.

RH: This $ value [for trunk area replacement] may seem radical, but this valuation is used as a standard. We have a project in New York City, and we need to remove 9 trees. NYC's similar calculation mechanism tells us $1 million for those 9 trees.

2. Enhance the role of the Committee on Public Planting (CPP)

Provide the Public Planting Committee with resources to extend the discussion of subjects raised by the UFMP, including:
— interpreting recommendations
— updating analysis based on current research
— reviewing pilot projects
— reviewing progress toward city targets

TF: I think everything that's been said here we [CPP] have been saying for the pas twenty years. It's in a letter we sent to the group at the outset. It's both gratifying and frustrating to work with the City, and I'm sure they feel the same way. The reason you were hired is to do the work the Committee has been unable to do. The CPP is advisory and has no real power. We can do more, for instance, in reviewing projects. If we had an ordinance as rigorous as NYC or a trunk area valuation method, architects would not approach trees as automatic removals. For example, in Smith Campus Center construction, they wanted to remove 31 trees. If we had more demanding policies, architects would have looked at other strategies before coming to us.

TF: Have you considered statutory modifications for the CPP?
Owen: The planning board has approval authority and City Council. There's a pedestrian committee, a bike committee, the planting committee, but they're all separate. They're not together discussing who gets what. It is a challenge to assess all the comments from different committees in the city. We are talking that trees should be on the sidewalks but pedestrians and cyclers also need to share the sidewalk.

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TF: We are the Task Force, we need to advocate for trees and support strengthening protections for trees.
TF: These interests are not mutually exclusive. Bicyclists want shade and tree people want people to bike.
Owen: We could assemble these committees as a group multiple times a year.
TF: Landscape architects think holistically and think of everyone's interests. maybe there should be a a seat reserved on the Planning Board. There are no landscape architects in the Planning Board.
TF: Or a member of the CPP must be on the Planning Board.
Response: It's true there are plenty of architects but no landscape architects on the Planning Board.
TF: The Planning Board meets a lot. It's hard to ask them to do two roles.
RH: We should address the review process and where exactly is consideration for all these topics mandated. We can develop an organizational chart for the review process for large and small projects.

3. Expand tree protections to private property
Many cities locally and across the country have expanded the jurisdiction of local governments through tree protection ordinances by requiring a removal permit for all trees, regardless of whether they are on public or private property.

Circumstances under which the city approves a tree removal permit vary in stringency but could range from approving every request to prohibiting removal of any healthy tree. However, the success of this approach has not been well established.

TF: I worry about the unintended disincentive towards planting trees. If it's hard to remove, then why plant?
Response: Yes, we included that as a con on the summary sheet. Enforcement is hard and may not create a great community environment where neighbors report each other.
TF: It could bring along others less interested in the benefits trees, however.
Owen: We could give people a twenty year period in which they could take down a tree they have planted. So there may be a way around that. Similar to the concept of rent control.

TF: If there's more support for nonprofit planting programs it may be easier to plant?
Response: The downside is the difficulty of removal as a disincentive.

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TF: The difficulty of removal could also act as an incentive, knowing it can't be taken down.
Response: The Heritage Tree model is more effective in that case. It would protect the tree permanently. A property owner could also put protections into the deed.

4. Earmark Tree Replacement Fund dollars for community grants

The city could earmark some of the funds in the Tree Replacement Fund for community-based grant making that could help fund operations to encourage planting on private property.

5. Align planting protocols with City's commitment to equity

This aligns well with prioritizing ROW planting.

TF: In high priority areas for social equity, planting on right of way could mean investing in sidewalks and bike lanes, not just trees.

6. Increase oversight to ensure compliance

Currently, there is limited City oversight to ensure compliance.
The Tree Protection Ordinance does not currently define standards for tree protection during construction.

Require increased offset from tree dripline to protect tree roots
Require periodic review per an order of conditions to improve tree protection measures (fencing, watering) during construction
Require city arborist/city engineer inspection prior to obtaining Certificate of Occupancy

7. Strengthen zoning ordinance requirements
   a. Establish canopy coverage requirements
   b. Increase ratios for trees to parking spaces and/or dwelling units
   c. Increase setback and open space requirements in priority areas
   d. Establish flexible landscape mandate like Green Factor or Green Area Ratio

TF: Are we going to make zooming reommendations?

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Response: We're now advising the Resilient Zoning Task Force. They are making the recommendations, but we can bring the values of this project to them.
TF: But they may come to different conclusions.
Response: Yes, they're considering many interests. Also zoning only affects new projects, it's not the biggest impact.
TF: It's hard to develop zoning around trees in a vacuum. That likely would conflict with something right off the bat.

TF: For the Tree Fund, how about using the area calculation for larger projects and diameter for smaller projects? That way a homeowner could easily do the math.
TF: But it's the Tree Protection Ordinance, not Tree Removal .

TF: Strengthening the CPP could come through zoning. There are a few areas of the city where zoning empowers the committee.

As there are issues that policy cannot affect, we also looked at precedents for Education and Outreach.
Examples:
TREE TENDERS (PENNSYLVANIA HORTICULTURAL SOCIETY)
Empower existing NGOs to plant and maintain more trees, including on private property.

YALE URBAN RESOURCES INITIATIVE
Support community employment and involvement in tree planting and constructing bioswales.

ABROR DAY FOUNDATION — ALLIANCE FOR COMMUNITY NETWORK
Build capacity of existing NGOs through partnerships with national organizations.

DAVEY TREE
Educate city staff, institutions, and other grounds managers on the value of trees and how to be stewards of them.

PENNSYLVANIA HORTICULTURAL SOCIETY
Educate the public on the value of trees and how to be stewards of them.

TF: Add City Sprouts to the list

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TF: And Cambridge Open Space Trust

Let's take a moment for comments and questions from the Task Force before opening it up to public comments.

TF: In terms of nature having a voice within city government, is there a city ecologist?
Response: The Conservation Commission fulfills that role.

TF: The grants to neighborhood groups is a great idea. The example of the Tenderloin Forest in San Francisco is great for community building.

TF: This Task force would be remiss if we didn't mention the DCR. Can we make a recommendation to the DCR? They represent the greatest opportunity to increase the urban forest.
Owen: We did invite them to be part of the Task Force but they did not respond.
TF: Regarding the cool corridors concept, the river could be more prominent as part of the strategy.

TF: Regarding expanding tree protection, we could have better protection during construction. Trees get the tar beat out of them. We could require a tree protection plan in the construction drawings.
TF: Could also add requirement of public posting of graphics showing how trees are supposed to be protected.
TF: Yes, tree should be treated as public utilities. People don't pull down power lines because they're inconveniently located. Is there a precedent for treating trees as infrastructure?
Response: Yes, that will be covered next as we work to calculate the value of the ecosystem services provided by the urban forest.
Response: Yes, there could be consequences related to trees as infrastructure such as having to pay your neighbor's increased cooling bills if you take down your tree that was shading their house.

TF: We need to see the pathway to implementation for these policies.

Public Comment:
Speaker 1: The trunk area is a good representation of the water carrying capacity of a tree. Should also consider carbon sequestration. The city shouldn't just take money into the tree fund and plant trees, should consider

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spreading trees around. Consider shielding the thermal mass of large buildings to reduce urban heat island. You should look at the recent Boston.com article on trees effect on carbon filtering in Milan. I'm on the Resilient Zoning Task Force and it's mostly City and business interests represented. There's only two residents. It's not a tree protection board and it needs your recommendations. Trees are important infrastructure. We could have a tax incentive for having trees on private property. Would help offset maintenance expenses.

Speaker 2: Regarding climate change, we need to be more active. We need an Exceptional Tree ordinance, and we need to protect all trees over a certain size. Consider that the City Council will whittle down whatever recommendations you make. Years are involved in growing a large tree and should be accounted for. Enforcement should not be a reason to not strengthen policies.

Speaker 3: I live in affordable housing in Jefferson Park in North Cambridge which is exempt from the tree protection ordinance. When they were proposing renovation plans, they originally wanted to remove 6 trees. Theuy kept 8 but then cut down 4 of those during construction. And then they replaced the removed canopy trees with mostly ornamentals. Now they're proposing removing eleven buildings and the site plan proposes clear-cutting everything. The ordinance treats people in affordable housing difrerently which is not right.

Speaker 4: Hello, I'm Councilman Zondervan. In your Right of Way study you only looked at sidewalks. Please consider car storage (parking) as potential planting areas. In terms of valuation the trunk area calculation could be multiplied by the current canopy coverage. As the coverage goes up or down it would be less or more expensive to remove a tree. I also want to suggest that the city should have a Forestry Department.

Speaker 5: How do we stop the current canopy loss given the large numbers of trees needed to keep up with current rate?

Speaker 6: Hi, I'm the executive director of Green Cambridge. I'm in favor of empowering the CPP rather than creating a new group. We have enough groups already. I'm excited to see how the city could work with nonprofits. I also want to make a plug for Heritage Trees. Get the public involved at the beginning of the Master Plan launch. Make it a celebration of trees. The

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Heritage Tree program was originally started by nonprofits and was then turned over to the city. Green Cambridge has been incubating ideas on Heritage Trees. The sycamores along Memorial Drive would be a great pilot group. All these ideas shouldn't compete but should support each other to make great streetscapes.

Speaker 7: Look at the various gatekeepers within the development process. Shouldn't just be a free pass. Every permit should have language regarding trees. I support requiring permits for any tree removals over a certain size.

Speaker 8: I'm Jan Devereux, Vice Mayor. I support more ROW tree plantings and more trees in public spaces. The Alewife plan does not have enough green space. Yes, the Planning Board should have more landscape architects, and the same for the BZA. Tree protection during construction is also important. I agree that the affordable housing concern that was raised is a legitimate concern. And I feel that zoning should consider trees.

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ISSUE DATE
March 20, 2019

MEETING DATE
Feb 28, 2019

LOCATION
Cambridge
Rindge and Latin
School

CLIENT
City of Cambridge

PROJECT
NAME/NUMBER
Urban Forest
Master Plan 2953

RE:
Task Force
Meeting 9

ATTENDEES
City of Cambridge
City of Cambridge
Task Force
Reed Hilderbrand

1. Introduction
Opening remarks by Owen O'Riordan:
First, Owen mentioned Public Meeting #2 that will take place at Morse School on March 7th at 6:30 pm. He then noted the new Amendment to the Tree Protection Ordinance that has been passed by the City Council. This requires a permit for anybody who proposes to take down a "Significant" tree on private property. No permits will be issued unless one of the following conditions is met: the tree is dead or dangerous; it's an emergency situation; it's a significant utility project with state or federal funding; it's a city park project; or the tree could have significant impact on a structure. The amendment becomes effective on 11th of March. If anyone is found in violation of the ordinance, the person may be subject to a fine of $300 per day and also be subject to the mitigation replacement cost.

This is the 9th meeting, there will be two other meetings and then there will be a draft report in summer. The final report will be published in fall.

TF: Does this committee sign off on the report?
Owen: Not as such. We do have detailed minutes of our meetings recording your comments. We could have a meeting in the fall if you were all willing and able to come back.

2. Design Team Presentation
At the last meeting, we talked about the policies and didn't get to the practice section. Today, we will present the broad principles, planning approach, design concepts and practices. We started to narrow down the ways of describing what this process leading us towards. Then, how we get from principles to implementation.

PRINCIPLES
We looked at Envision as a model of how to articulate "Vision and Core Values" [slide 4]. We are interested the broad statement and detail statements and how these align well with our discussions, such as livability of the city, diversity and equity, sustainability and resilience, health and wellbeing, learning and education.

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MEETING NOTES

Core Concepts
In terms of core concepts, we have these draft layouts to discuss [slide 5]. The three broad statements:

Value the forest as a public resource [slide 6]

The urban forest is a public resource and has measurable value and impacts to everyone. It provides shade to cool our environment, gives scale and character to our streets, provides habitat for diverse species, improves our air quality, reduces stormwater impacts, and improves our health and well-being.
To shift the trend from increasing loss to sustainable growth, we must manage the urban forest as urban infrastructure (like water, sewer, power) investing for the long term, managing resources collectively, and understanding the value (i.e., ecosystem services) of the canopy.
To balance the value of the forest with the complex needs of the city, we should focus on the performance of the forest as a system over the specific value of individual trees.

Invest in canopy in the public realm [slide 7]

The urban forest is felt most strongly in our public realm and common spaces (sidewalks, parks, schoolyards, and commercial and institutional campuses). Enhancing the canopy within the public realm, where the impact of loss is felt most strongly and the significance of gain is most equitably distributed, deserves our primary attention and investment.

Prioritize canopy corridors and areas of canopy deficit and equity.
Canopy corridor: A resilient, connected ecosystem that enhances shading and cooling along networks and connects green spaces across the City, which relies on thriving trees within the public right of way, publicly accessible spaces, and front yards and private lands that front on the public realm.
Areas of canopy deficit and inequity: A more evenly distributed forest increases equity in the distribution of canopy cover, reduces disproportionate impacts from urban heat island effects, and increases the well-being of vulnerable populations.

Share responsibility for a healthy forest [slide 8]

A thriving urban forest requires the mutual care of many parties, including city government, homeowners, businesses, developers, local organizations,

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institutions and state agencies.
Policy should be balanced and fair, linking the interests of all parties around smart solutions that encourage tree preservation, planting of new trees, and effective maintenance. The city should support education efforts as a catalyst for partnerships between interest groups to encourage stewardship of the urban forest.

The ways to enact these values are multi-pronged. There is no one single cause for canopy loss in the city and no one single response to it. We grouped it under three categories: Curb loss, grow canopy and encourage alternative approaches that advance the goals of the Urban Forest Master Plan [slide 9]. In the next two meetings we will focus on prioritizing which of these items are most important.

Let's pause here for discussion.

TF: I am concerned about the emphasis on the public realm. You identified that most of the available space to plant is on the private property. Even if we maximize the public space, it will probably not get us there. So, given that there is more opportunity on the private property, we should educate people about the importance of their backyard trees. So, they understand the importance of the trees and they won't cut them down.

Response: That's a great point, and we have to be careful about the language we're using. Because in our mind, the front yards are part of the public realm. Even though they're privately owned they have a huge impact on a day-to-day experience. We could consider tax incentives to encourage people to retain their trees and plant more.

TF: The front yards are almost nonexistent in Cambridgeport. I am concerned about the city penalizing tree removal. And by focusing on investing in canopy in the public realm, we are closing the door to tax incentives for private owners. Curb loss will not extend beyond the curb into private property?

Response: Curb loss is about stopping the loss of tree canopy in the city. One strategy is creating “Exceptional trees” category, in addition to “Significant trees”. Another is increasing the cost of removals.
The goal for next time is to take all of the options we've looked at, look at the cost benefit analysis, and prioritize. This list is not a finished product.

TF: There is no language around supporting the small landowner. We should say

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MEETING NOTES

something about education, community building, and also encouraging owners to plant or maintain trees not only on front yard but at the back yard too. We should find language for how we find money to support small owners and also to directly invest.

TF: There needs to be a program, because for many people, it costs money to maintain the trees. There might be ways such as tax credit.

TF: I didn't see anything on the importance of diversity of the forest. The challenges that street trees face might limit the diversity. Also, the value of design and aesthetics was not mentioned.

TF: We should add to the language about trees as urban infrastructure that trees are living, they're harder to move than pipes. They are "living infrastructure." They are residents without a voice.

TF: I feel we should be focusing on the public realm. We have 14,000 tree wells and I would like to see where they are.

TF: We should discuss what the plan is for filling the tree wells.

TF: The language is important. To justify the public realm focus, you wrote “the urban forest is felt more strongly in the public realm” but we need to talk about the real canopy values, how trees function. And just because it is felt more strongly in the front, we shouldn’t miss the opportunity to get the people on board. The innovative stuff is how to crack private property. It would make a big statement to invest in canopy in the private realm and also prioritize public trees to create canopy corridors.

TF: New developments don’t have any front yards, so maybe this is about the zoning.
Response: We will talk about private space in Design section, but also being more aggressive about making space in public realm. We are trying to push the City to be more aggressive.

TF: Paris has civic spaces that allows for planting. Cambridge is denser, and people want more housing. This push to infill with development puts pressure on the public realm. The message to invest in the public is important.

TF: If we say that we want to increase the number of trees, we will fall into a status

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quo of how we do things. I would like to see a document that came out as radical as possible, in a strong language as possible. Then we can draw back from that, because it is going to be drawn back.

TF: Make no small plans.

PLANNING APPROACH

We showed you this strategy matrix [slide 11] before which talks about policy, planning/design, practice and outreach.

Looking at the priority map [slide 12] showing the priority areas and corridors, there is a pattern that comes both from CCPR and cool corridors but also our attempt to make connections between public open spaces and parks. Priority areas are an overlap of environmentally vulnerable populations, areas of heat island concern and community infrastructure (schools and hospitals) [slide 13]. When you layer them together, two or more layers makes the high priority areas, which is the darker red color and when there is only one layer, it is the priority areas, which is the lighter color.

Our two strategies are curb loss and grow canopy.
Curb loss is the "do not harm" category across the city. Even in the places where there are not many trees, we want to keep them [slide 14].

We want to focus our energy and resources on the areas on the map [slide 15] that are shaded that has less than 30% canopy cover. The white spots are either parks that have enough canopy or don't fit into the data.
And there are also the canopy corridors [slide 16].

We developed a way of categorizing the city according to conditions and uses [slide 17]. It is descriptive of opportunities or limitations of planting trees. The categories include mixed use with setbacks 10' or greater, residential with limited setbacks, residential with no setbacks, parking lots, large blocks with limited/no setbacks, large lots with open space, mixed use with no setbacks, DCR land, institutional and development zones.

Mixed use with setbacks 10' or greater [slide 18]: Most of this type is in West Cambridge where there is sufficient canopy. These have sufficient space in the front yards. This kind of typology needs education for planting.

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MEETING NOTES

TF: Are you using setback not as a zoning term but as an urban design concept?
Response: Good question. Yes, we use setback here to mean distance from back of sidewalk.

Residential with limited setbacks [slide 19]: These are areas that have less than 10' and limited setbacks. There is not enough room to plant trees. This typology is seen in Cambridgeport, Mid-Cambridge and the canopy relies on the street trees.

Residential with no setbacks [slide 20]: East Cambridge and The Port have this kind of typology, where the building face is built up to the edge of the sidewalk. These areas rely on the Right of Way [ROW] trees. The focus here should be on the street design.

Large blocks with limited or no setbacks [slide 21]: These areas are mostly in East Cambridge, The Port, Area 2 / MIT. These large commercial buildings don't have any setback and there isn't any room for trees. They also have very harsh conditions such as wind, heat and drought and trees require additional maintenance to survive in this environment. Parking lots create an opportunity to add canopy to these areas.

TF: The parking lots are privately owned, how do we do that?
Response: Most of the parking lots are privately owned but through zoning changes, there are opportunities. There is currently a requirement in Zoning Ordinance to plant one tree in every 10 spaces. We could propose to increase that ratio.

Mixed use with no setbacks [slide 22]: Along heavily trafficked pedestrian corridors such as Central square, Porter square, Mass Ave etc. These are areas where the only canopy is the public realm and in need of street design or alternative strategies.

Owen: Protected bike facilities are a priority in these areas, and it is challenging to accommodate multiple interests.

Large lots with open space [slide 23]: Large spaces such as schools, hospitals and fields that might be opportunity to plant trees especially on the edges.

Institutional [slide 24]: This is an ownership type rather than use type. Encouraging canopy growth at MIT, Harvard and other institutions will require partnerships and outreach.

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Development Zones [slide 25]: These are currently developing areas such as Alewife area and North Point. Zoning is important for these areas.

DCR Land [slide 26]: DCR Land is also in ownership category. Again, this will require outreach to try to develop a partnership.

The open space map [slide 27] shows the comparison of overall city canopy cover in open spaces, (43%) and DCR canopy (36% along Memorial and 55% along Alewife).

For each of these areas, how do we deploy our strategies [slide 28]? What will be the most effective based on the specific conditions in these areas?

TF: In this matrix, I think #3 should say "Changing Planning and Zoning" rather than "Clarifying."
Response: Yes, we will revise that language.

TF: Yes, I think we should be making recommendations to the Zoning Task Force.

DESIGN CONCEPTS

We focus on “how we start to impact the public realm” in this section [slide 30].

Where you plant trees but also where you don’t plant trees are important questions so as not to waste resources. We need to ask ourselves, where the sidewalk is very narrow and there is not much soil [slide 31], is this a place for the City to spend energy?

TF: And even if there was enough soil, the tree would need to be fastigiate [columnar] which is not a large canopy.

We recognize the soil volume is important to the long term health of a tree [slide 32]. If the sidewalk is only 6’ wide, in order to get the minimum soil volume of 750 cubic foot [cf], the minimum space between the trees needs to be 40’, and for 8’ wide sidewalks, the space between the trees needs to be 30’. This increased soil volume would increase the cost of planting in Cambridge exponentially, and we will model that as part of our cost/benefit analysis.

TF: Does this include permeable pavers?

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MEETING NOTES

Response: Yes, it could. Or it could be planted.

When you plant a tree, in a very limited space between the sidewalk and the curb, there is not much space for the roots to grow [slide 33]. The soil medium needs to go under the sidewalk and where there is front yard on the other side, it is connected to it. It could include permeable paving or it could include a standard sidewalk with soil going underneath.

We are also working with Kleinfelder to develop integrated systems where the soil volume is part of a stormwater management system connected to the catch basins [slide 34].

There is also this comparison of savanna and forest and how we want to get a hybrid typology within the city [slide 35]. Planting trees 40’ apart, disconnected by soil volume and not having the other layers of vegetation is not how trees have evolved in the northeast. We want to look at more complicated and nuanced ways of planting.

We looked at the condition of street trees around the city within different neighborhoods [slide 36], and then we also looked at the condition of street trees on sidewalks 8’ or greater [slide 37]. We thought those trees on wider sidewalks would do better, but we found that most of the wider sidewalks are streets with no setback where the trees have no adjacent soil to draw from. This may be why trees on wider sidewalks are struggling more.

TF: Also those are small tree pits.
Response: Agreed.

So then we looked at the sidewalk width distribution to understand where in the ROW there are areas that front yards will be valuable to plant trees [slides 38-40].

The checklist shows how we propose to respond to various sidewalk widths with different strategies [slide 41].

These ROW Canopy maps [slide 42] show the 2018 canopy with street trees (dark green) roughly differentiated from non-street trees (yellow) in West Cambridge and East Cambridge. The point of these maps is to convey how different neighborhoods rely differently on City’s street trees for canopy coverage. East Cambridge's tree canopy is very dependent on street trees while West Cambridge's much less so.

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The following street axons show a set of existing prototypical conditions for street trees within the city [slide 43].

Major commercial street with a wide sidewalk, parking and bike lane [slide 44]

First alternative: without changing the curb, the whole volume under the sidewalk becomes soil volume, aeration and drainage support the soil [slide 45]
Grove of trees, multiple stories of vegetation supporting each other, with pervious pavement on the surface [slide 46-48]
Suspended grate instead of a pavement, with vegetation underneath that support multiple layers of vegetation [slide 49]

Major commercial street with a narrow sidewalk, with a bike lane [slide 50]

A single planting strip with permeable pavement [slide 51]

Major street with commercial buildings [slide 52]

Creating cutouts within the buildings, having varied edges and landscaped spaces, including multiple stories of vegetation in verges [slide 53].

TF: Here you show the bike on the street. Could you show the bike lane on the sidewalk instead?
Response: Yes, we can show an option more like the new Western Ave design.
TF: And then you could extend the soil under the bike lane?
Response: Yes, absolutely.

Narrow residential streets with no setback [slide 54]

Removing pavement and shifting two-way traffic to one-way, pushing the curb out to get a wider planting zone [slide 55]
Shared street, moving the curb so that everyone gets a front yard, which might happen in dead end streets, (Longfellow road, implemented by the City) [slide 56-8]

TF: How do you take into account if you create more one-way streets, that the cars would be on the road longer and would increase the CO_2 emissions?
Response: These are broad strategies we think have value but each individual

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street would need a traffic study to understand how to best design a pattern of one-way streets.

TF: The denser neighborhoods tend to have one-way streets.
Owen: Except East Cambridge. If you remember during our big snow year, we converted East Cambridge to one way streets due to the amount of snow in the street.

TF: There are also places where you create one wide lane, wide enough for two cars go by. It is more a residential model. Like Upton Street.

TF: Shared street makes a narrow street and vehicles move slowly, where children can play, people can hang out, this helps to create a community.

Owen: Street design is a community process. We need buy-in from all residents. It's easier to reach consensus on a short street.
TF: Was Longfellow Road a DPW project?
Owen: Yes, we brought the design to the residents.

Narrow residential streets with front yard [slide 59]

Making connection between the planting strip soil and the front yards and encouraging people to de-pave their front yards [slide 60]
Taking some parking spaces and turning them into spaces to plant trees [slide 61-3]

TF: Raising the curb in such areas would help with the soil compaction because people would not step on it
Owen: We have this on Albany Street, but there's no adjacent parking. Also did it on parts of Western Ave.

Narrow residential streets with wide front yard [slide 64]

Encouraging the front yard planting when there is not enough space for street trees (Partnerships and Funding) [slide 65]

TF: I think we should be radical. The public realm is for all residents of Cambridge.

TF: Can we tie this work into stormwater infrastructure?

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Owen: Tree pits can allow for some stormwater management, but it's not sufficient volume to prepare the city for climate change.

TF: Another data layer worth looking at would be overhead wires which limit what we can do. It would be a radical policy direction, but can we move them underground?

TF: What percentage of the canopy is in these different typologies?
Response: We don't have that info currently but we could do that analysis.

TF: On slide 65, where's the fence?
Response: A fence could be at the back of sidewalk. We didn't draw one, but you could certainly have a fence.

PRACTICE

The City of Cambridge forest management practices are generally aligned with best industry practices [slide 68].

To curb loss and grow canopy, enhanced practices fall into four categories [slide 69]:
Improve monitoring and responsiveness
Remediate causes of decline
Improve planting and soils details
Expand routine maintenance

Monitor [slide 70-2]
Increase frequency of city-wide tree assessments
Expand pest/disease monitoring
Expand Cartegraph tracking to monitor success of practices

Remediate [slide 73-5]
Treat private trees during city-wide severe pest/disease outbreaks (EAB)
Remediate soils with liquid biological amendments
Remediate soils through decompaction/aeration

Plant [slide 76-9]
Enhance soil specs
Ensure proper drainage
Plant bare root trees

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MEETING NOTES

Maintain [slide 80-6]
Formalize a City-wide management plan
Implement structural pruning for young trees
Expand watering program
Expand mulching program
Annual soil treatment with liquid biological amendments
Investigate alternative de-icing methods
Create management risk zones

Each of these will have high and low version in the cost benefit analysis.

TF: What's the city's ability to do liquid biological amendments?
Response: City is starting a compost tea program and they are currently investing in the brewer. City has a small maintenance area in Fresh Pond Reservation for the brewer, and in the spring this year they will start treating new trees.

TF: Is it possible to change the tree pit size?
Response: Yes, we are looking to make it bigger.

TF: Are there any places to make a bare root nursery in the city?
Response: The golf course at the Fresh Pond can be used for this.

TF: How much space do you need for bare root nursery?
Response: 8,200 sf is required to store 456 bare root trees, they are very close together.

TF: I would love to see tree protection for new trees in high pedestrian areas.

TF: Are you going to make a recommendation about how many city employees are required to achieve these goals?
Response: We will not make a recommendation but, when possible, we will assess the costs of the labor required for each practice option in the cost benefit analysis.

TF: What about the cost of not doing anything?
Response: We will be calculating lost value as part of the analyses.

TF: What about the cost of professional training programs for DPW staff?
Response: We will factor that into the budget calculations.

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TF: How do you assess the cost of design?
Response: Linear foot costs of constructing a shared street, linear cost of removing two parking spaces etc. This is something City can provide and has a database. RH is developing the spreadsheet for this right now and will work with the City.

TF: Before treating the trees, we first need to understand the needs of trees in the city. It doesn't make sense if you keep mulching a poor tree, if it actually needs irrigation.

3. Public Comment Period:

Speaker 1: Will you commit to putting numbers to how much these recommendations will reduce loss by next week for the public meeting?
Response: No, as much as we can, we're trying to estimate how much these options could reduce loss, but we won't be able to do it by next week.

Speaker 2: I'm the executive director of Green Cambridge, and I want to express our support for these public realm changes. The city should serve the residents where they live. Regarding the beautiful precedent images, I say "Be Barcelona." We're in the process of redesigning Allen Street with the residents. And anyone who wants a tree in their front yard can call 617-349-6433 and leave their name and address.

Speaker 3: I'm concerned about equity. You could consider leaf surface area against the number of residents as an equity metric. Open space needs prioritizing and should be balanced against affordable housing. I'm on the Resilient Zoning Task Force and we need your input to drive zoning decisions. The Green Factor zoning would weight mature trees over young trees.

Speaker 4: I'm an interested observer from Watertown. Thank you for the effort you're putting into this. I'm thinking of this as a call to arms. We could recruit high school students to come to the public meeting next week to show support? They are an army in waiting.

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ISSUE DATE
April 18, 2019

MEETING DATE
March 28, 2019

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT Name/Number
Urban Forest Master Plan
2953

RE
Task Force Meeting 10

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Reed Hilderbrand

Introduction:
Catherine Woodbury announced the two replacements on the Task Force team, Megan Nichols Tomkins as the Chamber of Commerce representative and Joe Bendar as the Cambridge Housing Representative and everyone introduced themselves.

Eric Kramer reviewed the schedule:
This week's meeting includes the outreach about the value of urban forest. It's a living process and the work of the TF has informed about where to focus and where to dig deeper. We will continue through conversation and engagement rather than solving it all or coming to a conclusion.
Next Task Force meeting will be on climate modeling, heat island modeling loss investigations, cost benefit analysis. We will take the work and develop a report, like a white paper. All findings and feedback will be in one place. This process will take a few months, and then we will come back together in early fall with some meetings when TF has had time to digest and we can continue the conversation. We are setting out a framework. The report will set up a roadmap – some is policy, some is political, some is practice.

Design Team Presentation
Summary of the presentation and task force comments follows:

Outreach – precedents and approaches and which ones could be applicable
Resiliency – planning ahead- what species should we be planting
Canopy Valuation – how do we understand the value (monetary and on terms we cannot monetize)

OUTREACH
Outreach tries to respond some of these questions:
How do you engage the community, how do you talk about the share responsibility?

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MEETING NOTES

How do you communicate the value of trees?

Outreach to schools:
- Can build on existing school curriculum about the services that trees provide
- Utilizing ready-made lesson content from Audubon Society or Project Learning Tree which incorporates i-Tree and also Trees Louisville's science curriculum unit on ecosystem services

TF: How you communicate municipal goals into curriculum is a hard challenge, hard to input into the curriculum because teachers themselves are too hard pressed. Creating context between municipal team and the City needs strategic conversation. I'm happy to help with this. What are the right vectors?

Supporting citizen science projects: There are examples of air quality monitoring which is one of the benefits that the forest provides

Organizing tree tours for citizens: This was something David used to implement, tours foster support between community and DPW.

Public installations:
Publicizing ecosystem benefits, educating people on dollar value of trees, an example David Buckley Borden's *Tree Box* (Put something in to get something out). Another immediate example of tree health as a public education, Voice of Nature by Thijs Biersketer.

A report card on the forest:
What is the result of all of these efforts: a report on the forest – dialogue with the City. Goals and where we are. A yearly check-in.

How do you get people to take action?

Improving the online tree map to engage citizens:
The infrastructure is there with information of tree locations and species. However, there are engaging examples of online database- NYC as a precedent- it is clickable, tells how many times it's favorited, tree care, ecological benefits, "favorite" button, and you can input your activity.

TF: How often is the inventory updated for NYC?

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Owen: Cambridge would maybe update on a 6 year cycle per pruning contract (can be done at the same time). DPW needs to put a front face onto Cartegraph. Anytime the tree is touched it will be documented. ClickFix would go into the database.

Supporting community planting efforts:
Community care for the tree and more efficient allocation of resources.
Employ young adults for job training

Publicize existing programs more:
Adopt a Tree program, Junior Forestry program

How do you stem loss?

Engage with citizen science projects to protect threatened species:
An example, Tree Snap: App on your phone. Collaboration between various research groups and universities and focused on at risk trees (hemlock, larch, etc). You take a photo of a healthy individual so researchers can take genetic samples of that tree.

Pest monitoring:
There are examples that can support City's efforts such as Backyard Bark Beetles and Sudden Oak Death

Outreach to local businesses:
Asian Longhorn beetle- city of Worcester lost 35k trees.
Number of interceptions of contaminated wood palettes are on the rise – so very important for businesses to inspect that it has a stamp

How do you grow canopy?

Publicizing existing programs such as Back of Sidewalk program

Partnerships: We are looking into ways to partner with agencies.
- Multi agency partnerships (MA Greening Gateway Cities),
- Public and private partnerships (Green Tacoma Partnership),
- Carbon credits based on tree plantings (Trees Charlotte)
- Partnerships with institutions and organizations (Tree Pittsburgh)

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Owen: City is having discussions with law department on public/private partnership and potential use of mitigation funds from large projects and directed towards replanting on private property, there are significant challenges from the state Constitution. Hopefully by late summer City will have a response on whether there is a work around. DPW has talked to DCR.

TF: DCR is working in Springfield and planting trees on private property. Talk to mayor of Springfield?

TF: - carbon credits- sold to meet carbon reduction goals?

TF: Back of Sidewalk program?
Owen: It is allowed through state law but beyond that, anti-aid amendment prohibits actions that improve private property

Summary of Recommendations:
— Advocate for the value of trees in education curriculum
— Support citizen science projects
— Organize tree tours for citizens to engage with trees
— Continue to publicize ecosystem benefits of trees
— Support alternative education approaches, art installations
— Publish annual reports to give feedback on progress
— Improve the online tree map to engage citizens
— Promote existing City programs
— Educate local businesses about dangers of pest outbreaks
— Partnership outreach

TF: These all seem like disparate activities but bringing these all together would be important through a communications strategy. Cambridge is unique because of all the different types of people. Memorial grove- make the trees the statement. How do you communicate about these trees? We are challenged by the broader consolidated strategy.

We would have a larger strategy, working on what that is with the City to figure out the best way. Want to roll out with one voice, wants to feel like one program.

TF: Could you define individual "sacred" trees of Cambridge. These could be really powerful.

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Communication plan is needed: a way of thinking about the front matter of the report. What messages come out, who are the target audiences, and who will back it up?

TF: Tree appreciation is like music/art appreciation. How do you instill this?

TF: Economic model- what this is doing for you. We don't talk enough about the inherent value and the beauty. There's literary, spiritual. Have you seen a dollar of services work?

On a political level. About a decade ago, Mayor Daley in Chicago said he was going to plant 5000 more trees. Mayor Bloomberg's million trees program was about reaching to boroughs. Expectations raising which could be hard to navigate. We have evidence that people value space that the trees make on public ROW. We need to select and promote most potent of these messages.

Dollar values for cities works more for Parks departments to get money into tree fund for city departments than to raise value for individual citizens.

TF: Arnold Arboretum – can we look at how they foster appreciation for trees?

Really amps messaging part of the forest.

TF: Talk suggest that putting a dollar value on the tree take away from the overall value of the tree. SUNY researcher suggested this. Celebration of trees through having talks...

Intellectual and artistic capital is extraordinary and should acknowledge and celebrating. WEB Dubois example. Arbor Day – who in our community would champion this? Who has a voice that could reach a lot of people?

TF: Do we want images- great trees of Cambridge?

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FOREST RESILIENCY
We are at a moment when the forest is ever more important
Forward looking more explicitly, trees we plant today are the forest of tomorrow.

We started by looking at the City's current list. Red= low condition from on the ground at Cambridge. Blue= exceeds diversity target. Yellow= high susceptibility on climate risk.

Why these four species? Would we not blacklisted? Flagging and not blacklisting. Salt is a killer of Tilia. Constrained soil volumes.

Salt tolerance column

Can we weigh the native trees? For residential land owners The importance of native versus non native

Within a genus, there does not seem to be a significant difference between natives and non-natives

Street trees- looking for the best performers

We used this database to put together street tree recommendations. But will make this database available to the public to use.

TF: May be worth mentioning this list does not include any invasive species

Gary: This has been controversial for 30 years, literature search, there is a strong community that will push natives but we are taking a position here on street trees.

City is a garden, we are not in a woodland environment.

TF: From a paleo perspective New England forest is young, there is no native flora, there isn't one.

City is not self-regulating. Would not meet your diversity target if you would only plant natives.

We are shaping policy but don't want to shape values- important to

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communicate this.

Black locust- exception?

TF: some species support more wildlife – include this to the database.
Elena can get info on bees
Fruits are messy- can be in the backyard

TF: not sure about the climate resiliency score – we need more species and more diversity

Red maple- ALB – check why is it not resilient

How do we be projective? We don't know and want to mitigate risk

TF: Geographical tag- looking within a certain diversity – local diversity

Reevaluate every 6 years when redoing the inventory?

Not on the street- should be diverse as possible

TF: Chinese fringe tree is in the ash family. Would it survive emerald ash borer?

TF: Biggest list – target ratio or range of planting target with guidance

City can run the database to figure out

TF: – Carolina silverbell, Osage orange (seedless variety), magnolias (cucumber magnolia and sweetbay magnolia – has climate adaptation built in – can escape cultivation)

TF: Yellowwood is weak wooded

TF: What about Catalpa and Paulownia?

CANOPY VALUATION

Core concepts- Valuing the forest as a public resource

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The most effective way may not be quantifying by monetary value but we studied that for our cost benefit analysis.

We did some literature research. There is a list of urban forest benefits including social and economic benefits, ecosystem services (carbon, air quality, storm water, energy, habitat, noise, micro climate, health related benefits, visual and aesthetic benefits).

We created a short list and highlighted the ones that are quantifiable through i-Tree.

Different methods that people measure tree benefits:
- Methods for measuring benefit:
— top down aerial based approach (remote sensing, aerial photography) - iTree Canopy
— bottom up ground based assessment (individual trees, GIS based) - iTree Eco, CITYgreen
—specific areas of benefit (mathematical models) - iTree Hydro, Kleinfelder's Port modeling

Methods for measuring economic value:
— market prices, surrogate market approach, production function apporach, state preference approach, cost based valuation, cost benefit analysis

TF: ISA method of determining the valuation?
That is included in iTree, a way of understanding a one time assessment of tree value that goes into the property value as well.

TF: City of Philadelphia is calculating green infrastructure, tree, stormwater waste, probably according to pervious - impervious surface information. There might be one other way to calculate this with their model.

Kleinfelder is modeling the stormwater benefits in Port.

Since we have Bartlett's 5% survey, we thought that iTree Eco was a good way to evaluate the forest and to extrapolate.
- iTree uses field data along with local hourly air pollution and meteorological data to quantify forest structure, environmental effects,

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and values
- benefits depend on tree structure and physiology (e.g. tree size, trunk diameter at breast height, leaf area, leaf biomass, evergreen vs. deciduous)
- We used these inputs: dbh, species, condition, street tree/non street tree, land use
- Outputs:
  annual functional values (recurring, cumulative value of forest), such as air pollution removal, avoided runoff, carbon sequestration and energy savings
  one time value (if the tree dies, what are you losing?)- carbon storage and structural value

Air pollution removal:
We examine each value separately and all slides are organized by benefit estimate and value estimate. Benefit estimate used canopy deposition models and also measured values from literature. Value estimate is avoided health impacts (avoided hospital visits etc).

Stormwater runoff:
Pretty limited in iTree Eco. This looks at the interception of vegetation, so it only requires species information

Energy use reduction:
General estimate of the value

Carbon Sequestration:
Looks into the yearly growth of tree

Carbon storage:
Looks at how much an entire tree stores carbon above and below grade.

Structural value:
Loss property value- What if you need to replace the tree?

TF: Faster a tree grows, more it sequesters carbon, and large trees also great at carbon sequestering, another reason to protect them

Summary of results in terms of annual value:
Second column is the extrapolation of the 5% survey to 100%. However,

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when we multiplied it with 20, it didn't give us the canopy acres of the current forest. To get to that number, we needed to multiply it with 35. Then, we took the average to get the total benefit. Annual benefit is 1.64 million in those specific benefits we looked at, and one time value is 134.3 million. Overall value is 136 million dollars.

Carbon storage equivalent to:
— amount of carbon emitted in Cambridge in 10 days (estimated 1.4 mil tons/yr)
— annual CO_2 emissions from 20,400 cars
— emissions from 8,360 single-family homes

Nitrogen dioxide removal equivalent to:
— annual NO_2 removal from 500 cars
— 220 single family houses

Sulfur dioxide removal equivalent to:
— annual SO_2 emissions from 2,060 cars

TF: Did you look at what trees do to property values?

It is more about the structural value. But there aren't many studies about the property value except a case study in Georgia. But it is difficult to use that for Cambridge because the house types are different.

The highlighted benefits are not captured in our benefit calculation study, these are demonstrated value but not quantifiable.

There is a lot of research on physical health and mental wellbeing.

Going back to the scenarios of how the forest would look like in the future, we calculated the benefits of forest for each scenario. We came up with a number of $1551 per acre. The cumulative benefits of forest in 2070, is almost 100 million dollars for no action plan, 141 million dollars for grow canopy and 167 million dollars for reduce loss/grow canopy plan. It is a 67% difference.

TF: Does the city have a greenhouse gas reduction target? And does this calculation help with that?

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Owen: The expectation is 80% reduction by 2050.

TF: Last summer, I measured the temperature and it was 98 °F and 89 °F under a tree.

It changes up to 20°F degrees.

Where do we position the ecosystem services values in juxtaposition to the other values? What statement are we making about this kind of calculation? What would be the most actionable messaging around value?

TF: What would be the city worth without the trees?

We are trying to figure out the cost of the potential practices or plantings that city can do, such as doing biological amendments on all trees, depending on the cost, is this a good investment?

TF: How do we tie this back to priorities? Lens of equity in this discussion- implicit in public health. Job workforce training- that seemed to hit on some of the other issues. Urban forestry is a great tool. Want to reach more than a certain person in a socioeconomic class. Tie it back to community building and job force training- building local capacity.

Owen: Conversation that happens all the time with climate change. How can we make the climate change a priority for people that have other priorities

Gateways to address social equity- asthma rates

TF: I've spent a lot of thinking on deferred maintenance – similar curve applied to street trees? What level of investment is required to reverse decline of street trees/ROW trees?

Owen: as they are looking at 1200 trees, what does that mean as a work force, different technologies, etc? How does this actually happen? Life cycle cost of trees.

TF: education: specific recommendations for expanding curriculum – urban forestry trade program? Technical arts program? Other tie ins? Nine mile river watershed organization – started fee for service planting program

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targeting at stormwater reduction – review. Gentrification impact: underserved communities see trees as a threat. Do you plant more back yard trees in underserved communities?

TF: slow growing trees – as a characteristic to include? Growth rate? Recs for private vs public should be made clearer

3. Public Comment Period:

Speaker 1: Arborist came to do tree maintenance – maintaining trees will reduce canopy periodically during pruning. Fast growing/hardy trees what we need to get the canopy up quickly, then focus on diversity. Health cost savings- psychological benefits. 10 degree difference between front and back of house due to shading. Stormwater benefit- reduce sewer charges for those people with larger trees. I think we should use shorter term projection rate than the longer term rate.

Speaker 2: I'm unhappy about this discussion focusing on new planting and not about maintaining canopy. City should be protecting large mature trees. Harvard is removing a very large tree. Value of trees is low in the City. Need a large tree ordinance.

Speaker 3: Top down environment – communicate to the City and negotiate to the City to move budget around

Speaker 4: I attended a talk by Andrea Reimer former Vancouver City Councilor - Vancouver has an ambitious goal to become the greenest City – 150,000 trees. Many on private property.
Osage Orange? Look to the Midwest for species for trees that grow well in deluges of rain.
Community forestry conference at UMass Amherst – presented a different take on native vs non native. Go with natives if you can.

Speaker 5: Executive Director of Green Cambridge, I'm impressed by the level of detail the presentation went into. Our organization is outreach and education focused. Interdisciplinary approaches to valuing tree canopy. Working with Cambridge Latin on environmental curriculum. And DPW on tree planting blitz and engage neighbors. Concert for sycamores this

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summer- interdisciplinary approach – art/beauty and science.

TF member: In Envision, why does "Community Wellbeing" have nothing to do with forest, trees, green space.

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ISSUE DATE
May 16, 2019

MEETING DATE
Apr 25, 2019

LOCATION
Cambridge Rindge and Latin School

CLIENT
City of Cambridge

PROJECT Name/Number
Urban Forest Master Plan
2953

RE
Task Force Meeting 11

ATTENDEES
City of Cambridge
City of Cambridge Task Force
Reed Hilderbrand

Introduction
Opening remarks by Owen O'Riordan
Owen noted that tonight is the last Task Force meeting until the fall. We have a cake tonight to celebrate the effort and diligence of the Task Force.

RH reviewed the project schedule:
Noted that we are at the end of a conversation, but the design team will be bringing more information to you in the form of the report. As the analytical component and findings review closes now, the team will think through some of the impacts and ideas and will have a draft document in June. Some of the questions we have are: how can we communicate this with the public, how can the City use this document to make guidelines and how might this impact the process of drafting regulations.

Design Team Presentation
We focus on three things today: understanding potential causes of canopy loss; reviewing the scenario testing, climate change impacts, and their relation to urban heat island; and reserving 45 mins in the end to talk as a group.

Summary of the presentation and task force comments follows:

1- Canopy Loss Investigations
The first map in the presentation shows the canopy loss, gain and no change between 2009 and 2018. When we first showed the canopy change data, we used 2014-2018 data, then we broadened that and used 2009-2018 data. City is working with UVM on this, peer review. Data is corrected. Currently, Cambridge has 26% of its land area covered with canopy.

Task Force: What was the number you showed before?
Response: 29% in 2014

TF: From when is the data?

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R: LIDAR was taken in April 2018.

Canopy Loss Investigations
1- Is loss associated with increased impervious area?
2- Is loss associated with property sales?
3- What other causes are there for canopy loss?

The loss investigation sites are distributed across the city.

Increased impervious: We used the data from aerial mapping, overlaying change in impervious cover between 2010-2018 and change in canopy cover between 2009-2018. However, aerial mapping is not very precise.

The chart shows the canopy loss and gain associated with increased impervious and no increased impervious area, showing the gross areas. 156 acres of land with increased impervious surface, showed canopy gain. It may mean that people are planting trees, while there is increased impervious.

Ownership change: Using the aerial mapping and city records, we overlaid the property sales from 2015-2017 and change in canopy cover between 2014 and 2018 to assess correlation. The map shows the parcels that changed ownership and percent canopy change on that parcel.

TF: Does it also show replanting?
R: No, this only shows canopy loss.

TF: Did you differentiate residential and commercial?
R: We didn't but we can.

Here are some findings from this study:
- 2,945 parcel sales took place from January 1, 2015 to December 31, 2017 in Cambridge
- 22.3 acres of canopy loss (of 330 total gross loss) was on land sold during that time.
- 10.5 acres (almost half) of 22.3 acre loss was associated with just 179 parcels.
- 1,100 parcels showed only minor losses.

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- 29 parcels contributed 2.9 acres of new canopy.
- 313 parcels contributed 4.1 acres of new canopy.

Ground truthing: This category also shows loss but we didn't know why, tried to find out the reasons. These studies suggest an association between four conditions and canopy loss:

- New construction
- Renovation and site improvements
- Mortality (declining health)
- Miscellaneous decisions by individual owners.

The keymap locates the site within the city. Study number 1 is loss associated with increased impervious surface. Number 2 is loss associated with parcel sales and number 3 is miscellaneous decisions.

New development built multiple houses and some large trees were removed. New trees were planted as part of the project (Cambridge Housing Authority project)

New construction removed trees on the property but also the trees in the median.

Lesley university, relocation of church is associated with loss, they tried to save the street trees but they couldn't. There are a few small new trees.

New construction on the back parcel property sold.

Novartis project replaced the parking lot but provides open space and planted new trees.

During the restoration of Anderson Memorial Bridge, most of the trees on DCR land were removed.

New construction on Mount Auburn, took down a couple of trees

Large backyard tree was removed due to renovation on Copley street.

MIT Westgate, removal and reservation of trees (TF: Sugar maples were planted around playground)

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Harvard Winthrop House, trees in courtyards are gone

Porter square parking lot, most of the trees are replanted, small trees

Mass Ave, trees are removed due to utility project

Public library, large tree didn't survive the construction

Two trees were removed, but we were unable to determine a cuase.

Response strategies, moments people have to make decisions, how do you communicate with people?

TF: Are causes ranked?
R: Analysis allowed us to zoom in and try to understand what it was. We can't say the number overall the city. Instance by instance.

TF: It is interesting to see individual sites, can we see all of them?
R: The scale of loss on this project is immense. In some of them you see replanting, good decisions. Seeing the new trees is good but the LiDAR analysis doesn't pick up all the small trees.

Owen: The increase in new impervious area is disturbing

TF: Pervious/ impervious is big. We have permeable area requirements in the zoning.

Owen: It is part of Envision too.

TF: Does impervious cover include buildings or roads?
R: Yes, it includes any surface that has changed to impervious. It is the same data came from LIDAR, like canopy change. New buildings and new pavement

TF: Even on the surface, when you have a construction project, contractor says those trees have to come down. There is a tendency to empty the site. Some of them are decisions from the client.

TF: We face that at the Public Planting Committee too. Park or private

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development. Architects don't want to deal with trees but you can't replace it. Tree preservation is important for our town.

TF: We can do a better job as an institution to investigate at Harvard

TF: Constraints with the site development, use of the site whether you are capturing stormwater, trees sometimes disappear, sometimes replanted. MIT is not a bucolic as Harvard, there are fewer existing trees to start with. The forest is not static and always changes, we need to maintain it as a forest, not as individual trees. We need a comprehensive management plan.

TF: Harvard has done some successional plantings in the Yard. The work of the Task Force has prompted Harvard University to think more about tree planting.

Advocating for the value, but also we need to do things systematically as landscape architects.

TF: When trees are replaced, do you know what species?
R: Often the replacements are understory trees, it is a problem. They won't ever get large.

These studies will help us understand how the forest is changing and how to manage it.

2- Scenario Modeling
Modeling has been a pretty big effort, preliminary results from October. We made some updates to October's model.

Updates:
— Rename the "climate model" to "canopy change model"
— Model loss using canopy area rather than individual trees
— Define a baseline net loss rate (1.55% of canopy per year)
— Project a conservative and an accelerated loss rate for the scenarios

Conservative scenario looks at the historical rate, some species will not do well with climate change, will disappear from the palette with pest and diseases such as emerald ash borer.
Accelerated scenario: if climate change accelerates and also new

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diseases appear. The risk ranking is calibrated to each species, we assigned low, medium, high ratings.

Species composition of future is depended on each individual flooding and drought impacts. Findings will inform species recommendations.

Scenarios: 2030, 2050, 2070 baseline scenarios, 2030 flooding and 2050 drought scenarios.

Baseline Scenario
First map shows the current condition of forest, with 26% canopy cover. Species that are more resistant to
2030 Conservative Scenario: Considering temperature shifts/EAB threat the loss rate of 1.55% increases to 1.8%, resulting in 21.0% total canopy cover.
2030 Accelerated Scenario: Doubling the impact of pests/diseases on each species the total annual loss rate increases to 3.2%, resulting in 17.6% total canopy cover.

TF: Red Maple, why is the score so low?
Combination of vulnerability to pests and diseases and not being drought tolerant

TF: Native plants and trees are good at ecosystem services, biodiversity is important
R: On our previous presentation, we discussed the species recommendations but these are only findings

TF: Definition of forest? 25% is not a forest, canopies are not touching each other
R: We looked at that, single tree standing alone would be considered a savannah from an ecology point of view.

Flooding scenario
We removed trees that are flood intolerant, standing water for 24 hours, increase in mortality.
The flooding event resulted in 0.2% additional mortality (~0.7 acres of loss)
from the 2030 baseline scenario— resulting in minimal reduction of canopy in 2030.

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Species that are impacted in this scenario.
Current net loss, we are carrying it to 2050, then we run the drought model, it is a one-time event in 2050.

It is an assumption with the science we have, that there won't be an extreme drought in 30 years.

Additional mortality is higher, hemlock is high in mortality number.

Summary graph: colors relate to the event or scenario, conservative loss scenario and accelerated. There's a large range of impacts, so 2050 and 2070 outcomes overlap with each other. The scenarios assume that there isn't any large planting strategy.

Next we investigated how much can tree planting mitigate heat island and what strategies move the needle.

Indrani Gosh, Kleinfelder: This slide shows the methodology behind the Urban heat island model. It is the most robust that we have. We are using land sat data, an image of land surface, taken on a particular time, high temperature, hottest day on record, August 2010, output of the data, calculating emissivity. The resolution of the data is 100'x100' "pixels."
Ambient air temperature is important, we estimated the surface temperature and established a connection between the CCVA analysis, relative humidity.
For the model we are only using ambient air temperature.
The model is fairly flexible. 2018 UHI temperatures, canopy coverage, cooling relationship was used to determine what the future heat island would look like in different canopy coverages.

UHI map, using 2018 canopy, on a day average Cambridge temperature is 90 °F, there are certain spots 8-10 degrees higher in the city.
Then we correlated how the UHI was exacerbated by changes between 2009-18. 164 acres net canopy loss, differences between 2009 map and 2018 map. Red spots are 4 degrees warmer than 2009. 39% experienced an increase in temperature 0.5°F, 42% didn't change, 2% change for, more than 4 degrees.

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Stephanie: So in 2030, what would the canopy look like with the current loss rate?
Accelerated loss scenario in 2030, 17.8% canopy cover. 38% of the city experienced an increase in temperature (>0.5°F)
ROW planting (12,000 new trees), increase of canopy to 29.4%, 12.5 diameter trees, 30' spacing.
25% of the city experienced a decrease in temperature (>0.5°F).
Cooling, corridors, 100x100, more temperature decrease under a tree, Thick increase in Alewife, envision planting scenario.
There isn't a change in West Cambridge, because there is significant canopy there currently.

Neighborhood Case Studies
These are not proposals, but scenarios to test planting strategies.

We did two studies: Mid Cambridge (20% current canopy cover) and East Cambridge (15.1% current canopy cover).
East Cambridge: Residential areas are paved. Opportunities that we found are increasing ROW canopy, lane diets, encouraging backyard planting, increasing canopy cover on parking lots, buffering existing open spaces with more trees.
Calculations in terms of number of trees (1814 trees), what it would look like with canopy. Change is significant, 62% of East Cambridge experiences cooling.

Mid Cambridge: Here the canopy cover is lower than city average. Largely single family homes, with limited setbacks. In this scenario, we looked at increasing ROW planting, increasing canopy cover on parking lots, encouraging front yard plantings, diversifying and staggering trees on major streets. It required in total 2019 trees and resulted in 51% cooling.

Model showed pretty impactful effects, and helped us to understand what was possible.

TF: Did you look at only tree planting? In Alewife, trees plus green infrastructure, a lot more significant compared to only trees

TF: How about dense and light shaded trees?

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R: We didn't look at that, we only looked at the area covered by the canopy

Taking targeted actions feels impactful. What it takes to accomplish it is 20-30 years but it is meaningful.

3- Task Force Takeaways
Collective information and questions that you asked were important, and your questions have taken us to this point. We saw your photos and letters. We are aware of the challenges, and we look into the aspiration from different parts of world.

What do you think are the most important things you learned? Where should we focus our energy?

TF: Cambridge's good intentions create built environment but who is the overarching person that thinks about the ecology? We need a central authority that can represent the biodiversity, really critical.

TF: At the DCR JFK bridge project there were colliding interests making it ADA accessible, pressure on planting on that area. It incurred a lot of canopy loss. One of the challenges is getting advocates and specialists involved in projects to enforce the canopy protections. Should be addressed in practical ways.

TF: No representation for natural environment in the current city government structure. Fresh pond is managed by water department. What is the relationship of a child with nature going to be in the future? There are sociological way of designing the playground beyond using the sexiest play equipment. San Francisco and Austin have passed Children's Outdoor Bill of Rights, and we should consider a similar measure.

TF: Have a landscape architect on the planning and zoning boards.

TF: The report should include zoning changes in the recommendations section.

TF: City needs to look at restructuring, someone needs to advocate full

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time for trees and not have it spread amongst multiple entities.
How people would plug in their voices?

TF: City Hall has a door that says "Parks Commission" but that doesn't exist anymore.

TF: The new trees in Porter Sq at Lesley University where they moved the church. There is replanting but maintenance is mostly a lot of mulching. The City needs to work with private entities about practice, the current mulching is a terrible practice, there needs to be education and commitment. It is not about only replanting.

TF: The City needs to create sustainable maintenance guidelines. And there needs to be incentives to get results. If we don't give incentives to people, it won't happen. We want people to treat the city as an ecological place, not a place they make a profit.

TF: There could be a 10 year tax abatement for property owners who plant trees. People apply for a tree proposal, but we can't plant trees on private property if they won't take care.
All new street construction should require new trees, and we should identify candidate streets for conversion to one way.
We should require proof of no temperature intensification for all construction projects in the same way that the regulations require that we retain our own stormwater.
Open space requirements are generous already in the zoning ordinance.
Greywater systems on buildings, drought scenarios, we waste so much water, need to rethink.

TF: As the representative of a large landowner, we're looking at ways to manage the campus as one whole system. Having overall goals and targets rather than individual tree plantings. The attrition is general and the opportunities to plant are random. We need a project in the first place in order to plant new trees and we don't often have new projects.

TF: I second that. We tend to look at trees on individual project basis, and we should be looking at it in a much more complex way, as a system.

TF: I worked in tree planting directly, you did a very broad

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investigation. This is the only city doing this extent of investigation. It's exciting to see.
I think the important ideas are incentivizing new plantings, creating more partnerships, de-incentivizing cars or condensing car space.
Where could streets prioritize pedestrians, like woonerfs do?

TF: There should be a required parking permit for residency. Giving parking spaces to trees.

TF: Regarding deincentivizing car ownership, parking lots in California have a tree for every two spaces. We could replace spaces with trees.

TF: We could create non-profit partnerships, almost street by street, to engage the community. Might get more immediate results.

TF: Fruit trees would be appealing for people to encourage more planting

TF: As an ecologist not working in urban environments, it's encouraging that Dr Hayhoe's research is being used in practice beyond an academic setting. And also to see modeling being used is encouraging. I'd ask you to dream big. Surprise people, like a parking lot forest.

4. Public Comments:

Speaker 1: Relationship between retail and trees is missing. Why is it good for business or retail to have trees? They are the keepers of our trees. Trees on Mass Ave are not going too far.

Speaker 2: Thank you for all the work. It starts to give us leverage, there are other tree people and really good data. We at Green Cambridge are going to be using this data and what comes out of the plan for policy and culture, real positive change.
There is 900 acres of car storage that we can plant trees on. The city is building "Almost Complete Streets" because they don't have an ecological componenet. We should create true green streets.
I hope this project serves as inspiration for the rest of the state.

Reed Hilderbrand LLC
Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

MEETING NOTES

Owen's closing remarks:
We are at the end of the beginning. We understand that trees are living infrastructure and we have policy direction now to maximize tree plantings in our projects. And the policy of not planting in front of certain properties needs to go away. We have an imperfect transit system that cerates demand for parking and the city has sidewalks that are narrow plus very active bike lanes. We need collectively to get everyone together and we can organize workshops. We need to tackle the question of whether the moratorium deincentivizes tree plantings. We need to empower the community and create trust. Reed Hilderbrand will continue to be involved through the Resilient Zoning process, and they will be issuing a green paper instead of a white paper that we will share with you.

Reed Hilderbrand LLC
Landscape Architecture
130 Bishop Allen Drive
Cambridge, MA 02139

APPENDIX V: PUBLIC MEETING PRESENTATIONS

PUBLIC MEETING 1

PROJECT SCOPE

ANALYTICS / RESEARCH

PRACTICE

REGULATORY / POLICY RESEARCH

OPEN HOUSE

PROJECT SCOPE

ANALYTICS / RESEARCH

PRACTICE

REGULATORY / POLICY RESEARCH

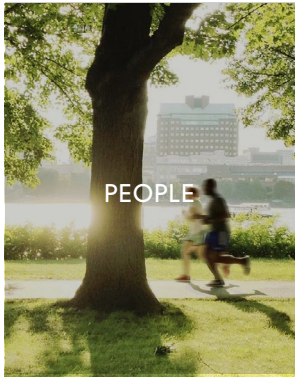
OPEN HOUSE

CHARGE

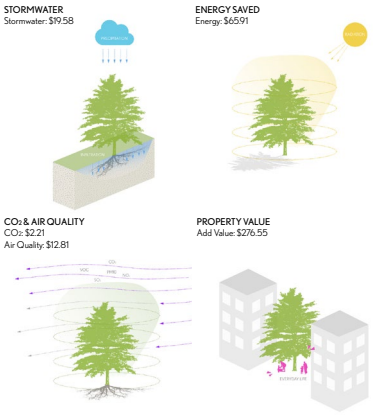
To maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.

REED HILDERBRAND CAMBRIDGE URBAN FOREST MASTER PLAN PUBLIC MEETING 1 | OCTOBER 3, 2018 4

HEALTHY AND CONNECTED SYSTEMS



THE BENEFITS OF THE URBAN FOREST

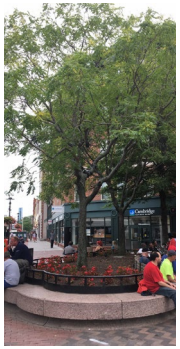


Ecosystem services for an average Pin Oak in Cambridge
Source: i-Tree Streets - Annual Savings for Average Pin Oak in Cambridge

Cultural Value

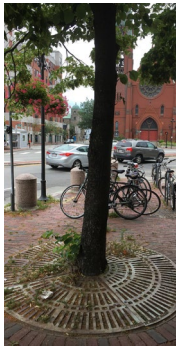
THE CONDITION OF OUR URBAN FOREST

OPEN PIT



PLANTING BED

MULCH



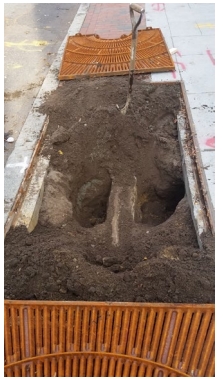
TREE GRATE

FLEXIPAVE

THE CHALLENGES OF PLANTING IN THE PUBLIC REALM

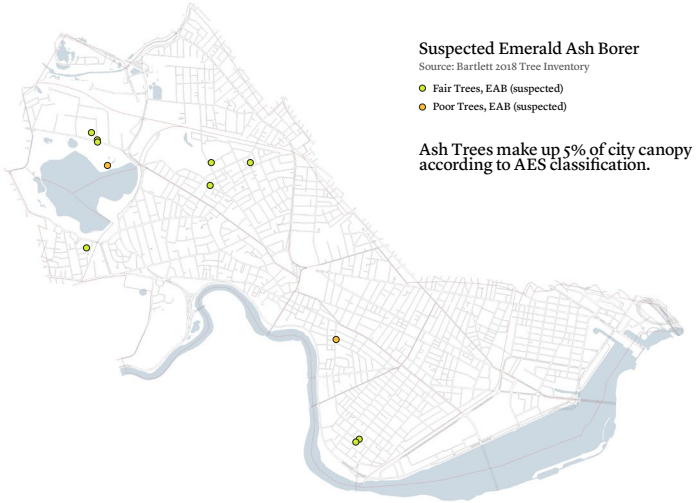
MASS AVE BETWEEN HUDSON ST AND SHEPARD ST

MASS AVE BETWEEN MARTIN ST AND HUDSON ST



EXETER PARK TREE WELL

OUR FOREST IS AT RISK – PESTS AND DISEASES

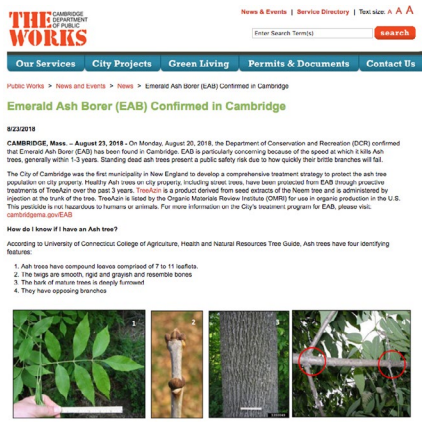


Suspected Emerald Ash Borer

Source: Bartlett 2018 Tree Inventory

- Fair Trees, EAB (suspected)
- Poor Trees, EAB (suspected)

Ash Trees make up 5% of city canopy according to AES classification.



THE WORKS — CAMBRIDGE DEPARTMENT OF PUBLIC WORKS

News & Events | Service Directory | Text size: A A A

Enter Search Term(s) search

Our Services | City Projects | Green Living | Permits & Documents | Contact Us

Public Works > News and Events > News > Emerald Ash Borer (EAB) Confirmed in Cambridge

Emerald Ash Borer (EAB) Confirmed in Cambridge

8/23/2018

CAMBRIDGE, Mass. – August 23, 2018 - On Monday, August 20, 2018, the Department of Conservation and Recreation (DCR) confirmed that Emerald Ash Borer (EAB) has been found in Cambridge. EAB is particularly concerning because of the speed at which it kills Ash trees, generally within 1-3 years. Standing dead ash trees present a public safety risk due to how quickly their brittle branches will fall.

The City of Cambridge was the first municipality in New England to develop a comprehensive treatment strategy to protect the ash tree population on city property. Healthy Ash trees on city property, including street trees, have been protected from EAB through preventive treatments of TreeAzin over the past 3 years. TreeAzin is a product derived from seed extracts of the Neem tree and is administered by injection at the trunk of the tree. TreeAzin is listed by the Organic Materials Review Institute (OMRI) for use in organic production in the U.S. This pesticide is not hazardous to humans or animals. For more information on the City's treatment program for EAB, please visit: cambridgema.gov/EAB

How do I know if I have an Ash tree?

According to University of Connecticut College of Agriculture, Health and Natural Resources Tree Guide, Ash trees have four identifying features:

1. Ash trees have compound leaves comprised of 7 to 11 leaflets.
2. The twigs are smooth, rigid and grayish and resemble bones
3. The bark of mature trees is deeply furrowed
4. They have opposing branches

I have an Ash tree. What do I do?

If you have an ash tree on your property, please consider one of the following:

- **Treat-** If you have not yet begun a treatment program, we recommend that you work with a certified arborist to develop an ongoing treatment plan for your Ash tree. It is far more cost-effective to treat a healthy Ash tree than it is to remove it. You can find a certified arborist at www.massarbor.org
- **Remove-** Dead and dying trees become a risk for public safety. Remove and replace unhealthy Ash trees with different species. Doing nothing may put you and your property at unnecessary risk

For additional questions or concerns regarding Emerald Ash Borer in Cambridge, contact the City's Urban Forestry staff at cambridgetrees@cambridgema.gov.

OUR FOREST IS AT RISK – CLIMATE CHANGE

Aspects of climate change that impact the urban forest:

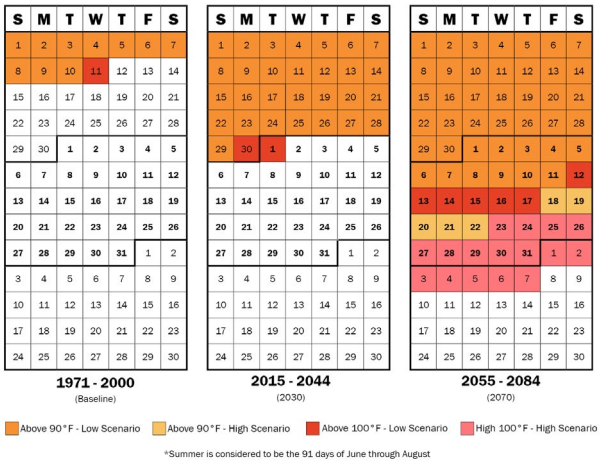
— Increasing temperatures

— More frequent drought

— Increased flooding (Precipitation / Sea Level Rise)

— New pests and diseases

OUR FOREST IS AT RISK – CLIMATE CHANGE



S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

1971 - 2000
(Baseline)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

2015 - 2044
(2030)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

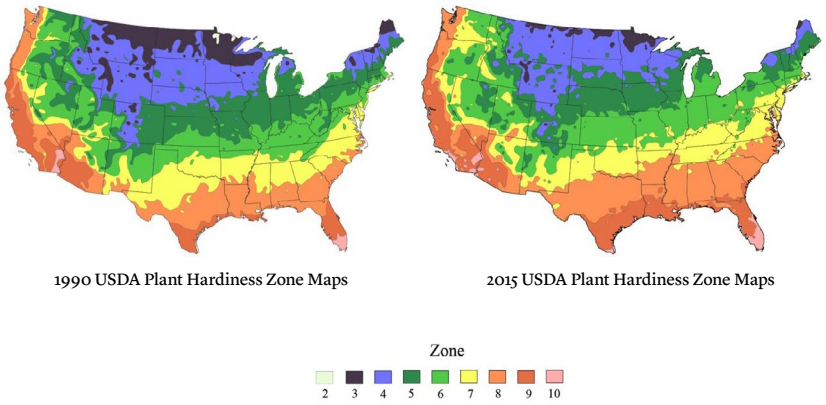
2055 - 2084
(2070)

Above 90°F - Low Scenario | Above 90°F - High Scenario | Above 100°F - Low Scenario | High 100°F - High Scenario

*Summer is considered to be the 91 days of June through August

Source: CCVA

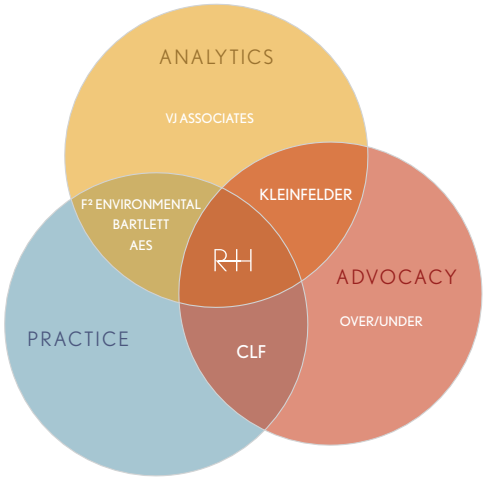
OUR FOREST IS AT RISK – CLIMATE CHANGE



1990 USDA Plant Hardiness Zone Maps

2015 USDA Plant Hardiness Zone Maps

PROJECT TEAM



PROJECT SCOPE

ANALYTICS / RESEARCH

PRACTICE

REGULATORY / POLICY RESEARCH

OPEN HOUSE

OBSERVATION | CANOPY COVER

Today, Cambridge has **25.3%** of its land area covered by canopy.

Cambridge has had an average net loss of **31 acres** of canopy cover every year.

At this rate, canopy cover will be **16.2% in 2030**.

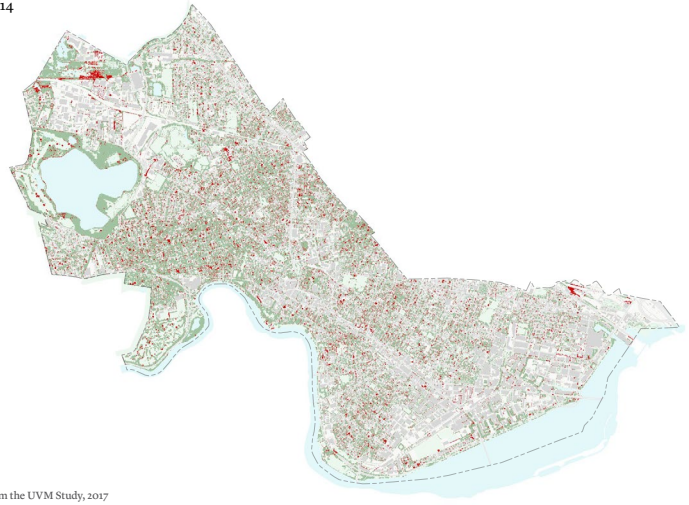
A TREND OF CANOPY LOSS

Change Between 2009-2014

2009 30.8% COVER
2014 28.3% COVER

GAIN 2.5% (101 ACRES)
LOSS 4.9% (200 ACRES)
NET – 99 ACRES

0.48% AVERAGE LOSS
OF PERCENT CANOPY COVER
PER YEAR



DRAFT

- Area of Canopy Loss
- 2014 Canopy Cover
- Open Areas

Source: Prepared by RH Team from the UVM Study, 2017

A TREND OF CANOPY LOSS

Change Between 2014-2018

2014 28.3% COVER
2018 25.3% COVER
(1,027 ACRES)

GAIN 5% (206 ACRES)
LOSS 8.1% (330 ACRES)
NET – 124 ACRES

0.76% AVERAGE LOSS
OF PERCENT CANOPY COVER
PER YEAR

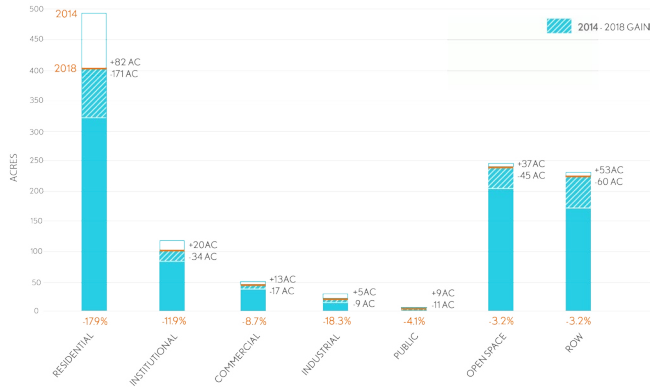
DRAFT

- Area of Canopy Loss
- 2018 Canopy Cover
- Open Areas

Source: Prepared by RH Team from the 2018 AES classification data.

WHERE ARE THE LOSSES HAPPENING?

Canopy change by land use



DRAFT

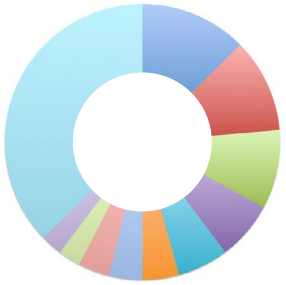
Source: Prepared by RH Team from the 2018 AES classification data and City GIS data.

OBSERVATION | CITY-WIDE SPECIES DIVERSITY

Today, **3 species** make up over **30%** of the Cambridge forest.

Catastrophic loss of those 3 species would result in **17% remaining** total canopy cover.

WHAT IS THE MAKEUP OF THE CURRENT CAMBRIDGE FOREST?



Other	36.4%
Norway Maple	12.5%
Pin Oak	11 %
Honey locust	9.2%
Red Maple	6.8%
Red Oak	6%
Littleaf Linden	4.2%
Callery Pear	3.9%
London Planetree	3.6%
Ash	3.4%
Crabapple	2.5%

DRAFT

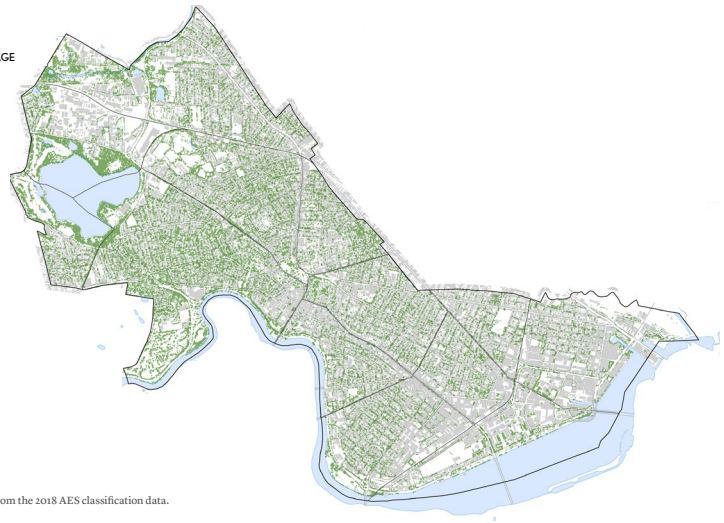
Source: Prepared by RH Team according to the 2018 AES classification data.

More vulnerable populations tend to live in areas of Cambridge with **less canopy** cover.

Density, urban form, and land use tend to limit opportunities for tree planting in these neighborhoods.

WHERE IS CANOPY COVER TODAY?

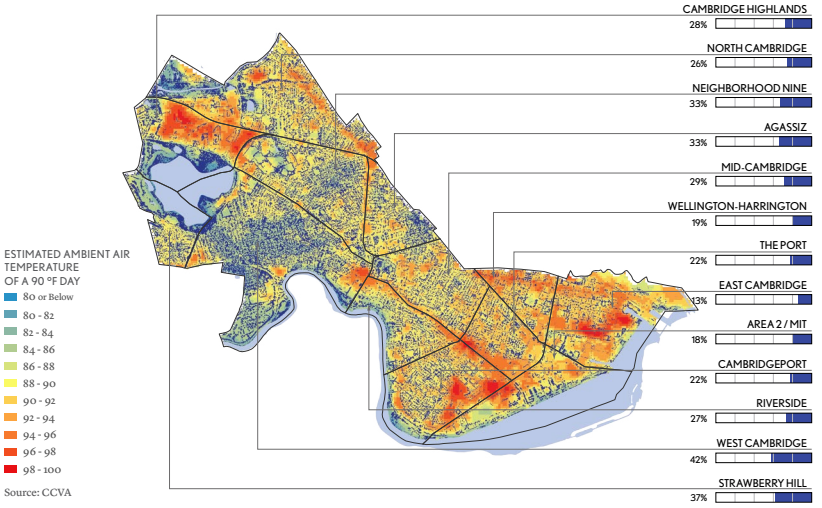
CAMBRIDGE CANOPY COVERAGE
25.3% OF CITY LAND AREA



DRAFT

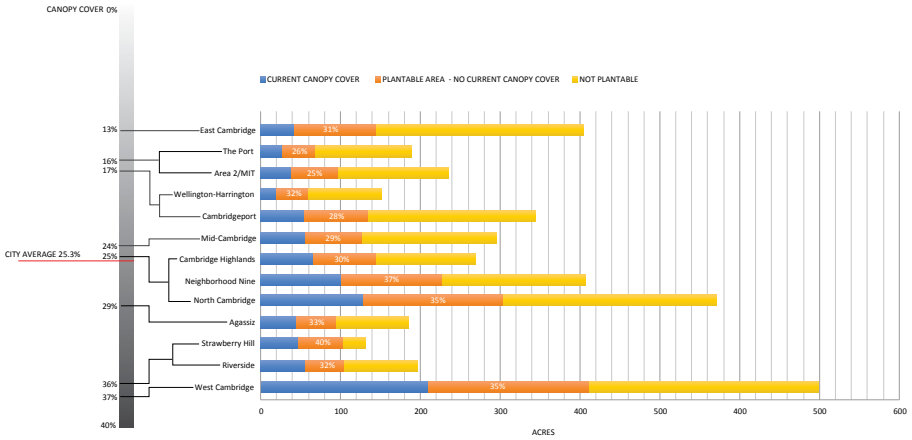
Source: Prepared by RH Team from the 2018 AES classification data.

URBAN HEAT ISLANDS ALIGN WITH LACK OF CANOPY



Source: CCVA

CANOPY COVER AND PLANTABLE AREA BY NEIGHBORHOOD



DRAFT

Source: Prepared by RH Team from the 2018 AES classification data.

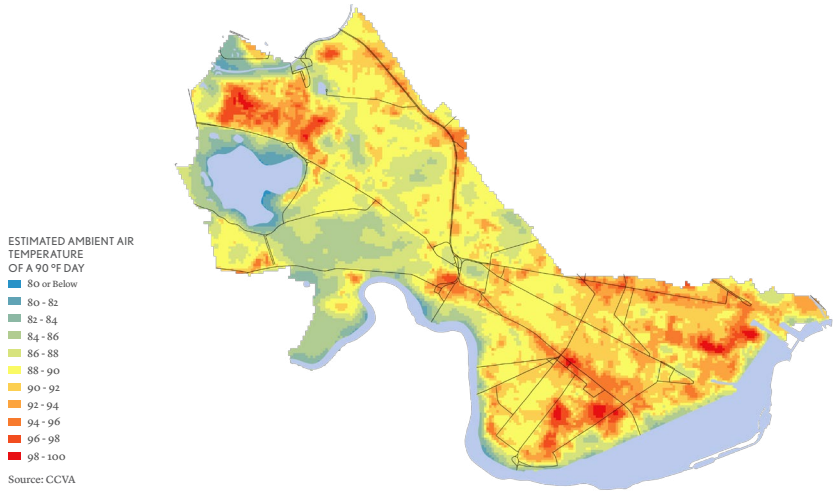
OBSERVATION | HUMAN EXPERIENCE

Lack of shade, resulting in **heat island** effect, is often aligned with primary pedestrian corridors and commercial centers (squares).

As summer temperatures rise, developing connective corridors of shade (**cool corridors**) will be increasingly important.

CRITICAL URBAN CORRIDORS LACK SHADE

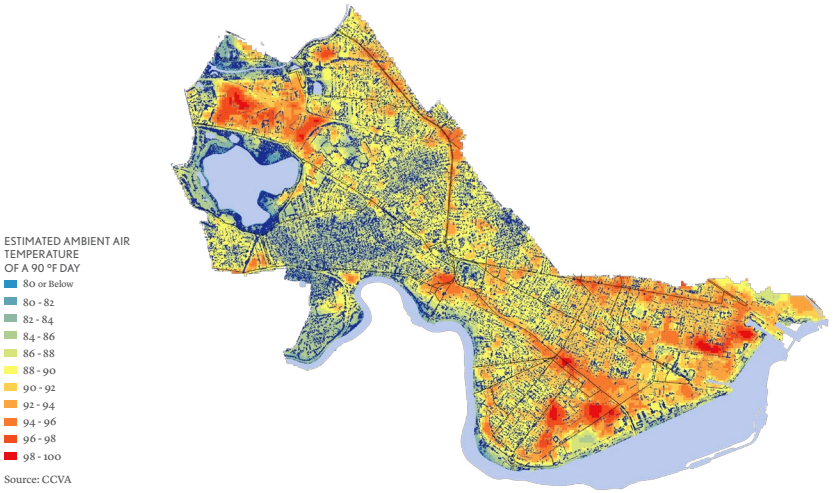
Heat island + bus routes (cool corridors)



Source: CCVA

CRITICAL URBAN CORRIDORS LACK SHADE

Heat island + bus routes (cool corridors)



Source: CCVA

PROJECT SCOPE

ANALYTICS / RESEARCH

PRACTICE

REGULATORY / POLICY RESEARCH

OPEN HOUSE

PRACTICE | URBAN FORESTRY

Cambridge has a strong and growing department

— Forestry Budget: $18 per capita in 2016 and $19.75 per capita 2017. (Compare with $7.30 average per capita spending for other Tree Cities in MA)

— Today the average municipal expenditure on tree planting in U.S. is $5.83 per capita (Nature Conservancy report)

— 6 out of 8 forestry staff are certified arborists

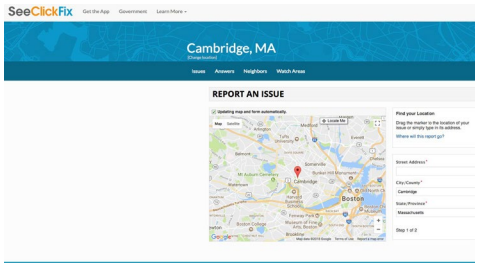
— Forestry division growing

— Cartegraph, new Tree tracking system

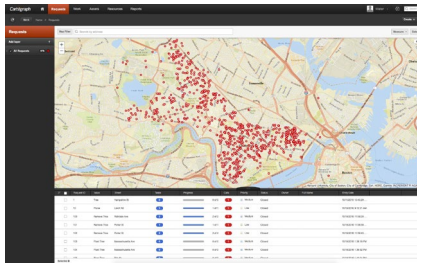
TREE CITY USA®

ABOVE GROUND | TREE REMOVALS

Canopy issues are currently identified and tracked electronically



SEE -CLICK-FIX



CARTEGRAPH

SOILS MANAGEMENT IS AS IMPORTANT AS CANOPY MANAGEMENT

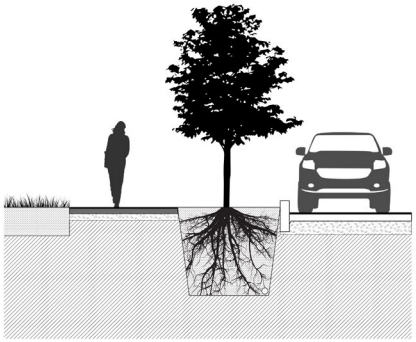
Tree soils section / axonometric view

Soil sample analysis

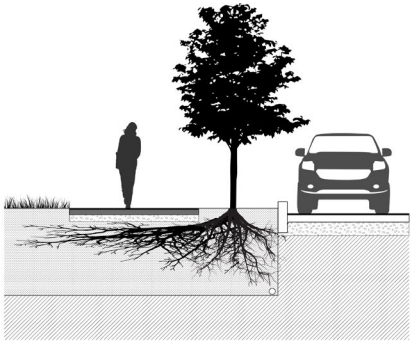
PLANTING DETAILS IMPACT LONG TERM SURVIVAL OF STREET TREES

Strategies maximize soil volumes

Ideal volume: 1250 cu ft per tree



TREES CONFINED IN PITS



TREEWAYS WITH STRUCTURAL SOIL UNDER SIDEWALKS

PROJECT SCOPE

ANALYTICS / RESEARCH

PRACTICE

REGULATORY / POLICY RESEARCH

OPEN HOUSE

CURRENT STATE REGULATIONS | SHADE TREES

M.G.L. Chapter 87: Shade Trees

— Applies to trees within the public right of way or within 20 feet of the public way with Tree Warden & Owner's consent

— Establishes powers for tree wardens

— Removal of healthy public shade trees requires advertised public hearing

— Trees that pose immediate hazards do not require a hearing to be removed

CURRENT CITY REGULATIONS

City Tree Removal Policy

City Tree Protection Ordinance
— Tree Replacement Fund
— Enforcement

City Zoning Articles 5 & 19
— Tree Study
— Tree Protection Plan

City Zoning Article 20 (Overlay Districts)
— Parkway Overlay
— Prospect Street Overlay

https://www.urbanforestprofessionals.com/wp-content/uploads/UrbanForestPro-68.jpg

Committee on Public Planting

— Advises City Council, City Manager, Public Works Commissioner, and other department heads on public planting issues

Tree Ambassador/Water by bike

— Paid summer position inspect, weed, and water young street trees via bicycle and cargo trailer

Planting Requests

— If a tree was removed from an existing well and you would like a replacement there is no expense to you

— If you'd like to have a tree planted where no tree well currently exists, the City will inspect the area and determine if it is suitable

Back of Sidewalk Program

— If a tree cannot be planted within the public right of way, the City will plant trees along the back of the sidewalk (up to 20 feet from the public way) on private property of interested, eligible owners

Adopt-a-Tree Program

— Residents commit to water and tending a tree near a specific address (home, school, business, etc.)

Commemorative Tree Program

— For cost of $200 you can receive purchase a tree in remembrance of a loved one or important event

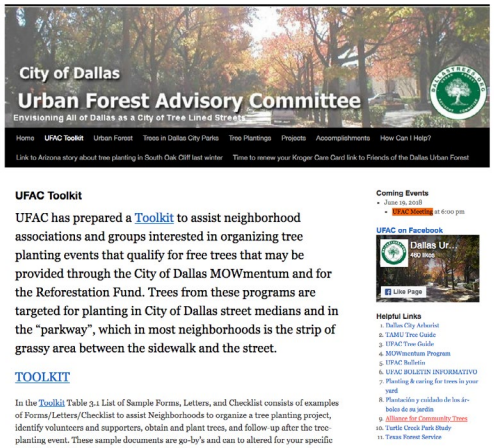
Seattle, WA

Atlanta, GA

Nashville, TN

Arlington, VA

Dallas, TX



Feasibility Survey/Study

— Why are things working or not working

— Insights about what will be well-suited for Cambridge

— Narrowing the world of possibilities – not supporting a particular policy or proposal

https://nexusofchange.wordpress.com/2012/04/08/occupy-atlanta-surveys-public-opinion-for-better-society/

PROJECT SCOPE

ANALYTICS / RESEARCH

PRACTICE

REGULATORY / POLICY RESEARCH

OPEN HOUSE

www.cambridgema.gov/ufmp

Today, Cambridge has **26%** of its land area covered by canopy.

Between 2009 and 2018, Cambridge's canopy declined on average by 16.4 acres* every year.

At this rate, canopy cover would be **21.6% in 2030**.

*per updated analysis for the period between 2009 to 2018.

Data in this study has been modified using an updated analysis of the loss rate between 2009 and 2018 rather than 2014 and 2018.

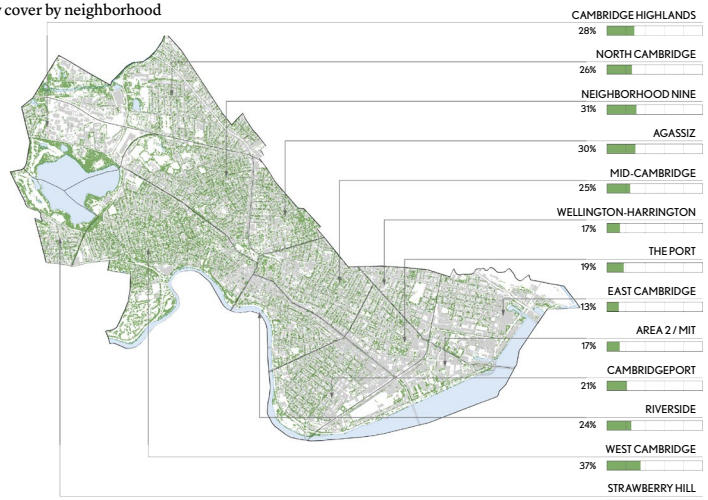
Ongoing research by University of Vermont will provide a final analysis of 2018 canopy.

The distribution of canopy across the city is **not equitable.**

More vulnerable populations tend to live in areas of Cambridge with **less canopy** cover.

TREE CANOPY COVER

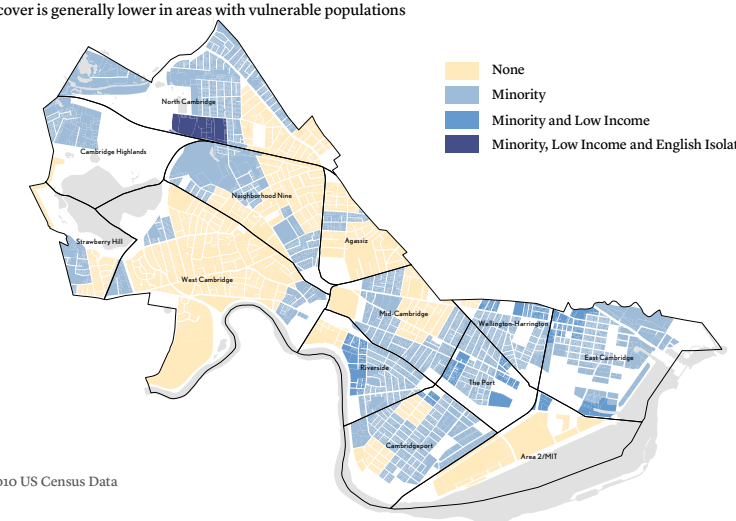
2018 canopy cover by neighborhood



Source: CUFMP 2018 canopy layer and City GIS data.

VULNERABLE POPULATIONS

Canopy cover is generally lower in areas with vulnerable populations

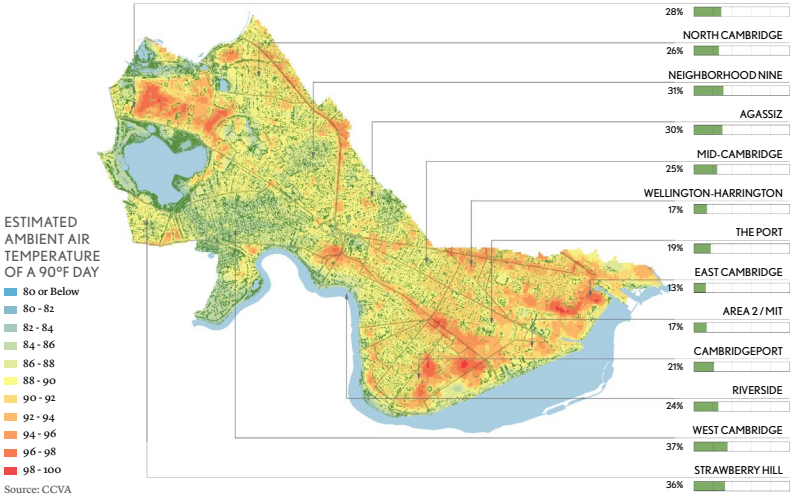


Source: 2010 US Census Data

As summer temperatures rise,
the impacts of the **urban heat island**
will be more intensely felt by the **most vulnerable**.

URBAN HEAT ISLAND AND CANOPY COVER

Predicted heat impacts 2030

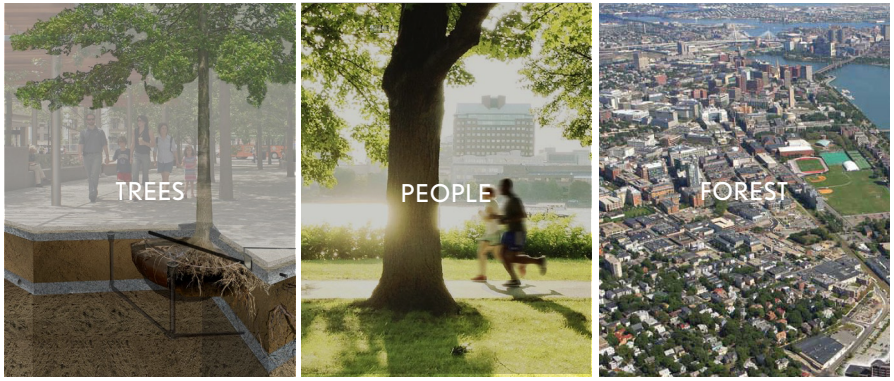


CHARGE

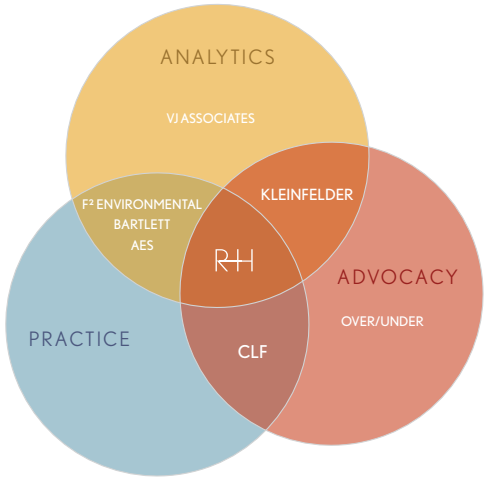
To maintain, plan, build, and sustain a healthy, connective urban forest at a time when the urban forest is more important than ever before.

APPROACH

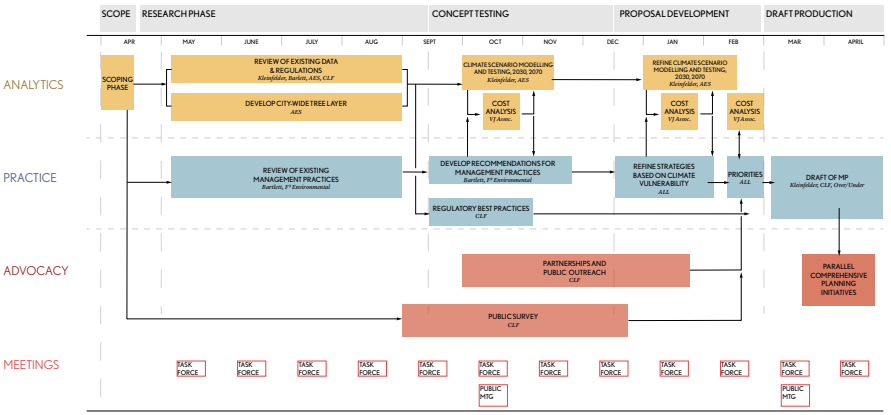
Healthy and Connected Systems



PROJECT TEAM



PROJECT SCHEDULE



RESEARCH FINDINGS

RESPONSE STRATEGIES

NEXT STEPS

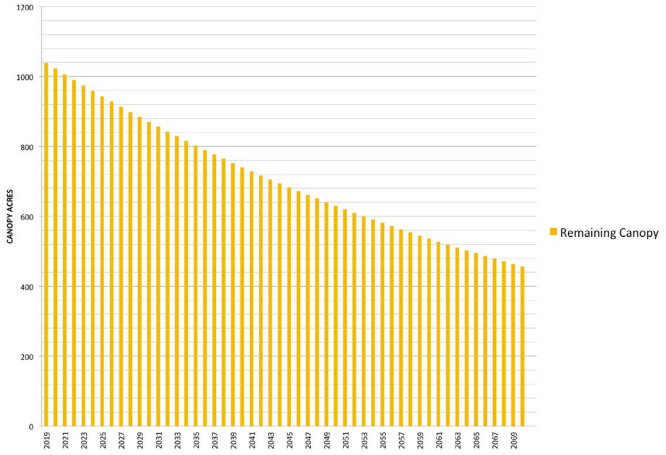
OPEN HOUSE

WHAT'S HAPPENING?

The percent of the city covered by canopy is declining.

WHAT'S HAPPENING?

The trend is for continued loss (1.6%/year)



Graph assumptions: 1.6% annual net loss rate from 2009 to 2018 derived from CUFMP 2018 canopy analysis

WHAT'S HAPPENING?

Forest cover trends are regional

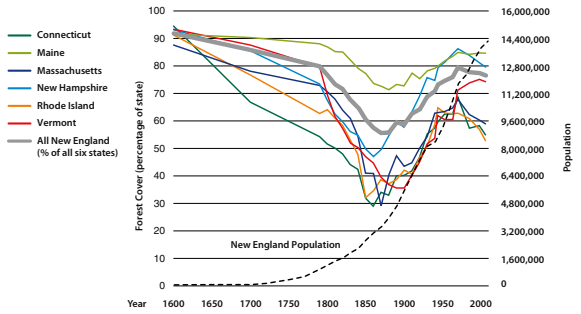
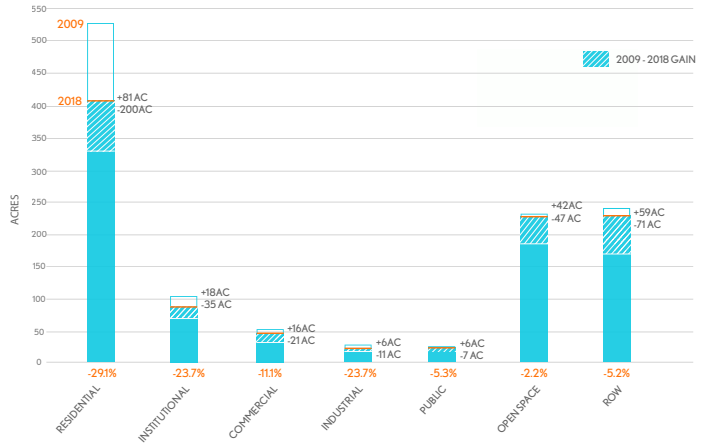


FIGURE 1: *Long-term trends in forest cover and human population in the six New England states shows that even as the population grew, forest cover increased between 1850 and the early 2000s. In recent years, forest cover has again declined due to conversion of forests to developed land.*

Source: "Changes to the Land: Four Scenarios for the Future of the Massachusetts Landscape", Harvard Forest, Thompson, et. al., 2014

WHERE IS IT HAPPENING?

The highest rates of loss are on Residential, Industrial, and Institutional land uses



Source: CUFMP 2018 canopy analysis and City GIS data.

WHY IS IT HAPPENING?

There is no one reason for canopy decline

Causes are historical, systemic, and cumulative...

WHY IS IT HAPPENING?

Planting happens in cycles along with residential development

Properties with homes built around 1920 have unusually high percentage of tree canopy. These trees are now likely reaching maturity. Development tapered off after 1930 so we can surmise that the residential canopy will also begin to taper off as those trees age.

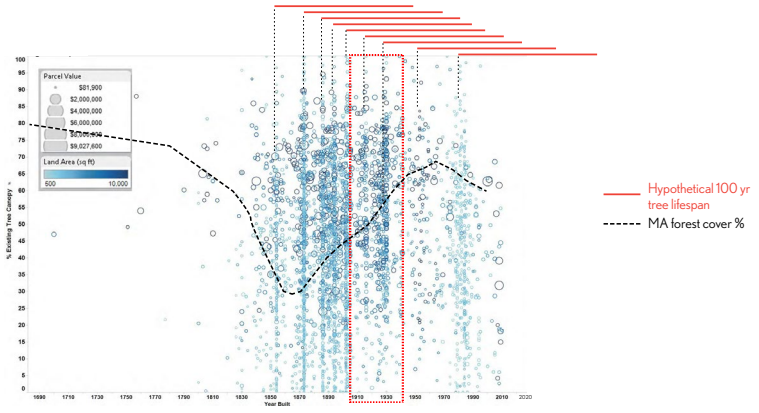
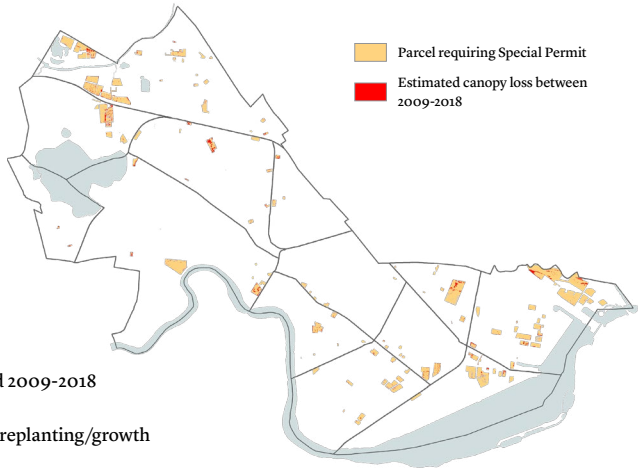


Figure 8: % Existing Tree Canopy in relation to year built, parcel value, and land area for single family residential parcels.
Source: UVM, "A Report on the City of Cambridge's Existing and Possible Tree Canopy", 6/1/12

WHY IS IT HAPPENING?

Special permits for large projects only account for 4.7% percent of loss over the last 10 years



207 acres (148 projects)

20.1 acres of canopy in 2009

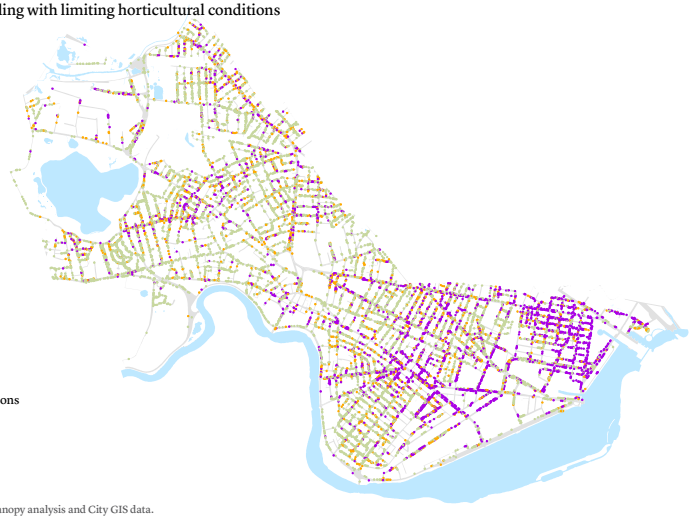
12.9 acres (~1,484 trees) removed 2009-2018

7.8 acres of net canopy loss after replanting/growth

Source: CUFMP 2018 canopy analysis and City GIS data.

WHY IS IT HAPPENING?

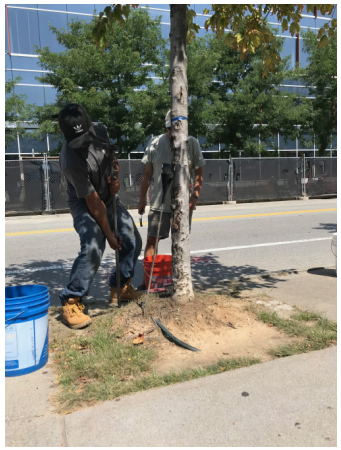
Trees are struggling with limiting horticultural conditions



Source: CUFMP 2018 canopy analysis and City GIS data.

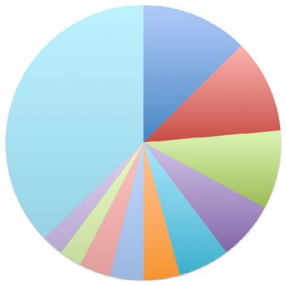
WHY IS IT HAPPENING?

Soils are overly compacted, have low nutrient cycling and have limiting drainage



WHAT ARE FUTURE RISKS?

Existing species makeup is susceptible to climate risks of increased pests/diseases, drought and flooding



SPECIES	% OF CANOPY	SUSCEPTIBILITY TO CLIMATE RISKS
Norway Maple	13%	medium
Pin Oak	11%	medium
Honey locust	9%	low
Red Maple	7%	high
Red Oak	6%	high
Littleaf Linden	4%	medium
Callery Pear	4%	high
London Planetree	4%	medium
Ash	3%	high
Crabapple	3%	high
Other	36%	

Source: CUFMP 2018 canopy analysis.

RESEARCH FINDINGS

RESPONSE STRATEGIES

NEXT STEPS

OPEN HOUSE

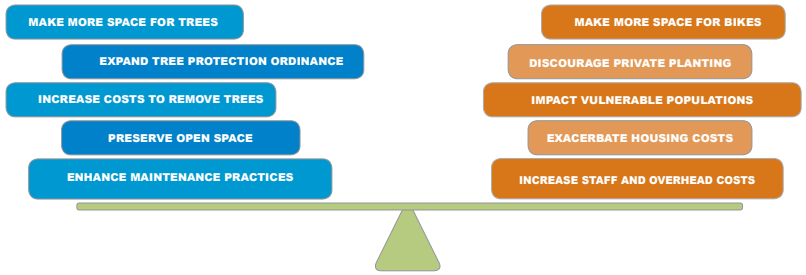
RESPONSE STRATEGIES

There are two primary approaches to reversing the current trend of urban forest contraction —

Curb the loss of existing trees

Grow canopy by planting new trees

BALANCE COMPETING PRIORITIES



CORE CONCEPTS

— Value the forest as a public resource

— Invest in canopy in the public realm

— Share responsibility for a healthy forest

CORE CONCEPTS

Value the forest as a public resource

The urban forest is a public resource and has **measurable value and impacts** everyone. It provides shade to cool our environment, gives scale and character to our streets, provides habitat for diverse species, improves our air quality, reduces stormwater impacts, and improves our health and well-being.

To shift the trend from increasing loss to sustainable growth, we must manage the urban forest as **urban infrastructure** (like water, sewer, power) investing for the long term, managing resources collectively, and understanding the value (ie., ecosystem services) of the canopy.

To balance the value of the forest with the complex needs of the city, we should focus on the performance of the **forest as a system** over the specific value of individual trees.

THE BENEFITS OF THE URBAN FOREST
Ecological, cultural and economic values

Table 5
Urban tree benefits reported in the 115 research papers on urban trees examined in this study.

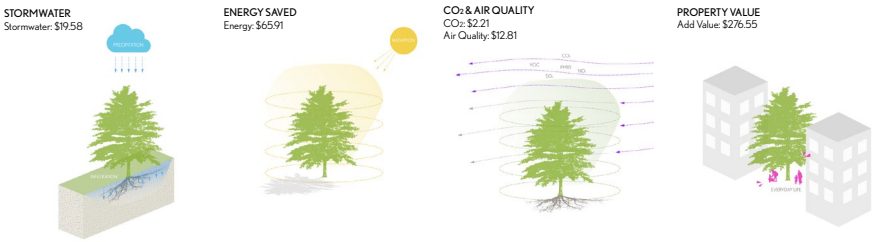
Benefits	Discussed	Demonstrated
Social benefits	7	5
Making urban environment more pleasant to live, work and spend leisure time	3	2
Providing significant outdoor leisure/recreation opportunities	3	2
Providing nature in the city	1	1
Enhancing quality of urban life	5	3
Promoting environmental responsibility and ethics	1	–
Building stronger sense of community	1	–
Enhancing community's sense of social identity and self esteem	1	–
Providing settings for significant emotional and spiritual experiences	1	–
Providing opportunities for inner city children to experience nature	1	–
Economic benefits	28	27
Saving substantially on fuel expenditure	1	–
Increasing land value	3	3
Increasing property value	13	12
Increasing rental price	1	1
Increasing neighbouring property value	2	1
Reducing 'time on market' for selling property	1	1
Increasing property taxes	1	–
Increasing tourism revenue	1	–
Increasing business activity	1	–
Contributing to the economic vitality of the city	1	–
Providing annual returns on municipal investments	2	1
Alleviating the hardships of inner city living for low – income groups	1	–
Reducing expenditure on air pollution removal	7	6
Reducing expenditure on storm water infrastructure	4	3
Saving annual heating and cooling costs	2	2
Savings on electricity costs	1	1
Avoiding investment in new power supplies	3	2
Providing potential for future carbon offsetting trade	2	2

Table 6
Urban tree ecosystem services reported in the 115 research papers on urban trees examined in this study.

Ecosystem services	Discussed	Demonstrated
Carbon related ecosystem services	30	27
Storing/sequestering carbon	30	27
Air quality related ecosystem services	38	34
Producing oxygen	2	2
Filtering air	11	9
Removing ozone	18	16
Removing carbon monoxide	12	10
Removing sulphur dioxide	17	15
Removing nitrogen dioxide	15	14
Removing airborne particle matters/suspended particles	22	20
Removing dust	1	1
Reducing smog	3	3
Reducing carbon dioxide emissions	9	8
Storm water related ecosystem services	10	9
Reducing rate of storm water runoff	10	9
Reducing volume of storm water runoff	8	7
Reducing flooding damage	4	3
Reducing water quality problems	3	2
Recharging ground water	1	1
Energy related ecosystem services	20	18
Reducing annual energy use	14	11
Reducing summer time energy use	5	5
Reducing seasonal cooling energy	4	4
Reducing carbon dioxide emission from power plants	3	2
Habitat related ecosystem services	7	5
Providing habitat for wildlife	7	5
Enhancing biodiversity	1	–
Providing stability to urban ecosystems	1	–
Noise related ecosystem services	8	5
Reducing noise	8	5
Reducing apparent loudness	2	1
Micro climate related ecosystem services	25	25
Providing shade	16	16
Reducing solar radiation	4	4
Modifying microclimate	9	
Reducing relative humidity	1	1
Reducing air temperature	15	15
Reducing heat island effect	10	10
Reduction of glare/reflection	3	3
Controlling wind	6	6

Source: Roy, et al., Urban Forestry and Urban Greening, 2012

THE BENEFITS OF THE URBAN FOREST
Infrastructure Performance



Ecosystem services for an average Pin Oak in Cambridge
Source: i-Tree Streets - Annual Savings for Average Pin Oak in Cambridge

THE BENEFITS OF THE URBAN FOREST
Physical Health and Mental Wellbeing

- Improved air quality and less urban heat
- Lower risk of diseases and mortality rate
- Lower stress levels
- Better cognitive function in students
- Improved attention among children
- Enhanced performance in the workplace
- Lower risk of mental health disorders

Source: Wolf, K.L., S. Krueger, and M.A. Rozance. 2014. Stress, Wellness & Physiology - A Literature Review.
In: Green Cities: Good Health (www.greenhealth.washington.edu). College of the Environment, University of Washington.

CORE CONCEPTS

Invest in canopy in the public realm

The urban forest is felt most strongly in our **public realm and common spaces** (sidewalks, front yards, parks, schoolyards, and commercial and institutional campuses).

Enhancing the canopy within the public realm, where the impact of loss is felt most strongly and the significance of gain is most equitably distributed, deserves our **primary attention and investment**. Specifically prioritize:

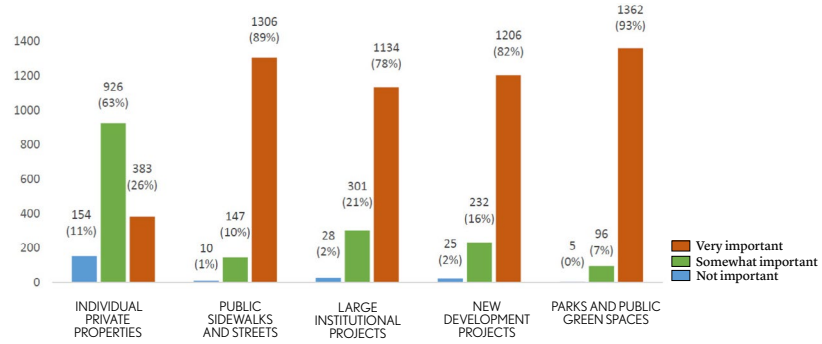
Canopy corridor
A resilient, connected ecosystem that enhances shading and cooling along networks and connects green spaces across the City relies on thriving trees within the public right of way, publicly accessible spaces, and front yards and private lands that front on the public realm.

Areas of canopy deficit and inequity
A more evenly distributed forest increases equity in the distribution of canopy cover, reduces disproportionate impacts urban heat island effects, and increases the well-being of vulnerable populations.

PUBLIC SURVEY RESULTS

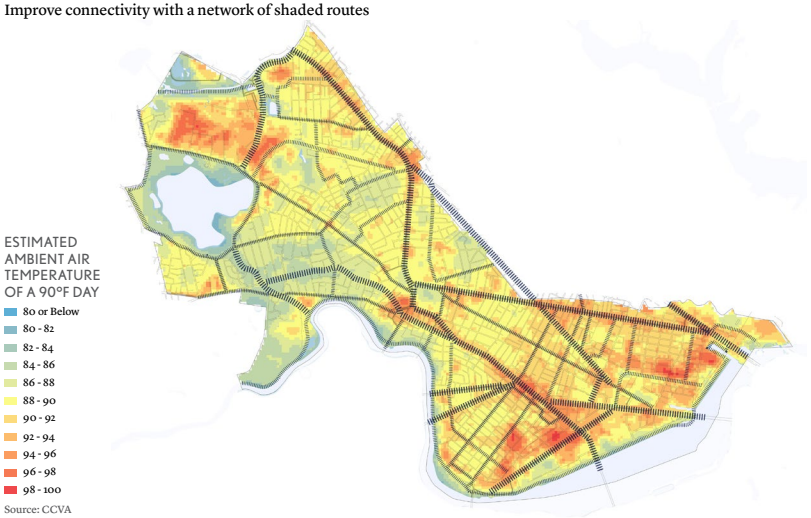
People value the trees in the public realm

A majority (55%) stated that **public sidewalks and streets** were the **single most important** location to plant new trees when asked a follow up question about the single most important location



HEAT ISLANDS AND CANOPY CORRIDORS

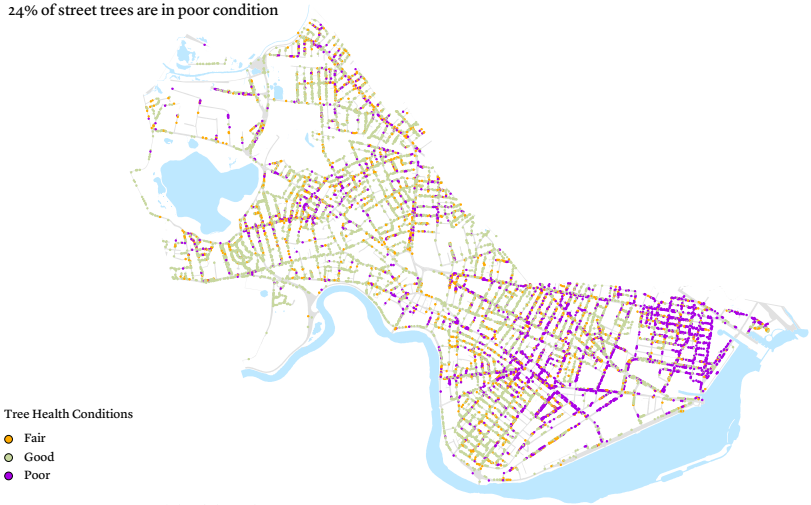
Improve connectivity with a network of shaded routes



Source: CCVA

CONDITION OF STREET TREES

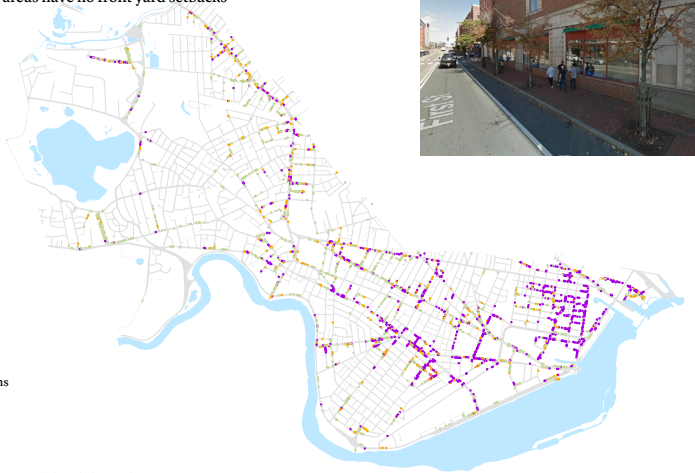
24% of street trees are in poor condition



Source: CUFMP 2018 canopy analysis and City GIS data.

CONDITION OF STREET TREES

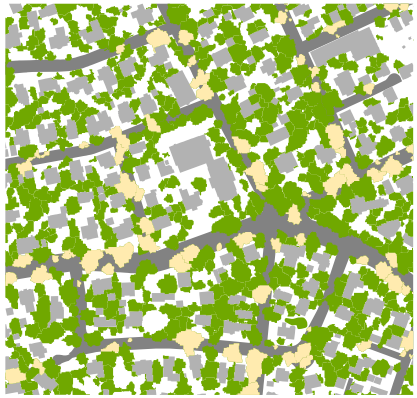
39% of trees in sidewalks greater than 8' are in poor condition. Frequently these areas have no front yard setbacks



Source: CUFMP 2018 canopy analysis and City GIS data.

R.O.W. CANOPY

Areas without front yard setbacks rely on street trees for canopy



WEST CAMBRIDGE

EAST CAMBRIDGE

STREET TREE CANOPY

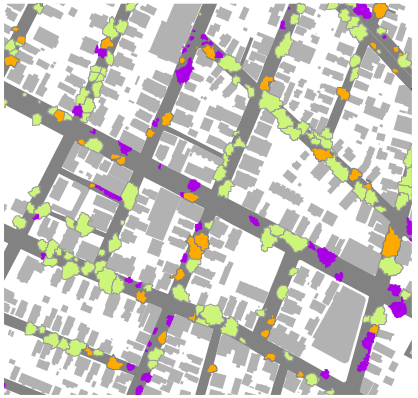
OTHER CANOPY

Source: CUFMP 2018 canopy analysis and City GIS data.

R.O.W. CANOPY

Street trees with setbacks are in better condition

WEST CAMBRIDGE



EAST CAMBRIDGE

GOOD CONDITION

FAIR CONDITION

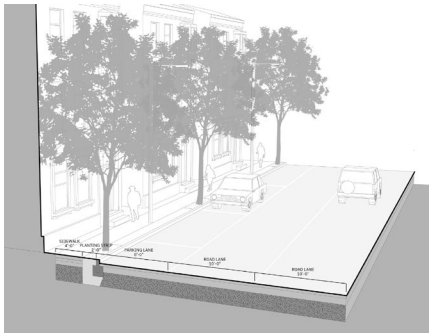
POOR CONDITION

Source: CUFMP 2018 canopy analysis and City GIS data.

R.O.W. CANOPY

Front yard setbacks

WEST CAMBRIDGE



EAST CAMBRIDGE

CORE CONCEPTS

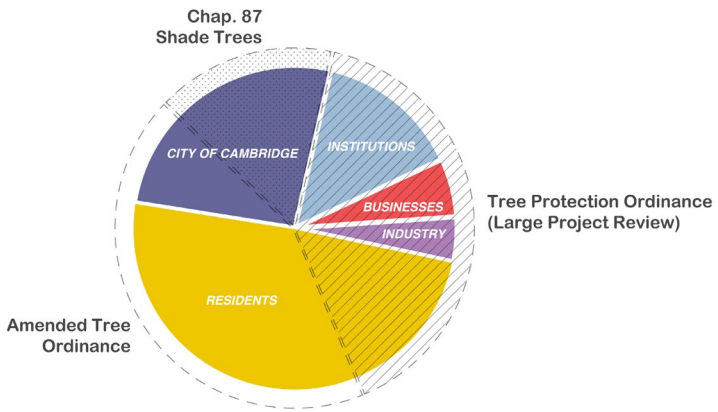
Share responsibility for a healthy forest

A thriving urban forest requires the **mutual care of many parties**, including city government, homeowners, businesses, developers, local organizations, institutions and state agencies.

Policy should be **balanced and fair**, linking the interests of all parties around smart solutions that encourage tree preservation, planting of new trees, and effective maintenance.

The city should support **education** efforts and as a catalyst for **partnerships** between interest groups to encourage stewardship of the urban forest.

SHARE RESPONSIBILITY + COMBINE ACTION



ENACT VALUES THROUGH A MULTI-PRONGED APPROACH

DRAFT

Curb loss

- Enhance management practices, especially around soil health, that improve tree vitality and longevity
- Protect exceptional trees of unique age and size
- Increase the cost of removals for large projects (de-incentivize removal and increase mitigation when retention is not possible)
- Enhance the city permitting and review process to track and seek alternatives to tree removals
- Educate residents on the value of their canopy as an important ecological/health resource for themselves and their community

Grow canopy

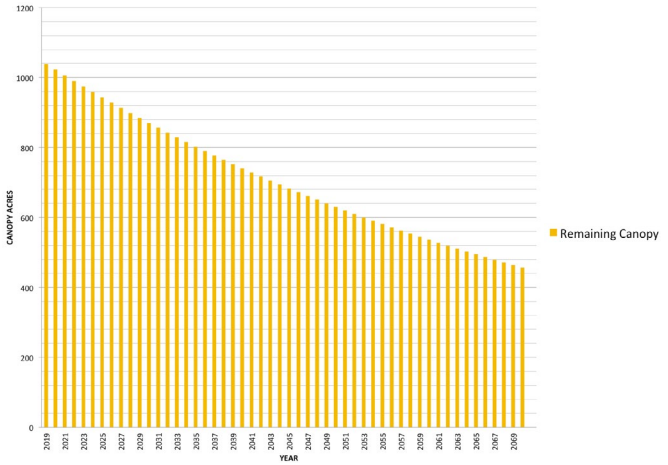
- Increase rate of planting within the public realm
- Enhance soil specifications and planting details to improve establishment and long-term success
- Develop alternative approaches to public realm design that increase opportunities, expand plantable areas, and enhance viability
- Provide resources for planting and maintenance to private landowners, especially in front yards
- Educate the public about the resources that are available and increase trust within the community
- Partner with local institutions and landowners to make commitments, set internal targets, and support community-wide goals
- Implement comprehensive zoning guidelines that represent the value of trees
- Modify recommended species and diversify forest to respond to a changing climate and increased risks of pests and diseases

Encourage alternative approaches that advance the goals of the Urban Forest Master Plan

- De-pave and enhance permeability
- Implement green roofs and living structures
- Encourage alternative shade structures where trees are not viable

CURBING LOSS AND GROWING CANOPY

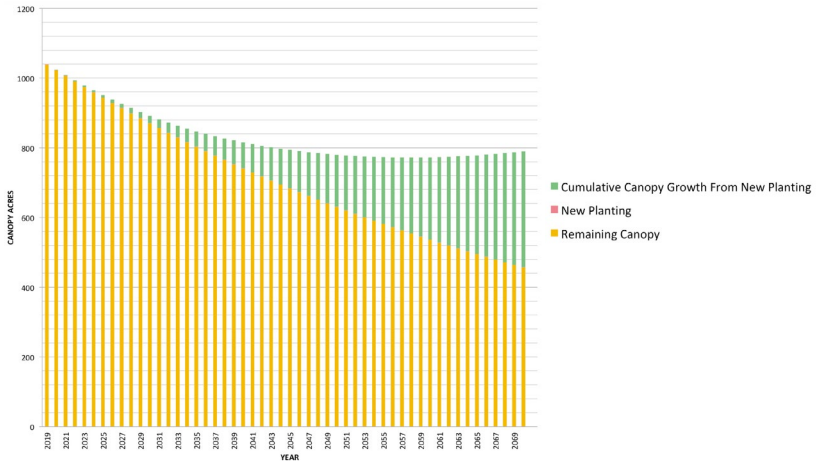
If the mortality rate remains unchanged with the current rate of planting ...



Graph assumptions: 1.6% annual net loss rate from 2009 to 2018 derived from CUFMP 2018 canopy analysis

CURBING LOSS AND GROWING CANOPY

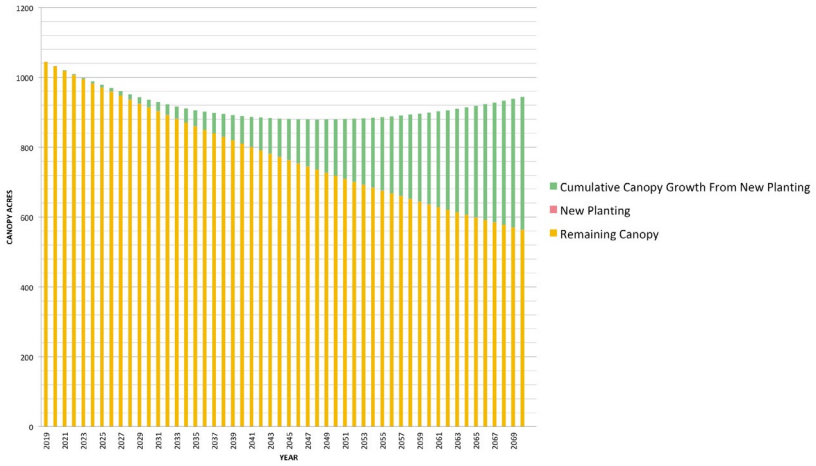
If the current mortality rate unchanged but plant 1,000 additional trees/yr citywide...



Graph assumptions: 1.6% annual net loss rate from 2009 to 2018 derived from CUFMP 2018 canopy analysis

CURBING LOSS AND GROWING CANOPY

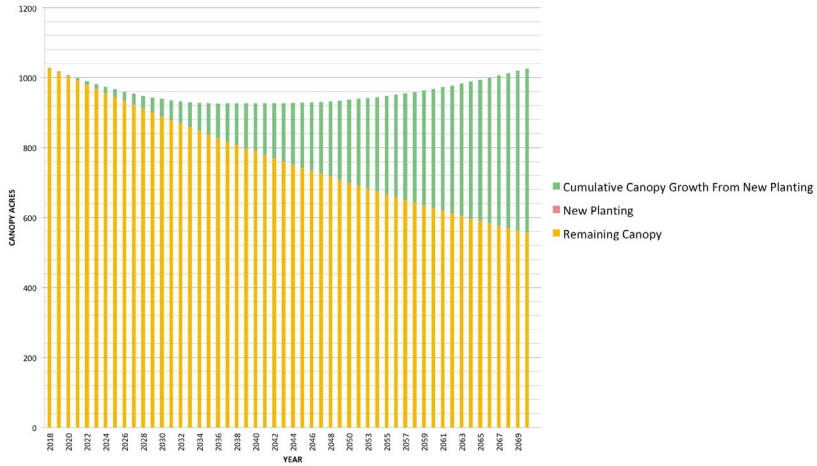
If we curb loss by 25% and plant 1,000 additional trees/yr citywide ...



Graph assumptions: 1.6% annual net loss rate from 2009 to 2018 derived from CUFMP 2018 canopy analysis

CURBING LOSS AND GROWING CANOPY

If we curb loss by 25% and plant 3,000 additional trees/yr for 5 yrs then 1,000 additional trees/yr citywide...



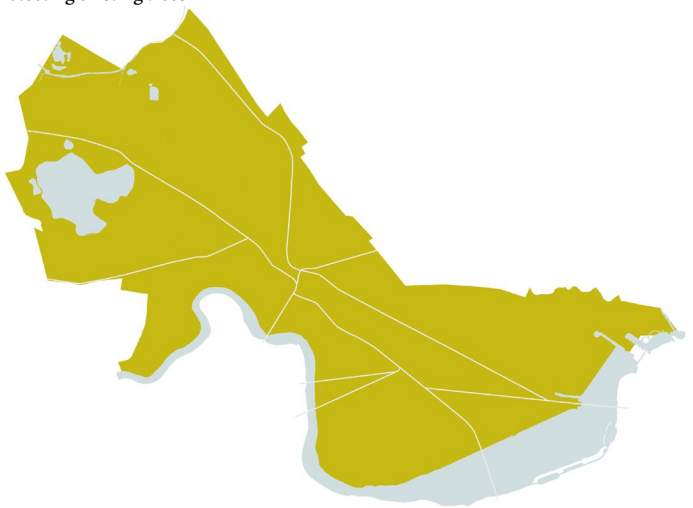
Graph assumptions: 1.6% annual net loss rate from 2009 to 2018 derived from CUFMP 2018 canopy analysis

RESPONSE STRATEGIES

		STRATEGIES														
		Policy			Planning/Design					Practices				Outreach/Other		
		Enhance Current Tree Protection Ordinance	Formalize City Practices	Integrate Canopy Values into Planning and Zoning	Leverage Envision Cambridge and CCPR planning studies	Restrict Street Tree Planting to Only Suitable Areas	Create New Typologies for Street Tree Planting	Implement City-Wide Planting Plan to Focus Efforts	Site New Parks/Open Spaces Strategically	Improve City Planting Practices	Improve City Maintenance and Care Practices	Implement Soils Management Program	Monitor Tree Canopy and Adapt	Invest in Educational Programs	Build Community Partnerships	Seek Alternative Green Strategies
ACTION	in response to ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Curb loss	Mature canopy decline	•													•	
	Land conversion	•		•	•							•			•	
	Residential removals	•		•										•	•	
	Poor tree condition	•	•	•		•				•	•	•		•	•	
	Narrow sidewalks			•		•										•
	Inadequate soil volume			•		•				•		•				
	Understanding the value of trees													•	•	
Grow canopy	Equity in distribution of canopy cover	•	•	•	•		•	•	•	•	•	•	•	•	•	
	Shading and cooling / pedestrian thermal comfort	•	•	•	•		•	•	•	•	•	•	•		•	
	Environmental quality / wellbeing and public health	•	•	•	•		•	•	•	•	•	•	•		•	•
	Ecological connectivity	•		•	•		•	•	•	•	•	•	•			•
	Diversity of forest composition						•	•		•			•			
	Disaster response preparedness				•			•		•			•	•	•	•

PLANNING APPROACH

Curb loss by protecting existing trees



POLICY STRATEGIES

1. Enhance Tree Protection Ordinance
    a. Change the definition of Significant Trees
    b. Create an "Exceptional Tree" category
    c. Change mitigation requirements
2. Enhance the role of the Committee on Public Planting
3. Expand tree protections to private property
4. Earmark Tree Replacement Fund dollars for community grants
5. Align planting protocols with City's commitment to equity
6. Increase oversight to ensure compliance
7. Strengthen zoning ordinance requirements
    a. Establish canopy coverage requirements
    b. Increase ratios for trees to parking spaces and/or dwelling units
    c. Increase setback and open space requirements in priority areas
    d. Establish flexible landscape mandate like Green Factor or Green Area Ratio
    e. Resilience Task Force zoning opportunity

ENHANCE PRACTICES

MONITOR
—Increase tree assessments
—Expand pest monitoring
—Expand Cartegraph tracking to monitor success of practices

REMEDIATE
—Manage soils
  —Liquid biological amendments
  —Decompaction/Aeration
—Treat private trees during severe pest outbreaks (EAB)

PLANT
—Enhance soil specs
—Ensure proper drainage
— Plant bare root trees

MAINTAIN
—Formalize a City-wide management plan
—Manage soils
  —Mulching
  —Liquid biological amendments
—Structural pruning for young trees
—Expand watering program

EDUCATION / OUTREACH STRATEGIES

Educate the public on the value of trees and how to be stewards of them.

Empower existing NGOs to plant and maintain more trees, including on private property.

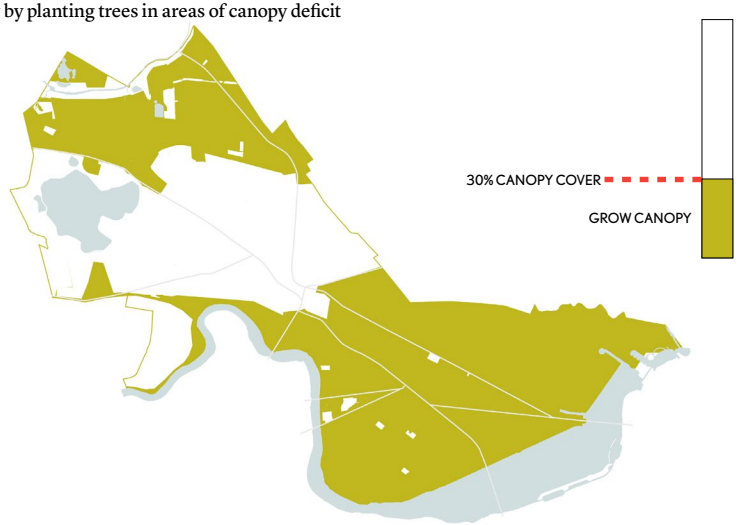
Educate city staff, institutions, and other grounds managers on the value of trees and how to be stewards of them.

Support community employment and involvement in tree planting and constructing bioswales.

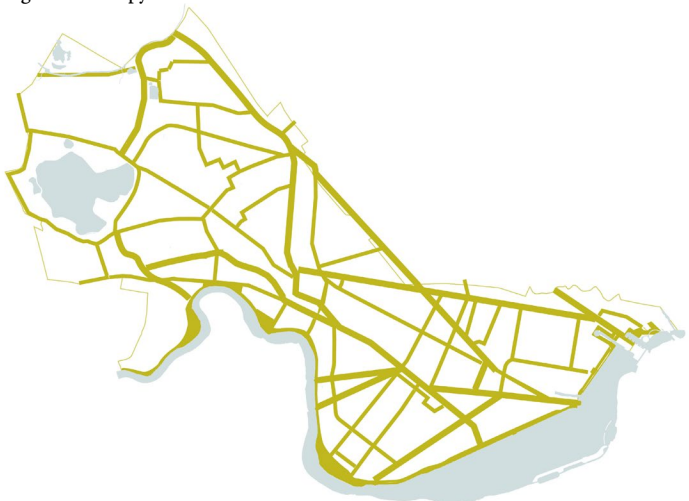
Build capacity of existing NGOs through partnerships with national organizations.

PLANNING APPROACH

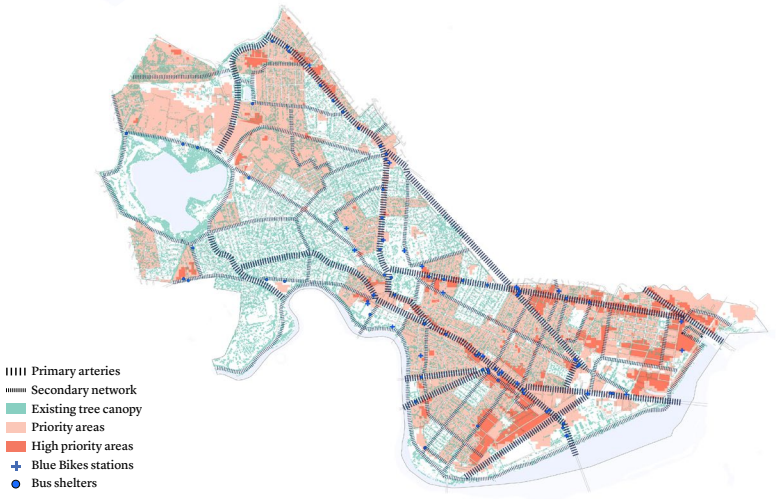
Grow canopy by planting trees in areas of canopy deficit



PLANNING APPROACH
Focus on creating robust canopy corridors



PRIORITIZE EFFORTS



PRIORITY AREA CRITERIA

ENVIRONMENTALLY VULNERABLE POPULATIONS

Minority population
Low income population
Non English speaking population

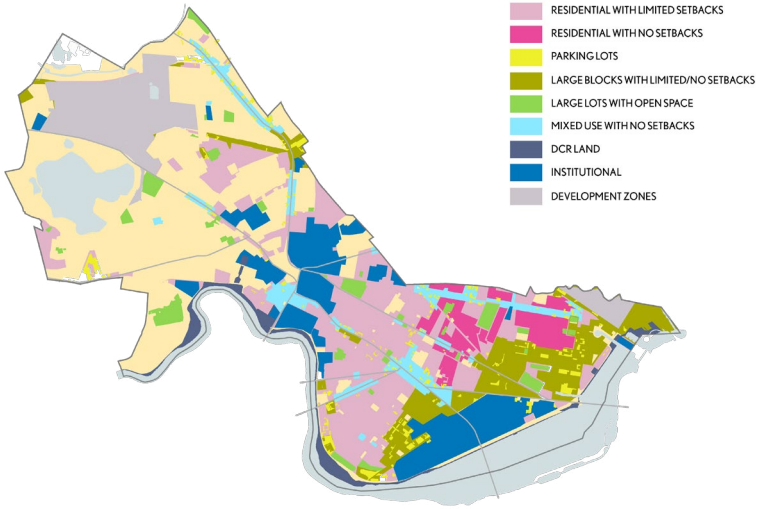
HEAT ISLAND HOT SPOTS

Greater than 92 degrees
on a 90 degree day
as modeled by KLF for 2030
ambient air temperature

COMMUNITY INFRASTRUCTURE

Public Schools and Hospitals

GROW CANOPY
Align strategies with site conditions and uses



SIDEWALK WIDTH + FRONT YARD SETBACK

SIDEWALKS LESS THAN 6' WIDE

SIDEWALKS BETWEEN 6' AND 8'

SIDEWALKS 8' OR GREATER

FRONT YARD SETBACKS GREATER THAN 10'

LIMITED SETBACKS

NO REQUIRED SETBACKS

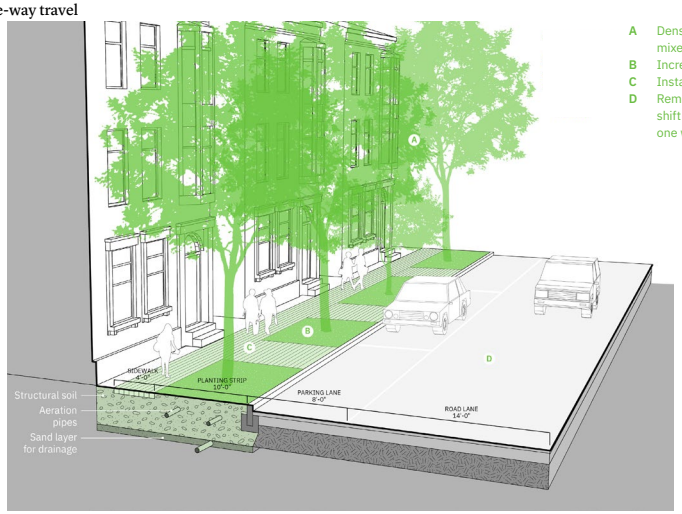
ALTERNATIVE DESIGN STRATEGIES: MAJOR STREETS, WIDE SIDEWALKS

Staggered trees with permeable paving

- **A** Densify tree planting
- **B** Install porous pavement
- **C** Increase the soil volume
- **D** Extend soil volume to the buildings

ALTERNATIVE DESIGN STRATEGIES: NARROW RESIDENTIAL STREETS, NO SETBACK

Lane diet, one-way travel



- **A** Densify planting with mixed species
- **B** Increase the soil volume
- **C** Install porous pavement
- **D** Remove pavement - shift two way traffic to one way

ALTERNATIVE DESIGN STRATEGIES: NARROW RESIDENTIAL STREETS WITH FRONT YARD

Planting area fit into parking lane

- **A** Alternate canopy and understory trees
- **B** Increase the soil volume
- **C** Remove pavement - bump out planting areas into parking lanes

RESEARCH FINDINGS

RESPONSE STRATEGIES

NEXT STEPS

OPEN HOUSE

NEXT STEPS

— Cost / Benefit Analysis

— Prioritization

— Refinement and Clarification

— Public Meeting #3

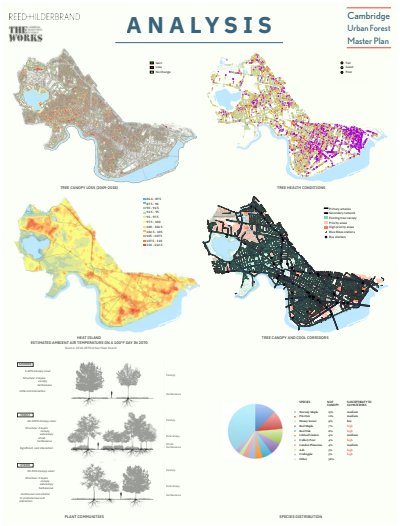
RESEARCH FINDINGS

RESPONSE STRATEGIES

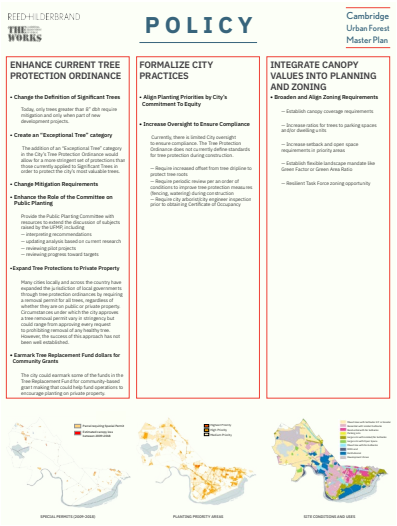
NEXT STEPS

OPEN HOUSE

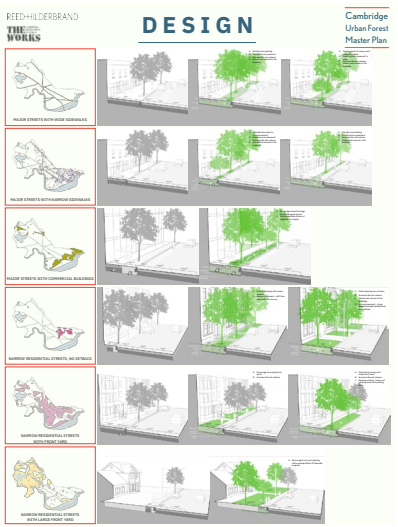
ANALYSIS



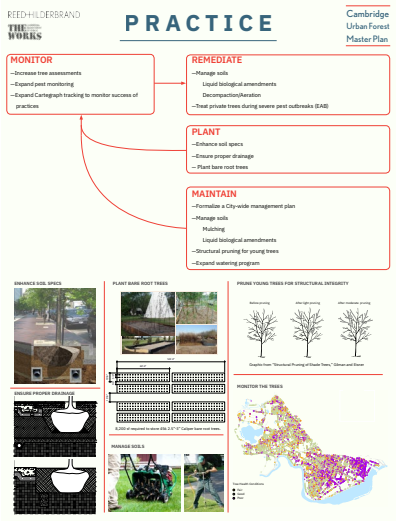
POLICY



DESIGN



PRACTICE



OUTREACH/EDUCATION

OPEN HOUSE

FURTHER INFORMATION

www.cambridgema.gov/ufmp

Design

cl like interspersing large + small species

Also suggest interspersing young + mature larger trees, so that when old trees die, there are large younger ones that are maturing.

White writing is unreadable

CAMBRIDGE URBAN FOREST MASTER PLAN

+ education of DPW around mitigation of rainwater runoff. Typical system designs today are a big underground tank which precludes tree planting.

CAMBRIDGE URBAN FOREST MASTER PLAN

CONSIDER REWARD RATHER THAN PUNITIVE MEASURES — NOT ONLY FOR PLANTING NEW TREES... BUT PARTICULA TO INCENTIVIZE MAINTAINING EXISTING LARGER, OLDER TREES — MAYBE A TAX CREDIT

CAMBRIDGE URBAN FOREST MASTER PLAN

- Please include bike lanes in your street designs
  - → Especially if you're thinking of making the streets narrower or taking out parking

CAMBRIDGE URBAN FOREST MASTER PLAN

Policy

- Site Conditions + Uses - clarify - setback means as required by zoning, not actual setback

- Planting Priority Areas - state ~~criteria for~~ how priority is determined

City needs policy for how city removes built up street tree wells (with soil + sides) + raised bed filled

City needs outreach/notification to property owner who installed raised bed.

CAMBRIDGE
URBAN FOREST
MASTER PLAN

- Please do an analysis of parcel ownership where tree loss has occurred (owner-occupied vs. a landlord with a few buildings vs. an assett management company with many buildings)

CAMBRIDGE
URBAN FOREST
MASTER PLAN

Tree canopy loss graph - hard to discern pattern - would be good to instead have % of canopy loss.

Tree health conditions - why is most of E. Cambr. poor health? Provide written some analysis.

CAMBRIDGE
URBAN FOREST
MASTER PLAN

PLEASE ADD A MAP SHOWING THE ~~COLD~~ ECOSYSTEMS (FOREST COVER) AND LANDFORMS OF CAMBRIDGE IN COLONIAL OR PRE-COLONIAL TIMES. THE VARIATIONS/PATTERNS OF TREE CANOPY ACROSS THE CITY ~~RESEMBLE~~ THOSE TODAY. ~~THIS~~ SOIL ~~CONDITIONS~~ QUALITY + HYDROLOGY MAY EXPLAIN THIS.

CAMBRIDGE
URBAN FOREST
MASTER PLAN

My biggest take-home from this presentation the most important thing for cities to do is persuade developers to include planning for large shade trees in their residential developments. We must plan for higher density buildings, true, but we MUST include planning for big healthy shade trees with long lifetimes.

CAMBRIDGE
URBAN FOREST
MASTER PLAN

EAST CAMBRIDGE

- TREES CANNOT GET WATER DUE TO INSUFFICIENT SIZE OF TREE WELLS TREE ROOTS OCCUPY ENTIRE WELL
= NEW TREES KEEP DYING AND BEING REPLACED SEVERAL TIMES
- EXCESSIVE TREE TRIMMING FOR OVERHEAD UTILITY LINES ARE PROBLEMATIC AND CREATE LOPSIDED TREES THAT CAN COLLAPSE

CAMBRIDGE
URBAN FOREST
MASTER PLAN

On the DESIGN board the inset of "Narrow residential streets with large front yard" does not reflect reality. North Cambridge homes predominantly do not have any front yards. Also, I would question how large the front yards are in the Cambridge part.

CAMBRIDGE
URBAN FOREST
MASTER PLAN