Human Environment Regional Observatory (HERO) 2023 Stakeholder Presentation

Assessment of tree health and resident perspectives in the Longhorned Beetle Regulation Zone from 2008 to 2023

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Caleb Kluchman, Ksenia Smart,
Ramón Colón, Tanner Honnef

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Meet the 2023 HERO Team

From left to right: Nicholas Geron, Jason Andrews, Ramón Colón, Amritha Pai, Aaron Richmond-Crosset, Ksenia Smart, Caleb Kluchman, Adlai Nelson, Tanner Honnef, Clio Bate

Undergraduate Research Fellows

Aaron Richmond-Crosset, Adlai Nelson, Amritha Pai, Caleb Kluchman, Ksenia Smart, Ramón Colón, Tanner Honnef

Team Managers & Graduate Mentors

Nicholas Geron, Clio Bate, Jason Andrews
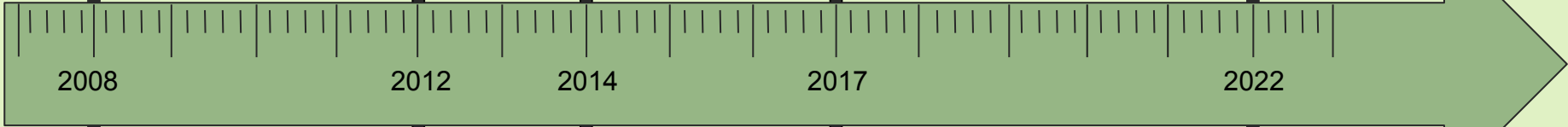
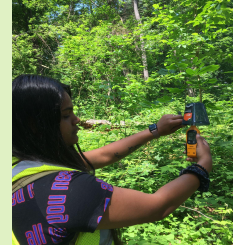## Directors

Dr. John Rogan and Dr. Deborah Martin

https://www.clarku.edu/departments/hero-program/

Worcester's Urban Forest: Past Observatory Research

HERO joins collaboration with USDA and DCR

HERO partners with GGC

LB eradication program begins

HERO begins survey in LB study area

HERO studies juvenile tree health, air quality, and stewardship

2008   2012   2014   2017   2022

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Tree Benefits: Past HERO Research Contributions

10% increase in impervious surface = 1.66°C increase in land surface temperature
(Rogan et al., 2013)

Summer warm period was extended in tree canopy loss areas by 15 days
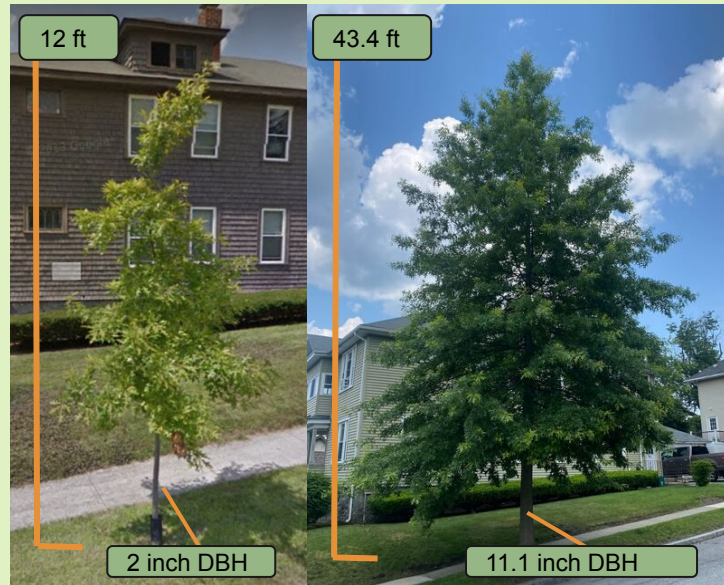*(Elmes et al., 2017)*

Policy contributions

Adaptive **capacity to address tree loss from LB is determined by relationships of individuals and organizations** across scales
(Palmer et al., 2014)

State funding of tree stewardship **can enhance tree survivorship**
(Breger et al., 2019)

12 ft

43.4 ft

2 inch DBH

11.1 inch DBH

Pin Oak (Quercus palustris) planted by the DCR in 2011 on Dorothy Ave as photographed in 2014 and 2023

Economic benefits

Tree planting density of **three trees per acre** achieved the **largest energy savings and $1520 in total annual ecosystem savings** from juvenile trees
(Moody et al., 2021)

Tree canopy density of 31% near a house results in **$1,891 increase of property value**
(Wilkens et al., 2018)

2023 Study Objectives

Biophysical Assessment:
Monitor growth and survivorship of trees planted between 2010-2012 by the DCR and Worcester Tree Initiative after the LB outbreak

What is the current status of tree health and structure and what factors have the greatest impact on tree health and structure?

How does the tree health and structure compare to the past HERO tree survey?
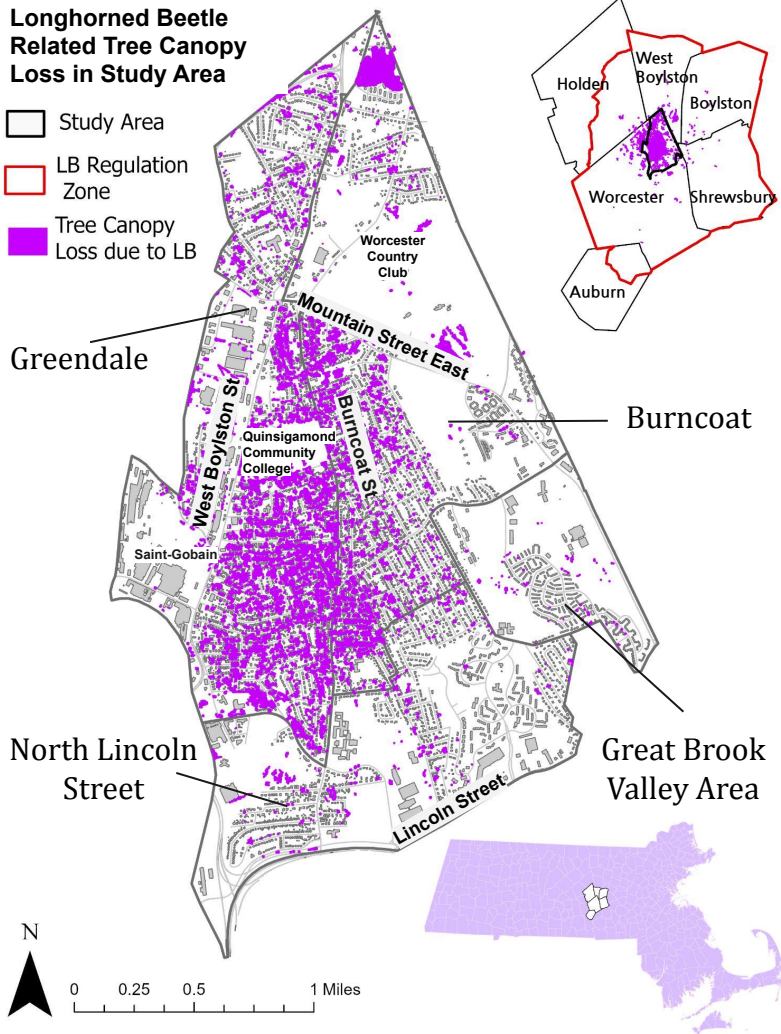
Social Assessment:
Interview neighborhood residents in the study area to understand perceptions of trees and post-LB tree planting initiatives

How do residents perceive the role of trees and DCR's tree planting initiative on their property and in their neighborhood?

How do residents' past experiences and beliefs impact tree stewardship?

Longhorned Beetle Related Tree Canopy Loss in Study Area

- Study Area
- LB Regulation Zone
- Tree Canopy Loss due to LB

Greendale
West Boylston St
Quinsigamond Community College
Saint-Gobain
North Lincoln Street
Mountain Street East
Worcester Country Club
Burncoat
Burncoat St
Lincoln Street
Great Brook Valley Area

Holden, West Boylston, Boylston, Worcester, Shrewsbury, Auburn

N

0   0.25   0.5   1 Miles

The Longhorned Beetle in Worcester

- Longhorned Beetle found in Worcester in 2008

- Worcester's urban canopy is contiguous with the hardwood/maple forests of the Northeast

- 337 sq km regulation zone enacted around the infested area

- Large scale, proactive tree cutting program launched by the USDA working with the DCR

- ~34,196 trees removed by Oct 2014

  - At the time, was the largest US infestation in terms of trees removed

- Tree loss concentrated in Study Area

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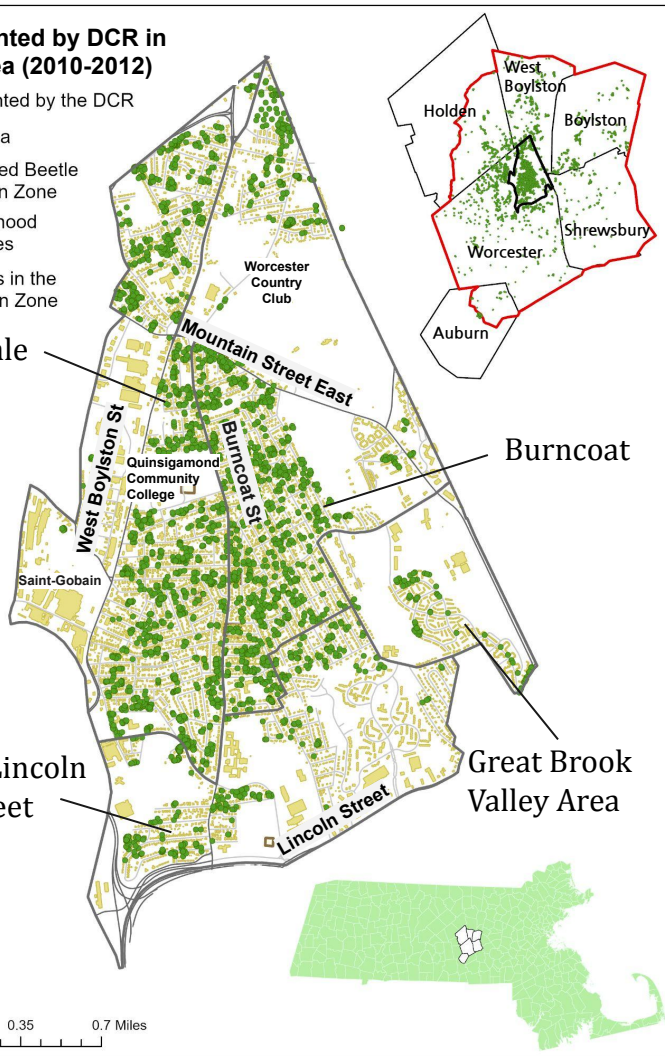Trees Planted by DCR in Study Area (2010-2012)

- Trees planted by the DCR
- Study Area
- Longhorned Beetle Regulation Zone
- Neighborhood Boundaries
- MA Towns in the Regulation Zone
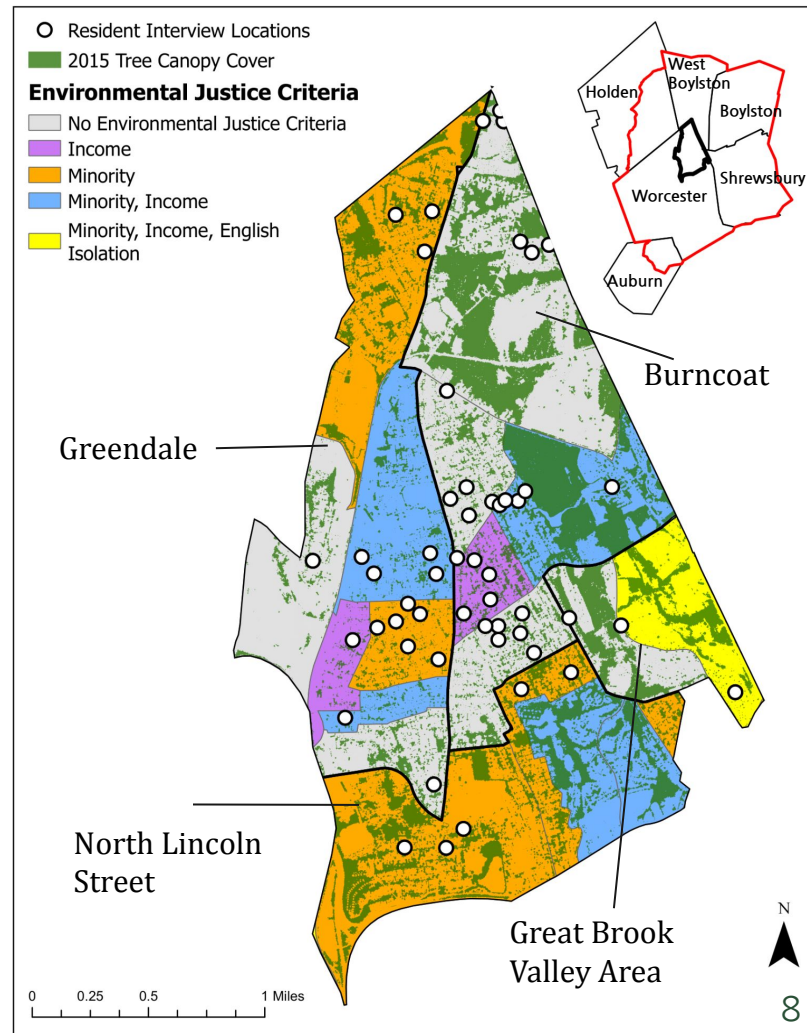
DCR Tree Planting Program

- The DCR's tree planting program planted 17,000 trees to rebuild the region's urban canopy

- ~7000 trees planted in our study area

- Tree planting began in spring 2010 and continued until 2017 - first trees were planted in study area

- Funded by the American Recovery and Reinvestment Act (ARRA)

- High proportion of arborvitae were initially planted to keep up with the large demand for trees to plant

- Sourced trees from Bigelow Nursery

Neighborhoods in Study Area

Study area comprises Worcester neighborhoods: Burncoat, Great Brook Valley Area, Greendale, and North Lincoln Street

Massachusetts defines Environmental Justice areas as census tracts which meet certain criteria, including:

- Annual median household income is 65% or less than statewide figure
- 40% or more of population is racial minority
- 25% or more of households speak English less than "very well"

Legend:
- ○ Resident Interview Locations
- 2015 Tree Canopy Cover

Environmental Justice Criteria
- No Environmental Justice Criteria
- Income
- Minority
- Minority, Income
- Minority, Income, English Isolation

Burncoat

Greendale

North Lincoln Street

Great Brook Valley Area

0 0.25 0.5 1 Miles

N

Neighborhood Social and Biophysical Comparison

Socioeconomic Variables	Greendale	Burncoat	Great Brook Valley Area	North Lincoln Street
Percent English Limited*	2.5%	11%	27%	9.9%
Percent White***	64%	69%	21%	43%
Percent Renter**	43%	21%	96%	60%
Median Household Income*	$86,851	$72,962	$24,284	$68,932
Percent Bachelors Degrees	39%	41%	19%	33%
Total Population (2020)	7,915	6,146	3,439	5,992
Biophysical Variables	**Greendale**	**Burncoat**	**Great Brook Valley Area**	**North Lincoln Street**
Percent Tree Canopy Cover (2015)	16%	38%	32%	31%
Percent Impervious Cover	57%	32%	35%	44%
Number of Trees Planted	1,111	885	67	317
Physical Area (sq km)	3.96	4.06	1.12	2.79

*Statistical significance markers: * = p‹0.1; ** = p‹0.05; *** = p‹0.01*

Private Tree Survey Analysis of DCR Trees

HERO fellows take measurements on the first day of field data collection

Biophysical Assessment

Monitor growth and survivorship of trees planted between 2010-2012 by the DCR and Worcester Tree Initiative after the LB outbreak

1. What is the current status of tree health and structure and what factors have the greatest impact on tree health and structure?

2. How does the tree health and structure compare to the past HERO tree survey?

Biophysical Field Measurements

Diameter at Breast Height (DBH): Measured at 54 inches, or the next unobstructed point

Measurement equipment

Tree Height: Measured using the Nikon Forestry Pro II rangefinder/ hypsometer

Crown Width: Measured using a standard measuring tape

Tree Photos: Capture images of measured trees and add IDs

From left to right: Aaron, Clio, and Caleb take field measurements of a tree

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Data Collection and Input

ArcGIS Field Maps mobile app showing data collection fields

Vigor Assessment

What is the condition of the tree's canopy?

| 1: Tree is fully foliated | 2: Between 90% and 75% foliage | 3: Between 75% and 50% foliage | 4: Less than 50% foliage | 5: Tree is dead |

Japanese tree lilacs (Syringa reticulata) *in varying stages of vigor, showing Jason measuring DBH. Methods from(Roman et al., 2020)*

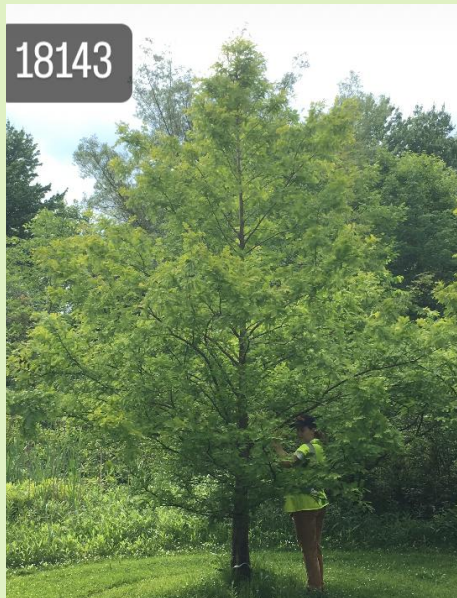# Mortality

What is the mortality status of the tree?

Alive

Standing Dead

Stump

Removed

Unknown
(Could not access)

Condition

Rated on a scale of "Good", "Fair", and "Poor" considering vigor and the following characteristics of tree health and structure:

Basal sprouts

Damaged bark

Damaged trunk

Insect bark damage

Aphids on leaves

Diseased leaves

Land Use and Site Type

On what kind of property is the tree situated?

Single Family Residence
Detached
Back yard

Single Family Residence
Attached (ie. duplex)
Front yard

Multi-Family Residence
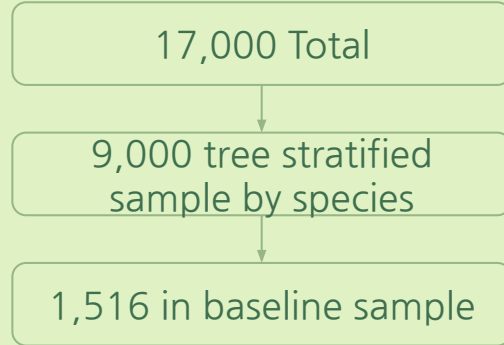(ie. triple decker)
Side yard

Institutional

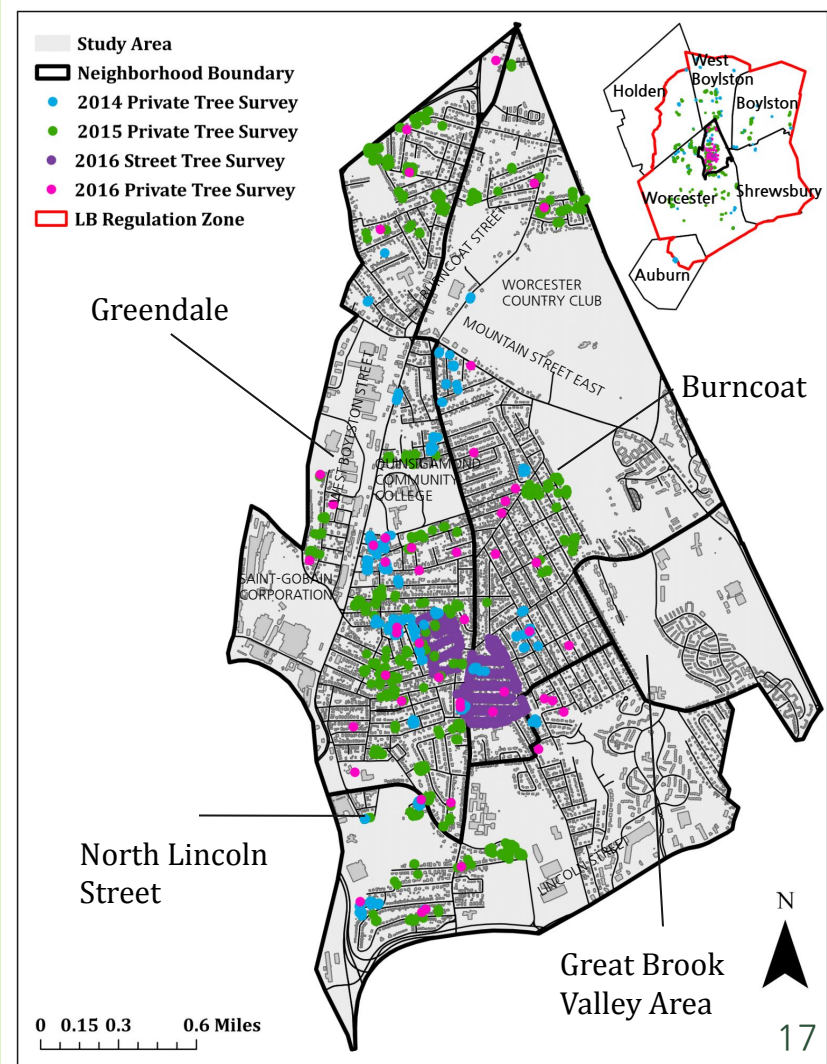*Maintained park*

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Baseline HERO Survey

Sampling:

Street trees were selected along transects in a randomly selected area

17,000 Total

↓

9,000 tree stratified sample by species

↓

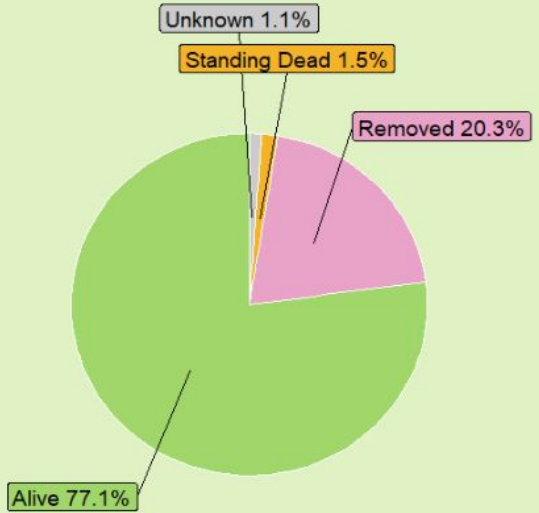1,516 in baseline sample

800 private trees surveyed in study area from 2014-2016

- **2014:** 251 Private Trees
  - 81.7% Survivorship
- **2015:** 633 Private Trees
  - 74.7% Survivorship
- **2016:** 47 Private Trees, 413 Street Trees
  - 100% Survivorship of Private Trees
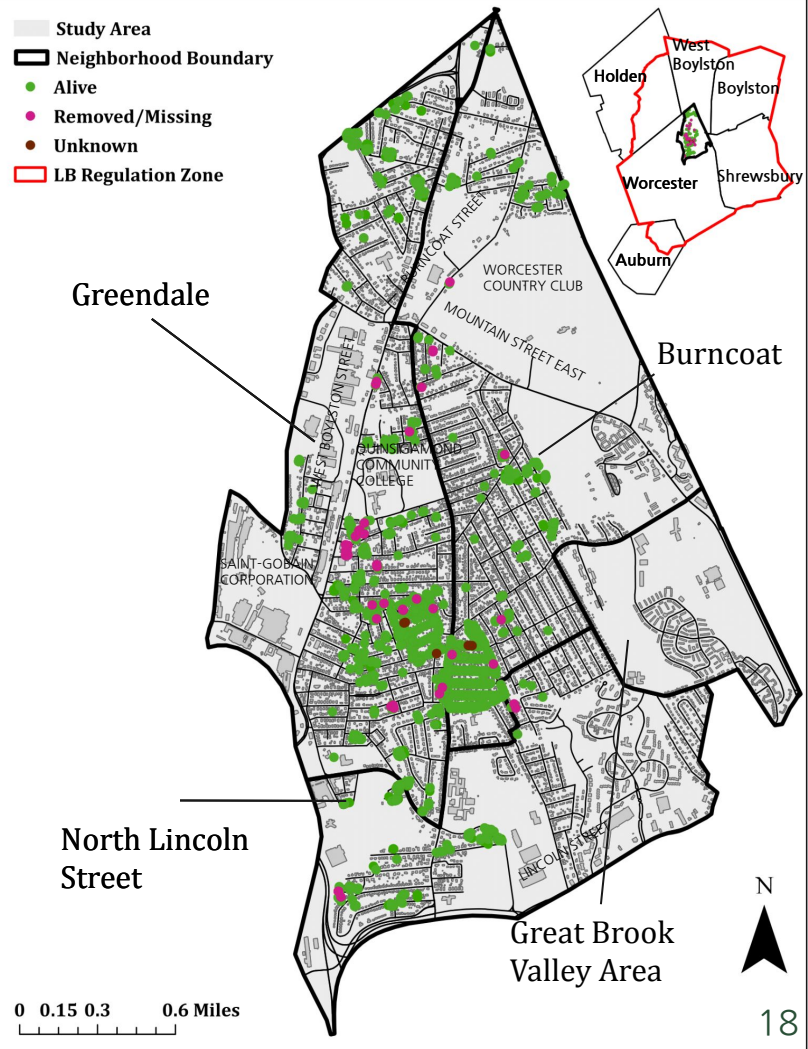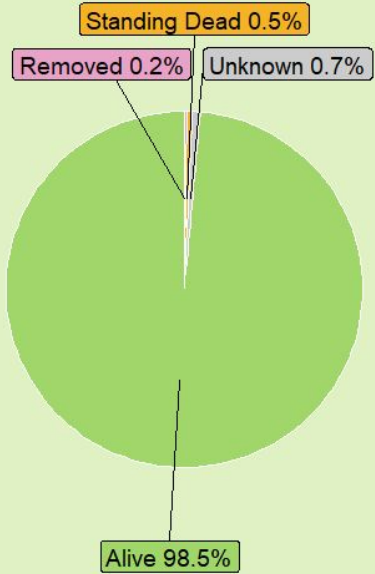 - 98.1% Survivorship of Street Trees

Baseline HERO Survey Findings
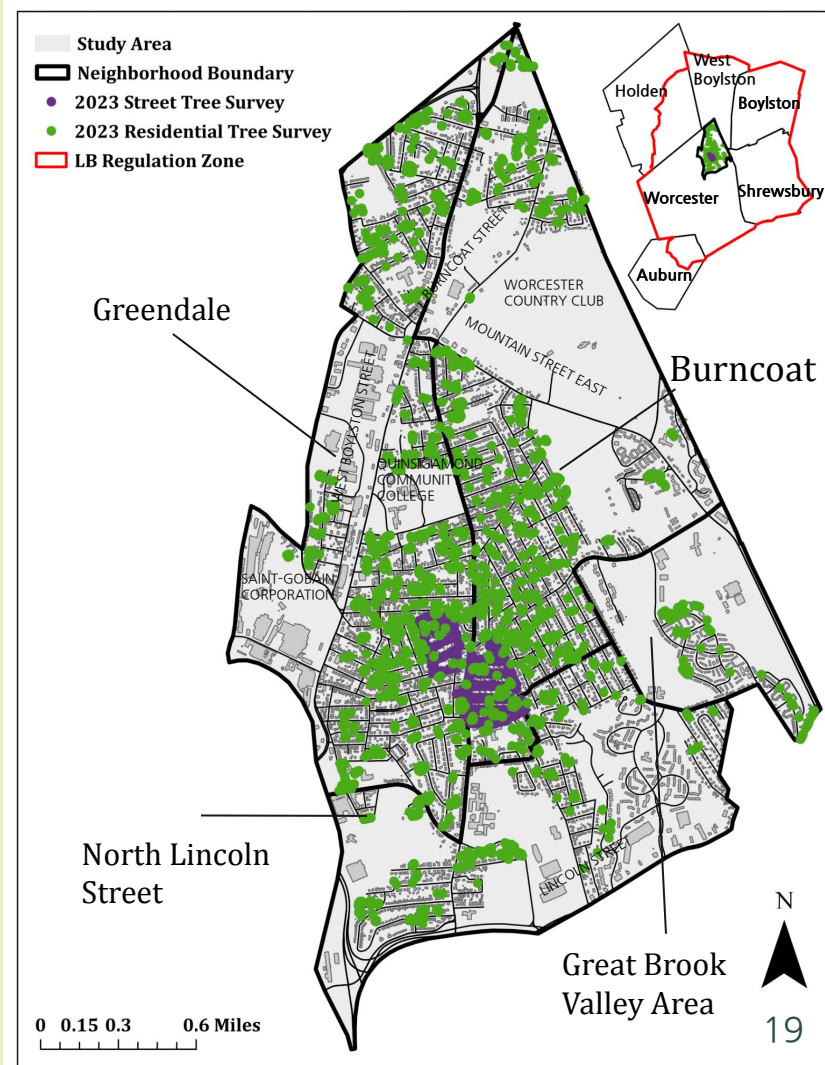
Private Tree Survivorship

Unknown 1.1%
Standing Dead 1.5%
Removed 20.3%
Alive 77.1%

Street Tree Survivorship

Standing Dead 0.5%
Removed 0.2%
Unknown 0.7%
Alive 98.5%

Study Area
Neighborhood Boundary
● Alive
● Removed/Missing
● Unknown
☐ LB Regulation Zone

Holden
West Boylston
Boylston
Worcester
Shrewsbury
Auburn

Greendale

Burncoat

WORCESTER COUNTRY CLUB
MOUNTAIN STREET EAST
BURNCOAT STREET
WEST BOYLSTON STREET
QUINSIGAMOND COMMUNITY COLLEGE
SAINT-GOBAIN CORPORATION

North Lincoln Street

Great Brook Valley Area

LINCOLN STREET

N

0   0.15 0.3   0.6 Miles
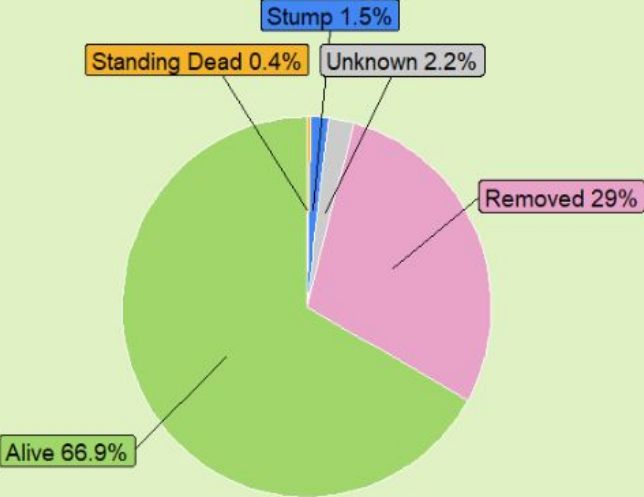
2023 HERO Survey

Trees Surveyed in Study Area

- 2,794 total trees surveyed:

    - **2,381 Residential Trees** Representing all of the trees from the species stratified random sample in the study area

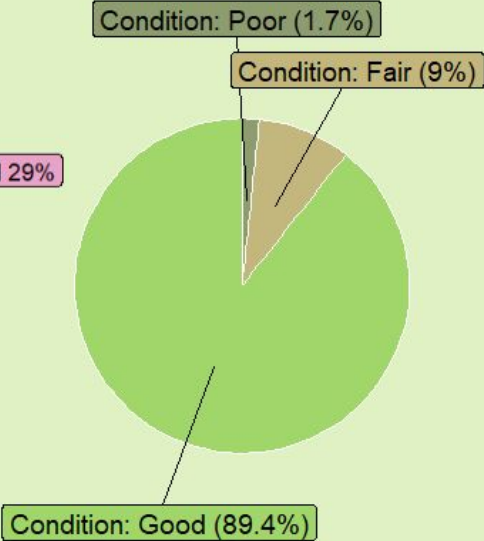   - **413 Street Trees** comprising the 2016 sample of street trees along transects planted by the WTI

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2023 Survey of Private Trees

Survivorship

- Stump 1.5%
- Standing Dead 0.4%
- Unknown 2.2%
- Removed 29%
- Alive 66.9%

Condition

- Condition: Poor (1.7%)
- Condition: Fair (9%)
- Condition: Good (89.4%)

Surveyed Tree Survivorship
- Alive
- Removed/Dead
- Unknown

Greendale

Burncoat

WORCESTER COUNTRY CLUB

MOUNTAIN STREET EAST

QUINSIGAMOND COMMUNITY COLLEGE

SAINT-GOBAIN CORPERATION

Great Brook Valley Area

BURNCOAT STREET

North Lincoln Street

LINCOLN STREET

WEST BOYLSTON STREET

N

0   0.25   0.5   1
Miles

20
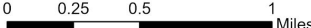
Private Tree Species' Status by Count
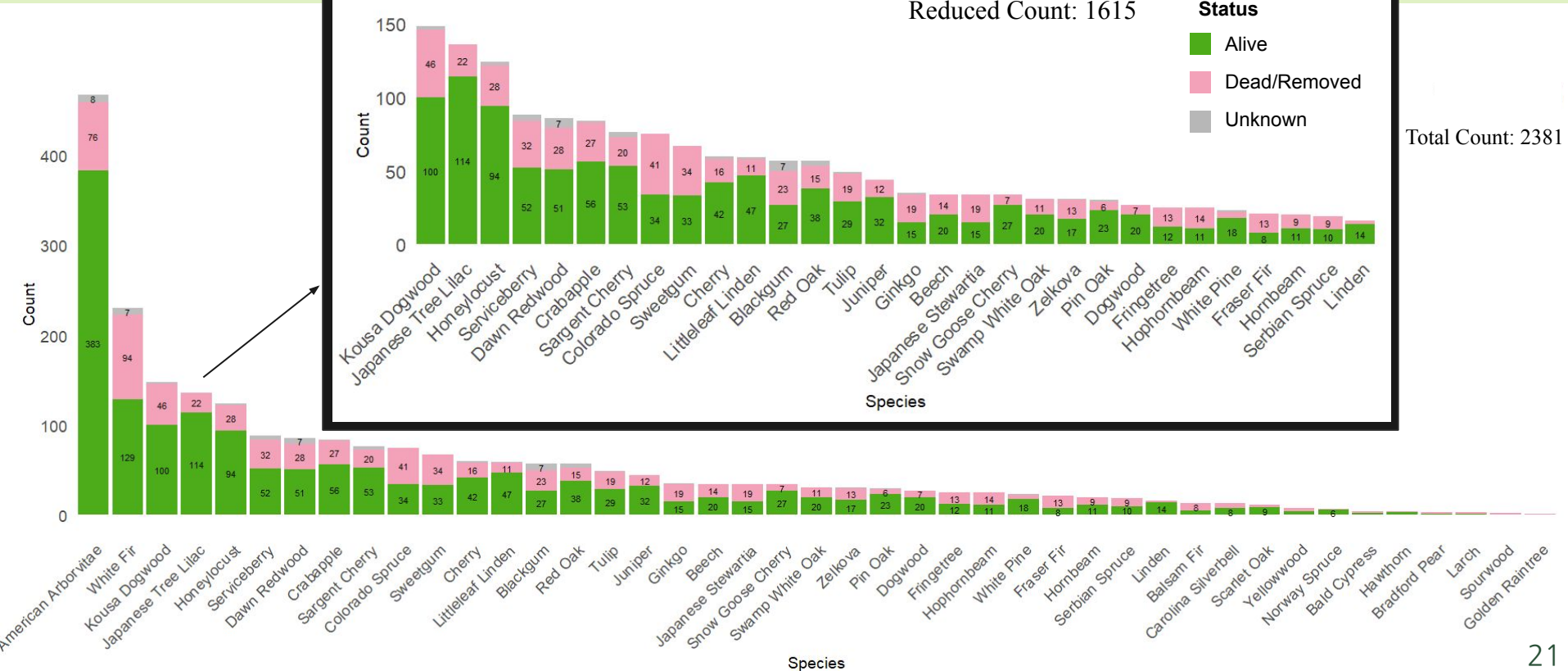
Comparing Survivorship with Tree Count
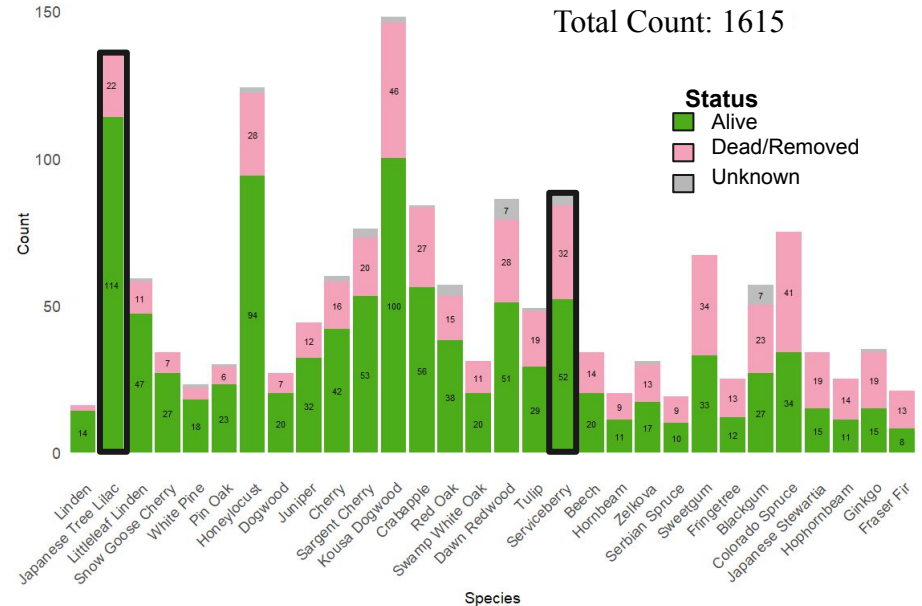
2023 Survivorship

Above: Japanese tree lilac (Syringa reticulata) in a front yard

Right: White pine (Pinus strobus) in a backyard

Left: Colorado spruce (Picea pungens) in a front yard

Below: Ginkgo (Ginkgo biloba) in a backyard

Top 7 species	Survivorship	N surveyed
Linden	88%	16
Japanese Tree Lilac	84%	136
Littleleaf Linden	80%	59
Snow Goose Cherry	79%	34
White Pine	78%	23
Pin Oak	77%	30
Honeylocust	76%	124

n=1615

Bottom 7 species	Survivorship	N surveyed
Fraser Fir	38%	21
Ginkgo	43%	35
Japanese Stewartia	44%	24
Hophornbeam	44%	44
Colorado Spruce	45%	75
Blackgum	47%	57
Fringetree	48%	25

n=1615

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Health By Site Type

% Trees Surveyed (2023)
- Backyard (58.3%)
- Front Yard (23.3%)
- Side Yard (13.6%)
- Maintained Park (4.8%)
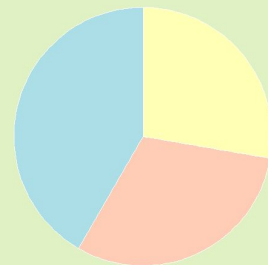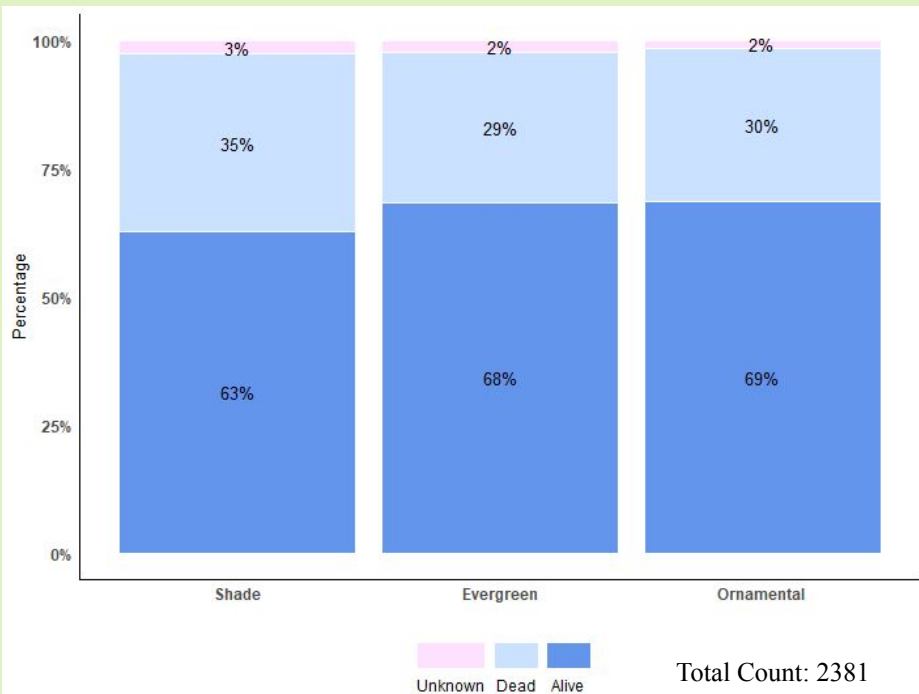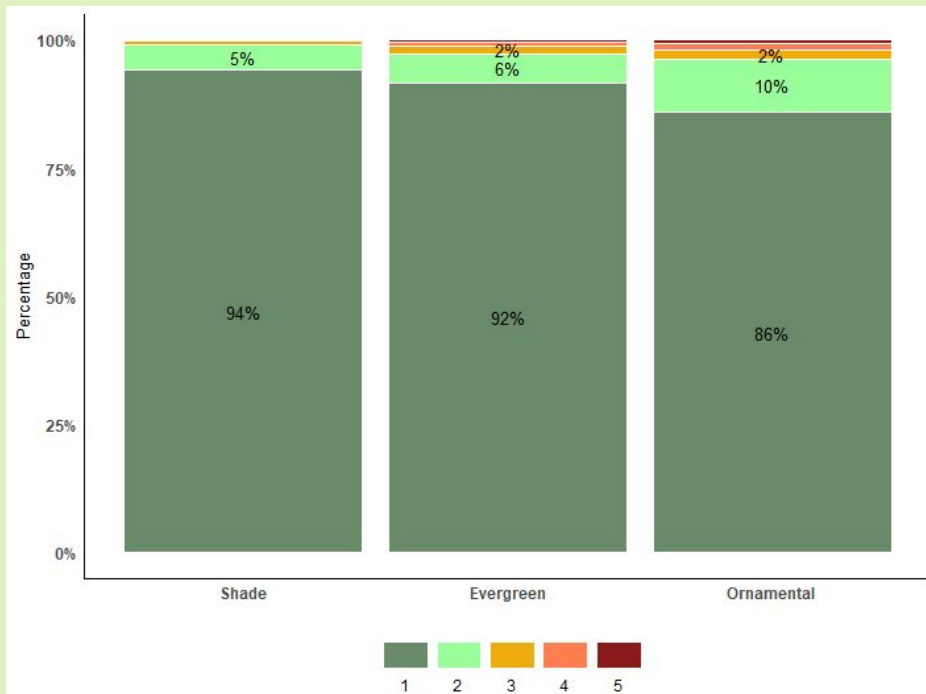
Survivorship

Unknown Dead Alive

Total Count: 2381

Vigor

1 2 3 4 5

24

Health By Land Use

Survivorship

Total Count: 2381

Unknown   Dead   Alive

Vigor

1   2   3   4   5

25

Health By Tree Type

Health by Native Status

Survivorship

Total Count: 2381
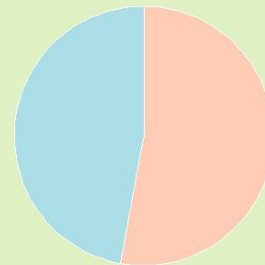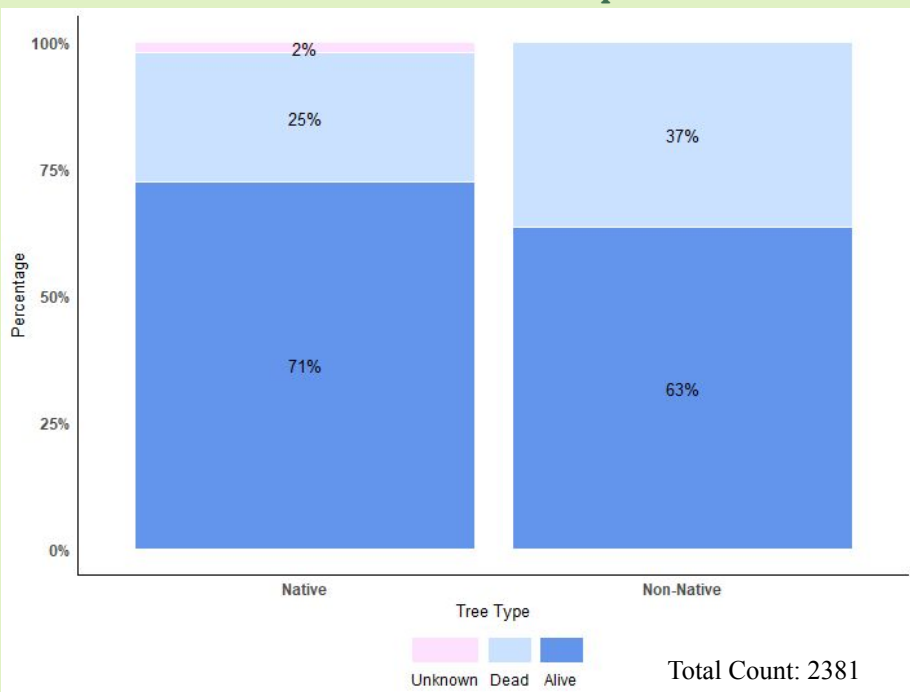
Vigor
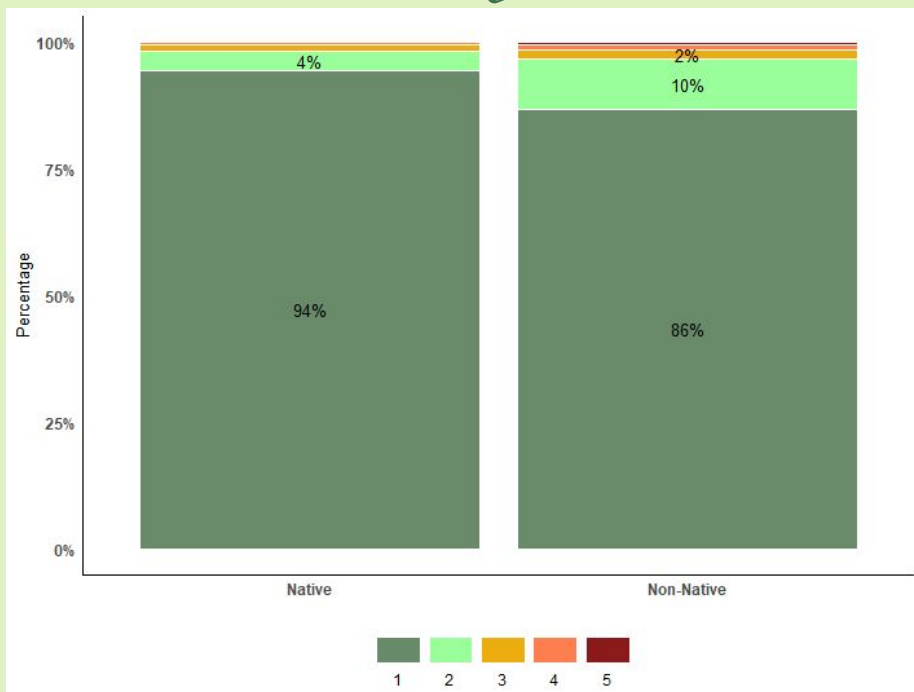
Change in Annual Rates of Survivorship

Red Oak
Year: Annual Survivorship [Count]
Baseline: 91.64% [24]
2023: 97.37% [57]

Japanese Tree Lilac
Year: Annual Survivorship [Count]
Baseline: 95.98% [37]
2023: 98.73% [136]
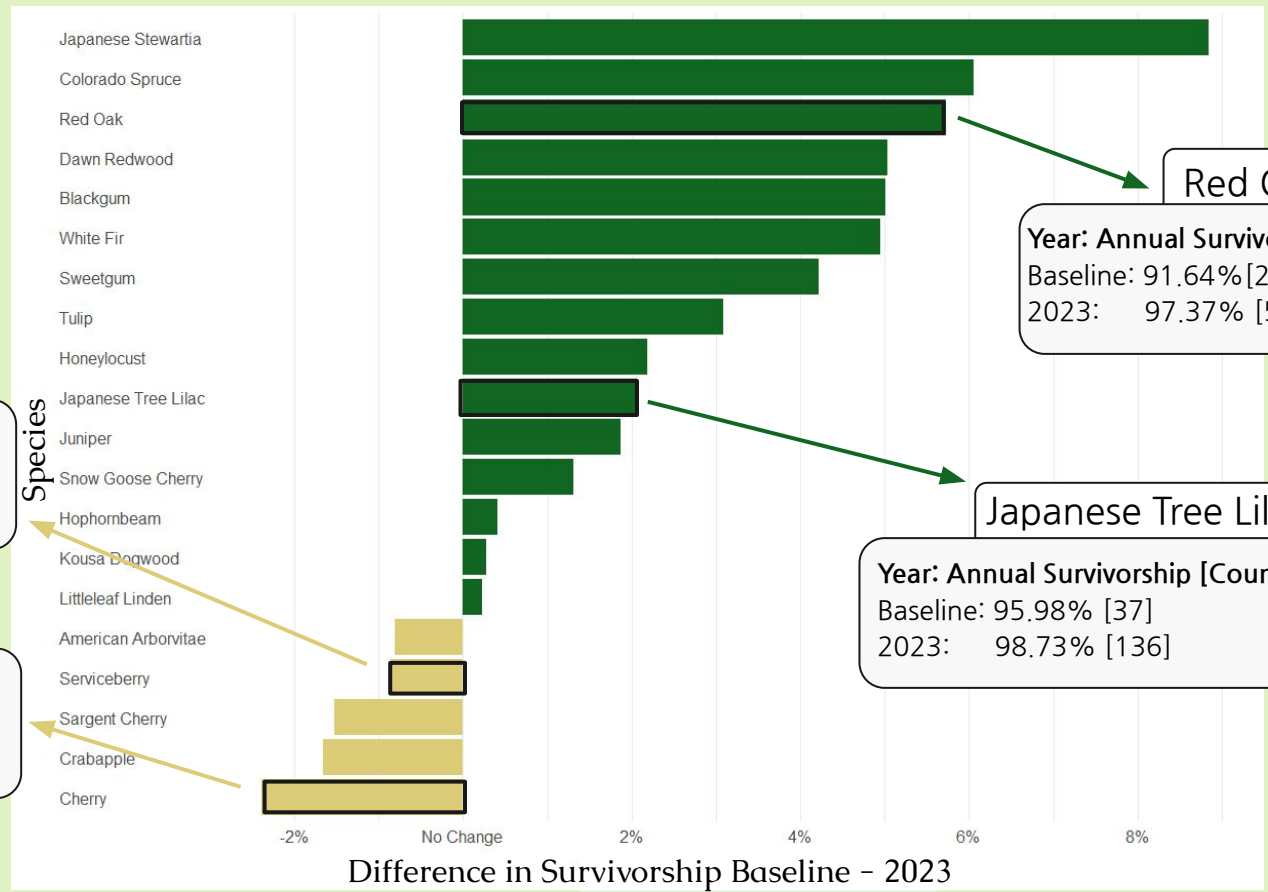
Serviceberry
Year: Annual Survivorship [Count]
Baseline: 97.7% [35]
2023: 96.83% [88]

Cherry
Year: Annual Survivorship [Count]
Baseline: 100% [21]
2023: 97.6% [60]

Change in Average Tree Height and DBH

Top 5 height growth species	Avg Height (ft)	Growth from baseline	Top 5 DBH growth species	Avg DBH (in)	Growth from baseline
Tulip	35.7	18.9	Snow Goose Cherry	12.6	10.4
Red Oak	29.0	16.8	Tulip	10.5	9.3
Littleleaf Linden	29.7	16.5	Cherry	9.2	7.7
Honeylocust	28.6	12.3	Sargent Cherry	8.8	7.6
Dawn Redwood	24.6	11.1	Littleleaf Linden	8.4	7.4

Bottom 5 height growth species	Avg Height (ft)	Growth from baseline	Bottom 5 DBH growth species	Avg DBH (in)	Growth from Baseline
White Pine	11.9	1.73	Serviceberry	2.8	2.1
Kousa Dogwood	13.3	3.5	American Arborvitae	3.4	2.7
Cherry	16.5	3.6	Kousa Dogwood	3.7	2.9
Serviceberry	14.3	4.8	Crabapple	4.2	3.6
Japanese Tree Lilac	17.4	5.4	Juniper	4.3	3.7

Snow goose cherry (prunus serrulata 'snow goose') in a backyard

Red oak (Quercus rubra) in a front yard

Summary of Private Tree Analysis

Rate of annual survivorship has increased since the HERO baseline survey for the majority of species surveyed

Standout Species:
- **Japanese tree lilac, Linden/Littleleaf linden,** and **Snow goose cherry** had the highest survivorship rates
- **Tulip** trees had the **largest increase** in height, crown width, and second largest increase in DBH
- **Snow goose cherry** had the largest change in DBH

Analysis Based on Factors:
- **Front and side yard trees** have the **highest survivorship** for site type
- **Single-family residences** have the **highest survivorship** of any land use type
- **Shade trees** have **lowest survivorship, but highest vigo**r
- **Native trees** do better in both **vigor** and **survivorship**

3028

Littleleaf linden (Tilia cordata), one of the fastest growing trees in our survey, in a backyard

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Street Tree Survey Analysis

Biophysical Assessment

Monitor growth and survivorship of trees planted between 2010-2012 by the Worcester Tree Initiative after the LB outbreak

1. Compare street tree survivorship and growth to private trees

2. Analyze changes in survivorship over time

Tanner and Ksenia, next to our tallest street tree, a tulip tree (Liriodendron tulipifera), measuring 49.6 ft

2023 Worcester Tree Initiative Street Tree Survey

Survivorship

Condition

Standing Dead 0.7%

Unknown 0.7%   Stump 1.5%

Removed 8.5%

Alive 88.6%

Condition: Poor (0.8%)

Condition: Fair (4.9%)

Condition: Good (94.2%)

Total Count: 411

Surveyed Tree Survivorship
- Alive
- Removed/Dead
- Unknown

32
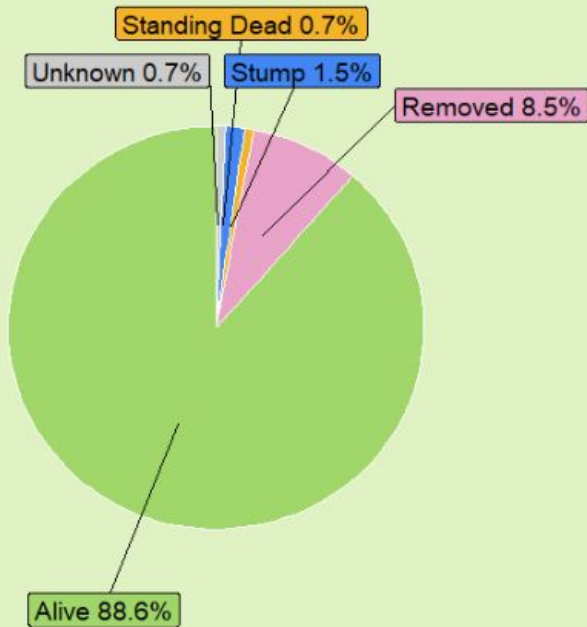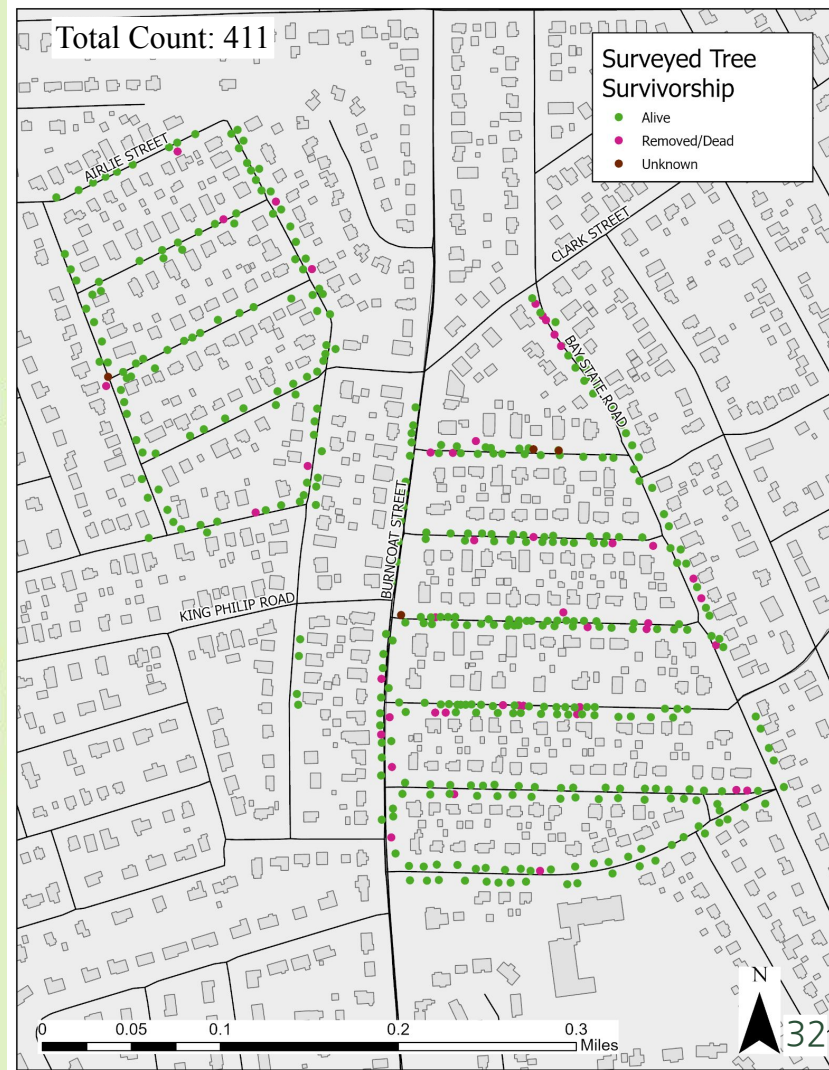
Street Tree Survivorship by Species

Showing species with four or more trees planted

33
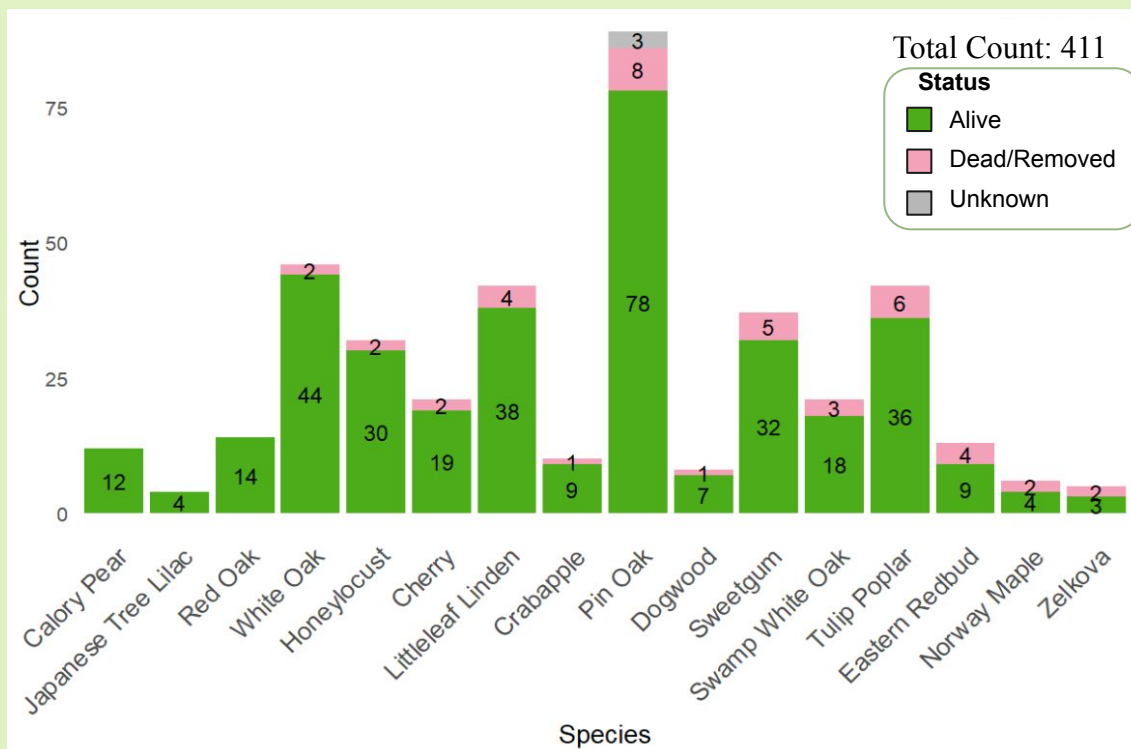
Private Trees Compared to Street Trees: Survivorship
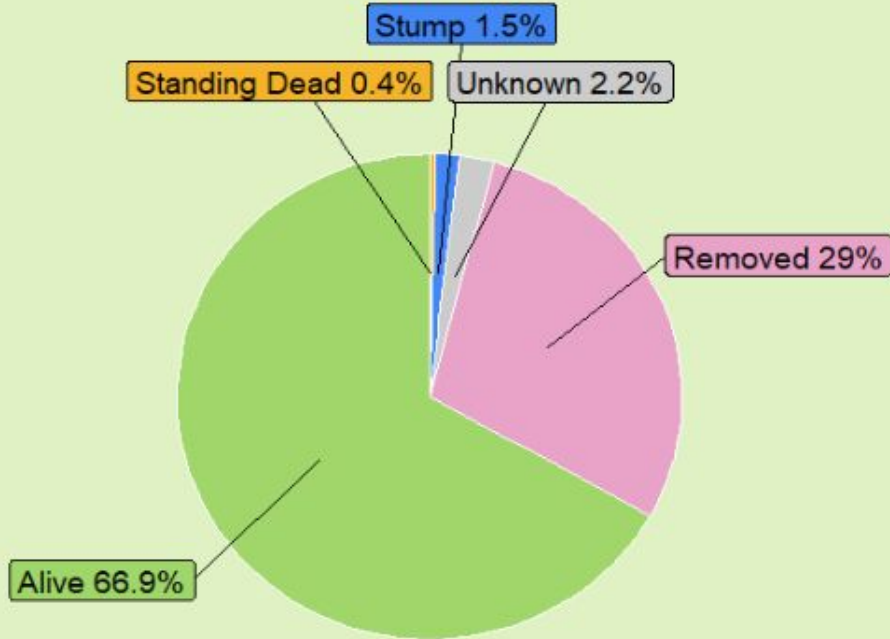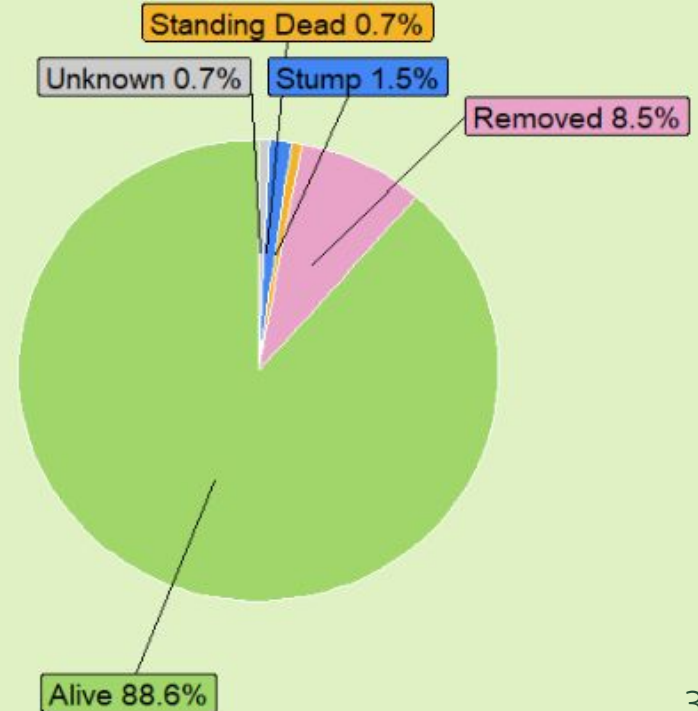
Private Trees Compared to Street Trees: Height
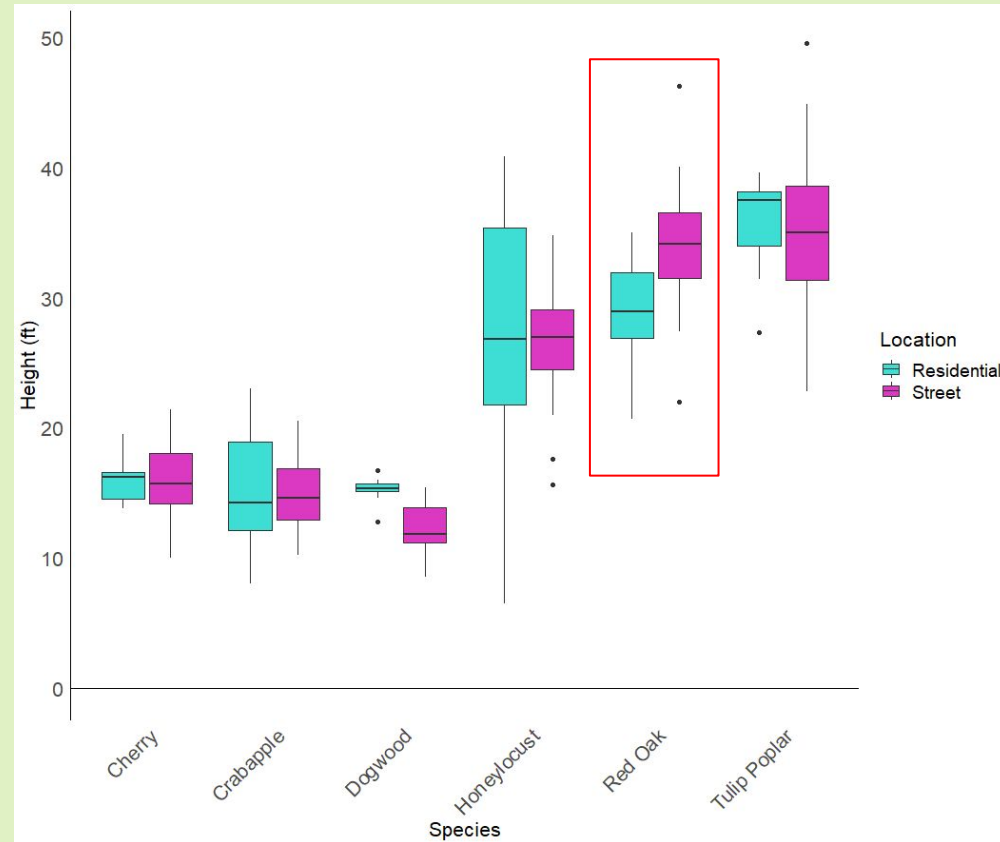
Red Oak Residential and Street

2244

98

A Red Oak (Quercus rubra) planted in the shade on a private property (pictured left) and next to the street (pictured right)

35

Private Trees Compared to Street Trees: DBH

Honeylocust Residential and Street
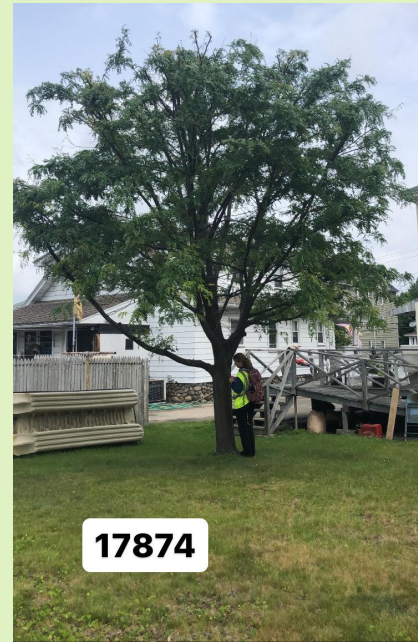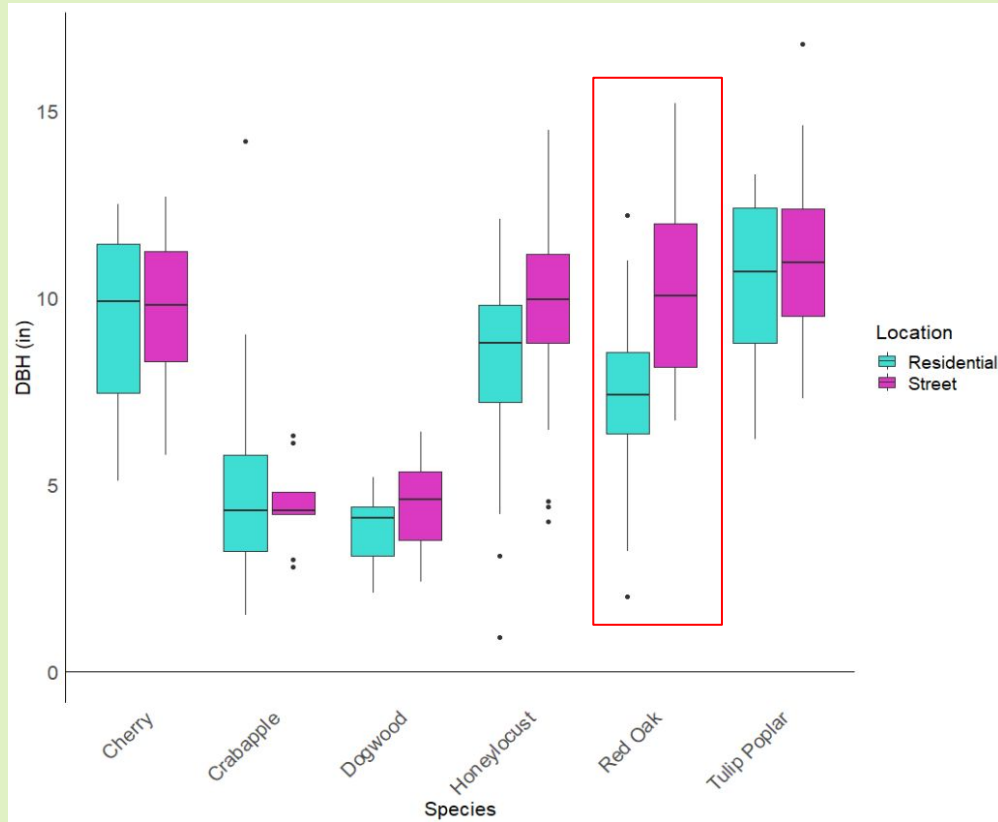
A Honeylocust (Gleditsia triacanthos) on a private property (pictured left) and next to the street (pictured right)

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Change of Street Tree Survivorship over Time
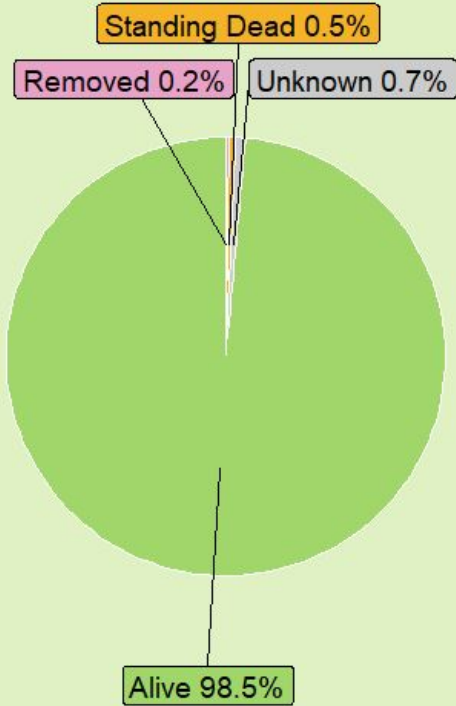
Baseline   2023
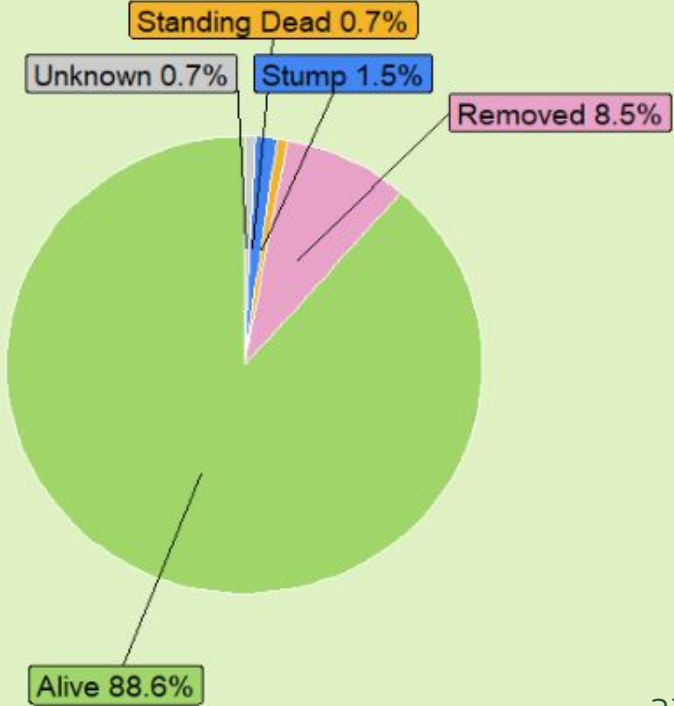
Summary of Street Tree Analysis

Major takeaways

- Street trees have very **high survivorship** both in the baseline and 2023 surveys and a **higher survivorship** than private trees.

  - Regular watering by WTI Young Adults Foresters Program

  - Fewer tree removals because street trees don't compete with yard amenities ie. pools, decks, sheds

- **Less species diversity** of street trees compared to private trees but **high proportion of shade trees**

- **Red oaks** had larger height and DBH compared to private trees.

Honey Locust (Gleditsia triacanthos)

Interview Analysis

Adlai, Aaron, and Professor Martin interview a resident

Social Assessment

Interview neighborhood residents in the study area to understand perceptions of trees and post-LB tree planting initiatives

1. How do residents perceive the role of trees & DCR's tree planting initiative on their property and in their neighborhood?

2. How do residents' past experiences and beliefs impact tree stewardship?

Resident Survey

Residents Contacted
- 582 residents called
    - 40 interviews scheduled
- 12 additional interviews conducted based on interactions during data collection

52 Interviews Conducted
- 27 in Burncoat
- 17 in Greendale
- 3 in Great Brook Valley Area
- 5 in North Lincoln Street

Planted Trees Associated with Interviews
- 233 trees
- Average survivorship was 77%
- 6 trees average per property
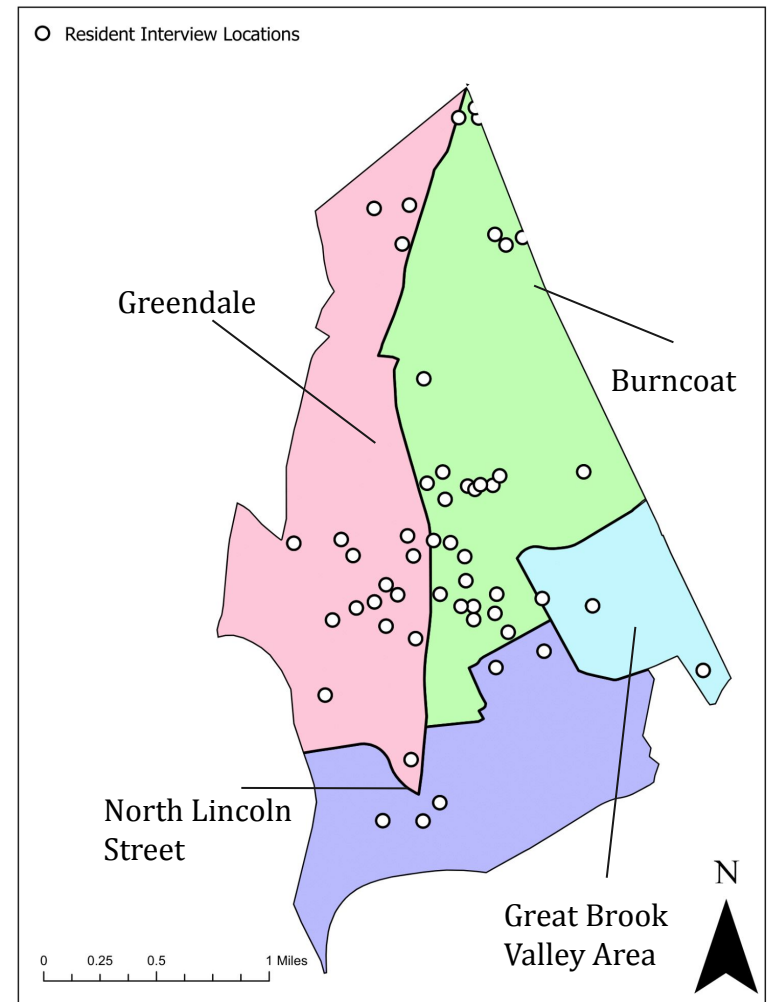
Interviewee Demographics

Demographic Variables	Worcester	Study Area	Interviewees
Percent English Limited	12.10%	9.1%	5.6%
Percent White	48%	56%	92%
Percent Renter	59%	47%	2%
Median Household Income	$61,106	$72,243	>$75,000
Percent Bachelors Degrees	31%	36%	71%
Population	206,518	23,492	52
Average Age	34.6	37.5	65+

Male to female ratio: 53% female
Average years lived in home: 26 years

Percent Renter by Census Block Group

○ Resident Interview Locations

Percent Renter
- Less than 15%
- 15% - 30%
- 30% - 45%
- 45% - 60%
- Greater than 60%

0   0.25   0.5   1
                    Miles
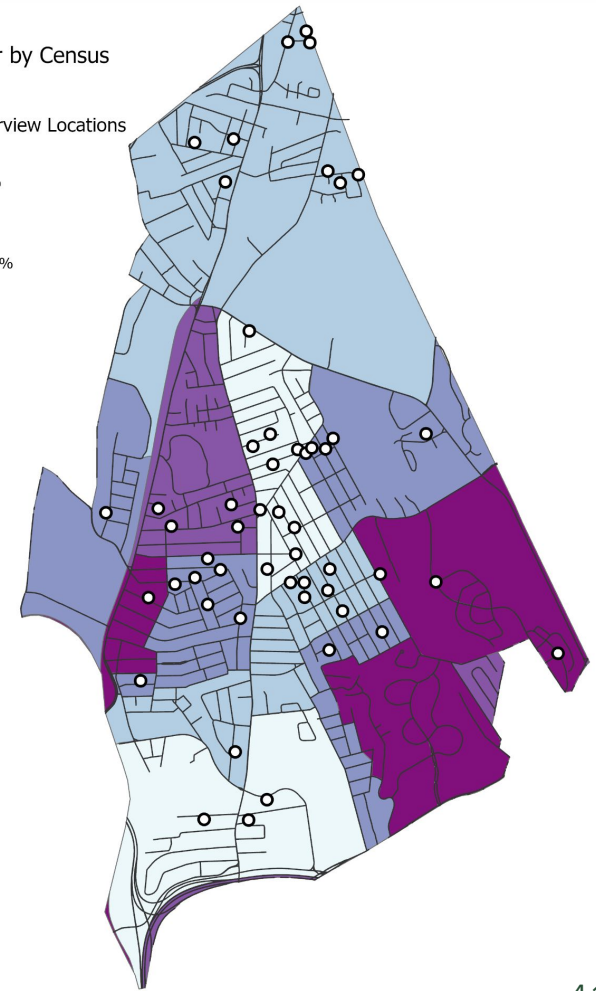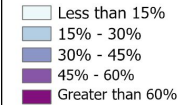
Conducting Interviews

Interview Categories:

1. Background: Personal History & Experience with DCR

2. Tree Stewardship

3. Perception of Trees

4. Perception of Neighborhood

5. Environmental Concerns

<u>**Background: Personal History & Experience with DCR**</u>

1. Were you living in this neighborhood during the Longhorned Beetle infestation? **(Y/N)**

If yes	If no

Are you living on the same property now?
 	
Did you have any trees removed on your property due to the Longhorned Beetle infestation?
  a. Were any trees removed nearby?
 	
Looking back, what do you think about the tree removal policy?
 	
Could you tell us about your experience with DCR and the re-planting process? Fine, came and did it
  a. How many trees were planted on your property?
 	
Are all your trees planted by DCR still alive?
  a. **If yes**, move to the next question.
  b. **If not**, when & how did they die?
    i. Did you have a chance to care for it at all before it died?
	When did you move here?
	
	Do you know about the Longhorned Beetle Infestation?

2. Would you plant a new tree on your property?

  a. If you would, what would you do differently than last time?

Processing Interviews

1. **Transcribe** interviews manually and using AI

2. Process interview transcripts using the **Nvivo software**

   - **Assign attributes** to interviews to understand how demographics impact our sample

   - Sort quotes into appropriate **codes**

   - Code each interview by two HERO team members to ensure **intercoder reliability**

3. Assess emerging **themes** based on fully coded interview dataset, to understand residents' opinions, perceptions, and experiences of trees and the DCR's planting program
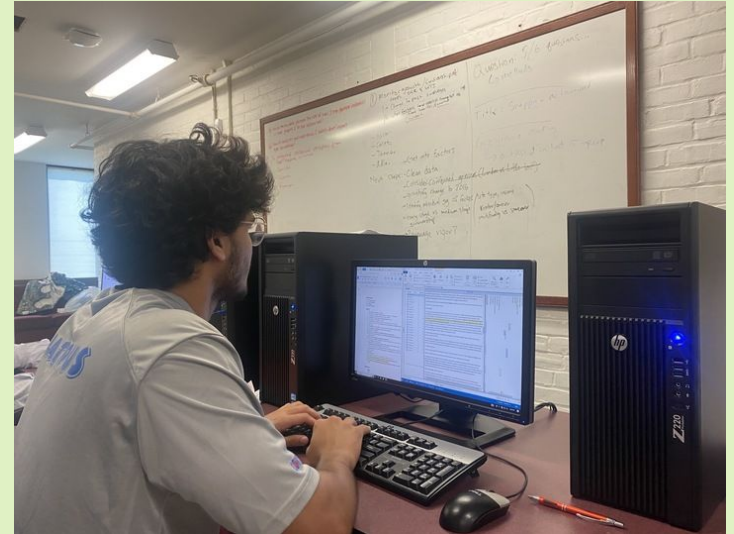
Ramón uses Nvivo software to code interviews

Coding interviews: Codes and themes
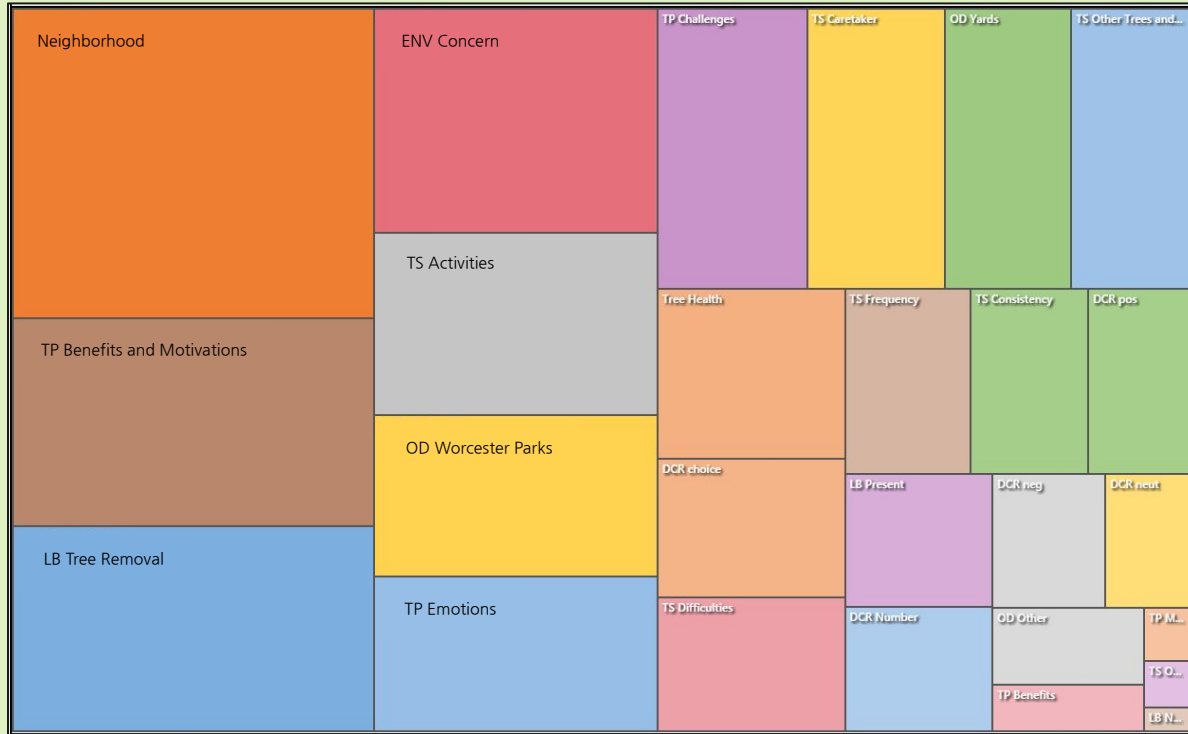
Main themes:

- Perception of tree benefits & challenges

- Experience with tree removal policy

- Experience with DCR planting

- Neighborhood recovery

- Tree stewardship

Perceptions of Tree Benefits

What are benefits of having trees on your property?

"It throws beautiful **shade for my tenant**"

"I just find trees **beautiful**"

"**I like the birds** and the birds like the trees"

"**I want a live fence**. So I chose that arborvitae **for the privacy**"

"Every tree is **worth 10 air conditioners**"

"By planting the trees closer to the road, **we get people to slow down**"

Benefit	Percentage
Shade	81%
Aesthetics	65%
Wildlife	40%
Privacy	35%
Energy	29%
Environment	27%
Property Value	17%
Well Being	15%
Wind	13%
Noise	13%
Water Control	10%
Carbon Dioxide Sequestration	8%
Air Quality	8%
Personal Health	6%
Smell	6%
Food	
Safety	

Tree Benefits by Scale

Neighborhood

Environmental concerns: air quality, extreme heat, aesthetic benefits

Property

Economic and aesthetic property benefits

Tree

Ecosystem services: shade, aesthetics, wildlife, noise, cooling

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Perceptions of Tree Challenges

What are the challenges of having trees on your property?

"We had two giant trees in the front, that, every **storm** would **drop limbs**, and we'd have to **drag them out of the street**."

"**Squirrels** can climb up that tree and then **they can get into the gutter**. We've had some birds in the attic in this house"

"That big tree over there is **blocking the sun** and my pool by the time I get out of work every day."

Leaves/Cleanup	48.1%
Hazard/Damage	34.6%
Wildlife/Environment	32.7%
Maintenance	21.2%
Space/Tree Height	21.2%
Solar/Powerlines	15.4%
None	15.4%

n = 52
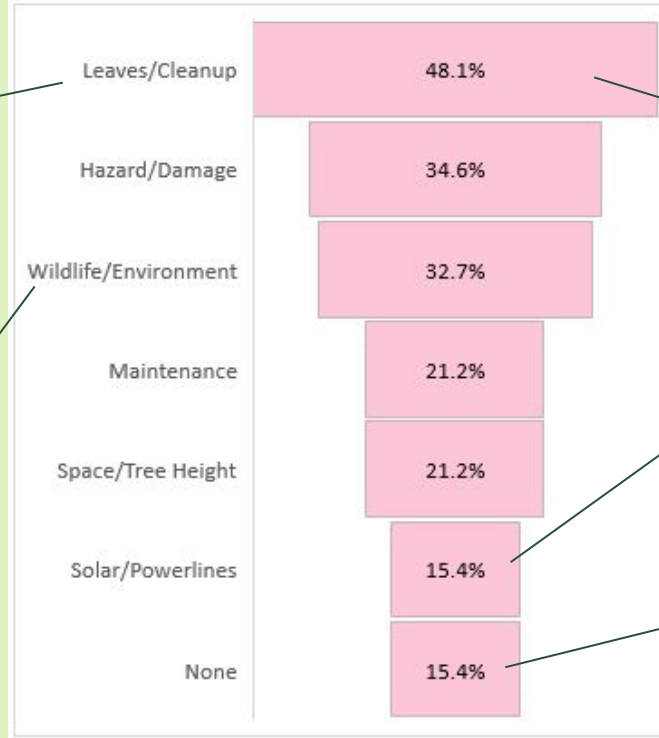
"The challenge is that all of the **leaves** and anything else that sheds from the tree ends up on the cushions of my patio furniture. It's like **you can never keep it clean**."

"This one's starting to become concerning, 'cause **it's kinda half dead** and it's getting **closer to the power lines** and what not."

"**There is no challenge**, because even taking care of a tree is relaxing."

Experience with Tree Removal Policy

Looking back, what do you think about the tree removal policy?

30.8% reported positive perceptions

38.4% reported neutral perceptions

13.5% had negative perceptions

17.3% not present or had no answer

"It's a shame, quite frankly, for that to happen. But **I'm glad they did.**"

"You **had to**. Yeah, I mean, there was **no ifs and buts about it**. It had to be done, or we would have been screwed, you know, **we would have had nothing.**"

"I think a lot of it's **experimental**… because you've got something new… there's so much blame going around when in fact people [were] just **doing the best they could with the knowledge they had.**"

"I think it was **overkill and devastating** and had such a **negative impact on the neighborhood** that we moved."

"I think they [contractors] were just **trying to make money**, at the time. And they were just **cutting down trees for no reason.**"

Experience with DCR Planting

Could you tell us about your experience with the DCR and the re-planting process?

46.2% reported positive DCR planting experience

26.9% reported neutral planting experience

17.3% reported negative DCR planting experience

9.6% not present

"Oh, they were they were **very friendly, very knowledgeable**. And they explained, **they gave me the choice** of trees that I could have."

"When that program came through to reforest, that was **very welcomed, very embraced**, you know, they came through and they offered to plant. And... **it felt like someone cared about our little neighborhood** here."

"**They did what they said they were going to do**. They gave us instructions... They were clean. They didn't leave a mess or anything. So, **everything was done well**."

"It was fine. They just came and did it. **A lot of people came in to plant one tree**."

"...there was **really no communication** at all."

Neighborhood Recovery

40.4% say yes, the neighborhood has recovered

38.5% say no, the neighborhood has not recovered

21.1% not present or no answer

"**It's the same**, the trees are coming back."

"As those trees are maturing, **it's starting to get back to that old look.**"

"**It hasn't fully recovered from that…** I still have memories of the Norwegian Maples creating this green canopy, you know, over the street, you could… walk through a tunnel of green… **It's still a little bit bare compared to my memory of it as a kid** growing up in this neighborhood."

"No, no, **definitely not.** Like I said, the canopy that we had with all the trees was, I mean, something out of a Robert Frost poem or something out of storybook. Yeah. **It'll never be the same.**"

Neighborhood Recovery

Overall Residents impressions of tree recovery vary dramatically street by street and property by property.

40.4% Residents who said the neighborhood had recovered are towards the north of the study area/sub-urban areas

38.5% Residents who said the neighborhood had not recovered are concentrated in areas with the most tree loss

Neighborhood Recovery
- Not Recovered
- Recovered
- Unknown (not there/not asked)
- Tree canopy loss

Greendale

Burncoat

North Lincoln Street

Great Brook Valley Area

N

0   0.3   0.6   1.2 Miles
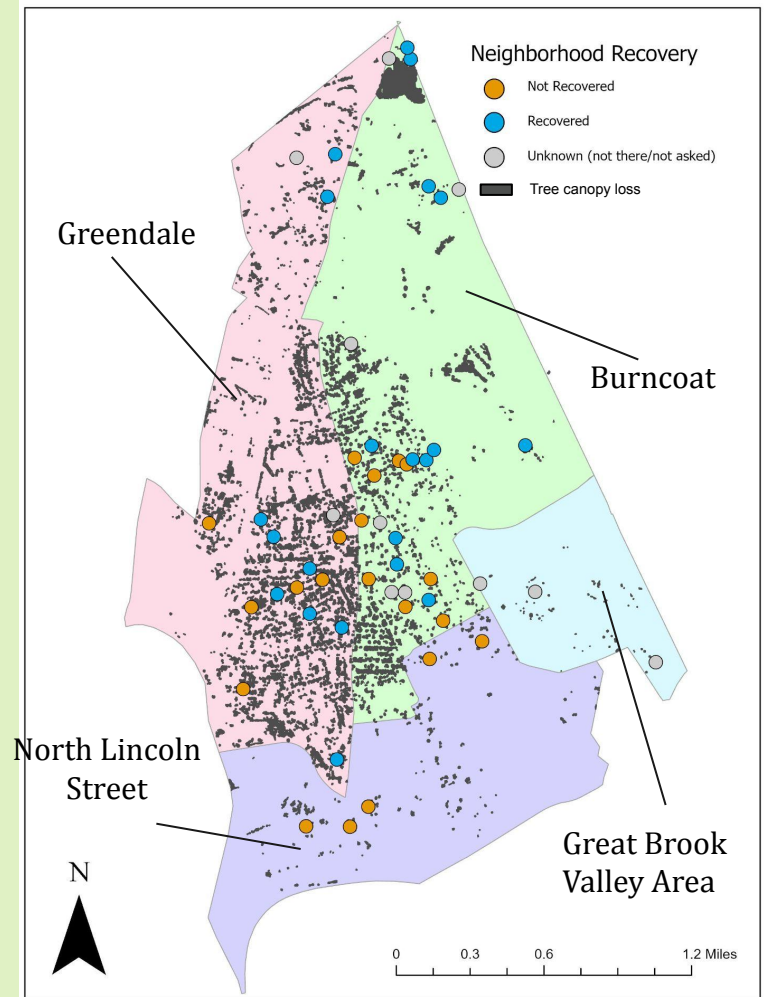
Tree Stewardship

"**I used to do the maintenance**, like landscaping, for a two family property. **But now I've had somebody come**…"

"They had some **watering bags** that we **faithfully maintained**. Once those came down, then we let **nature run its course** for the most part."

Tree Steward	Interviewees (n)	Trees (n)	Average Survivorship
Self/Household	39	149	82%
Nature	7	23	77%
Professional	17	93	71%
Friends/Family	6	13	70%

Who is stewarding trees
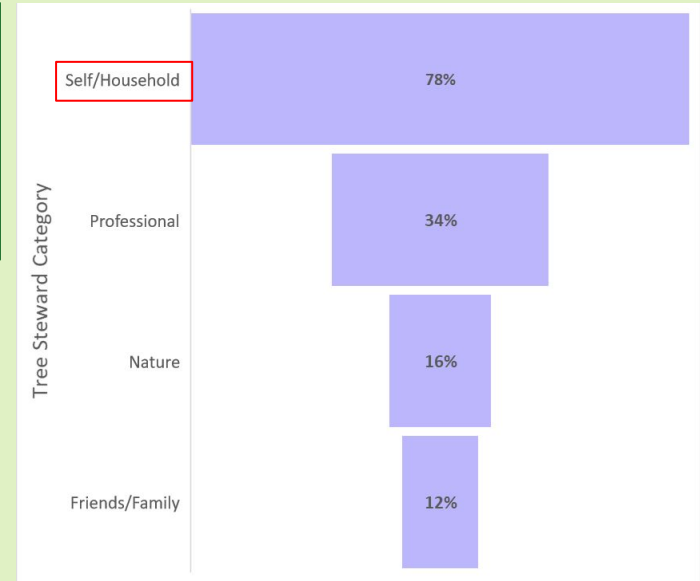
51

Stewardship Activities

- Many interviewees **diligently watered** their trees the **first few years**, and gradually **stopped** as they said their tree **"took."**

- **Pruning is more frequent as the tree grows** and slowly encroaches near property, driveway, power lines, neighbors' yards, etc.

- **Mixed views about** whether **mulching** is good for the tree or not.

- Many interviewees told us they "**just did what they [the DCR] told us to do."**

Stewardship Activities Performed by Interviewees at Time of Planting vs. Now

Tree Stewardship Activities	At Time of Planting	Current
Watering	39	24
Pruning	27	34
Mulching	14	13
Fertilizing	8	7
Pest Control	1	3

x-axis: **Number of Interviewees Who Perform Activity**

52
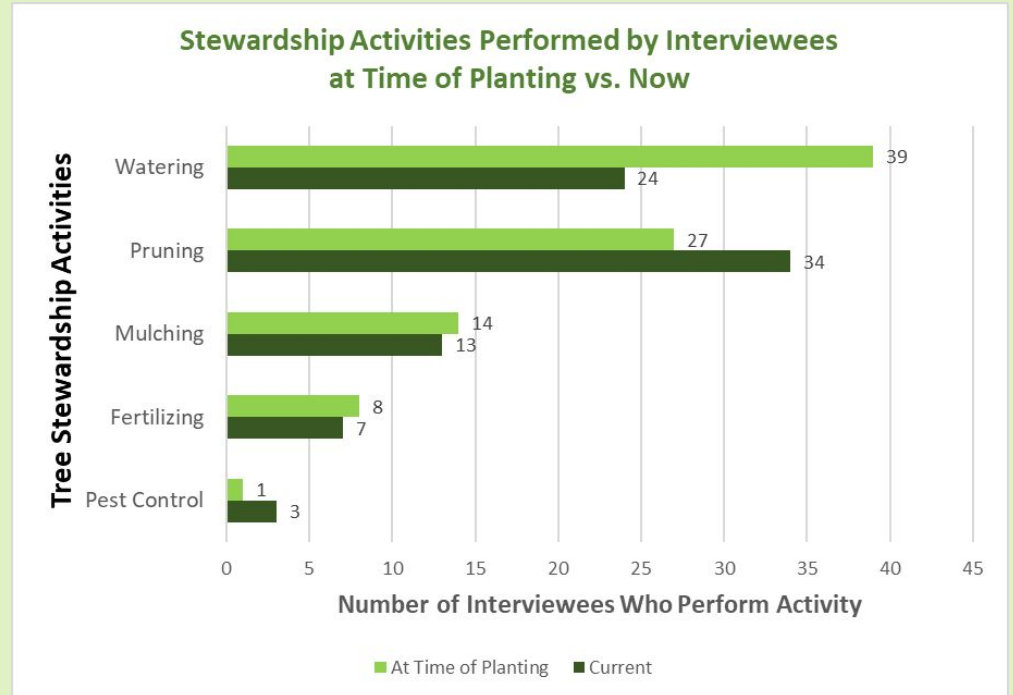
The Difference Initial Watering Makes

- Trees watered in initial 1-2 years of planting have much higher survivorship

- Watering more mature trees does not correlate with higher average survivorship

Watering at Time of Planting	Interviewees (n)	Average Survivorship
Not Watered	13	66%
Watered	39	80%

"Yup, about **twice a day**. Once in the morning and once the evening, that was it. That's what they told me to do. [Now,] I just prune, that's it I **don't [do] any watering**.I **let mother nature** do that, that's all."

Watering 2023	Interviewees (n)	Average Survivorship
Not Watered	28	77%
Watered	24	78%

Past Experience and Stewardship

DCR Planting Experience	Average Trees Planted on Property	Average Survivorship	Interviewees (n)
Not Present	4.75	41%	5
Negative	5	66%	9
Neutral	3.29	85%	14
Positive	7.79	82%	24

- Change in homeownership is associated with tree removal and lower average survivorship

- People with mixed or neutral opinions had the highest average survivorship

- On average, people with a positive experience with the DCR had more trees on their property and high survivorship

Common Barriers to Tree Stewardship

What difficulties have you encountered caring for your tree(s)?

"**Raking the leaves** was often a challenge"

"**I'm disabled now**, unfortunately. And the **maintenance is harder**"

"**I don't care**. You know, so, so like I said, **a labor of love**"

"**Definitely money**. It costs money to do it"

"We felt like the tree **might hit us**"

Category	Percentage
Capability	59.6%
No Barriers	32.7%
Interest	9.6%
Safety	7.7%
Pests	
City Issues	

Summary of Interview Analysis

Major takeaways

- Residents value s**hade, beauty/aesthetics, wildlife,** and **privacy** but face challenges such as **leaves/cleanup, hazards, effects of wildlife**

- Residents find **capacity** to be a major barrier to tree care

- Interviewees in the **north/suburban sections** of the study area were more likely to say their neighborhood had **recovered**

- Residents who believe that their neighborhood had **not recovered** tend to live in areas that experienced heavy **tree loss from LB**

- Stewardship:

  - Residents who tended to **water** their trees more in the **initial stages** had **higher average tree survivorship**

  - **Lower average tree survivorship associated with**

    - New homeownership

    - Negative opinions of DCR

Amritha and Ksenia conducting an interview on resident's lawn

Ksenia and Caleb conducting an interview

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Tree Planting Outcomes and Conclusions

HERO fellows, Ksenia and Tanner, assessing crabapple (Malus coronaria)

Outcomes

> What are the impacts of tree planting on ecosystem services and temperature?

Conclusions

1. Lessons from Our Study
2. Recommendations for Tree Planting
3. Future Research

Ecosystem Services

In 2023, private trees in our sample contributed over **$7,206** worth of **ecosystem services**. This is an **increase of 689%** from the baseline survey

Annual **energy savings** alone accounted for **$4,012** of this value

Other factors include the **sequestration of 4.6 tons of carbon** annually, the **removal of 238 pounds of pollution** from the air annually, and the **production of 12.2 pounds of oxygen** every year

Species ranked by 2023 Mean Value	Baseline Mean Value	2023 Mean Value
Tulip	$1.22	$18.12
Pin Oak	$1.85	$14.14
Zelkova	$0.80	$13.16
Linden	$0.83	$12.56
Littleleaf Linden	$0.71	$11.98
Bottom 5 Species	——————	——————
Balsam Fir	$0.17	$0.91
Serviceberry	$0.76	$0.83
Kousa Dogwood	$0.27	$0.77
Dogwood	$0.21	$0.76
Fringetree	$0.23	$0.47

Tulip tree (Liriodendron tulipifera) in a backyard

Fun fact: 4.6 tons of carbon annually is equivalent to approximately 3.5 Olympic-sized swimming pools

Analysis completed using i-Tree Eco v6

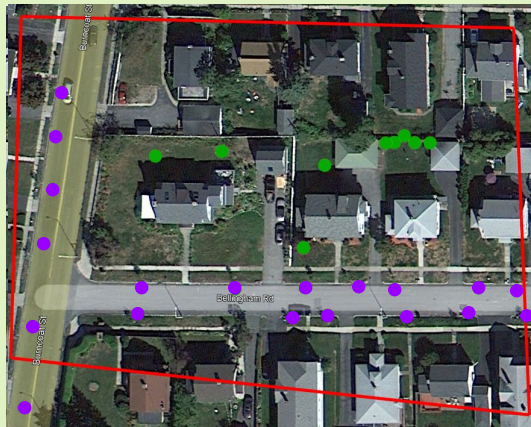# Tree Planting Impact on Surface Temperature
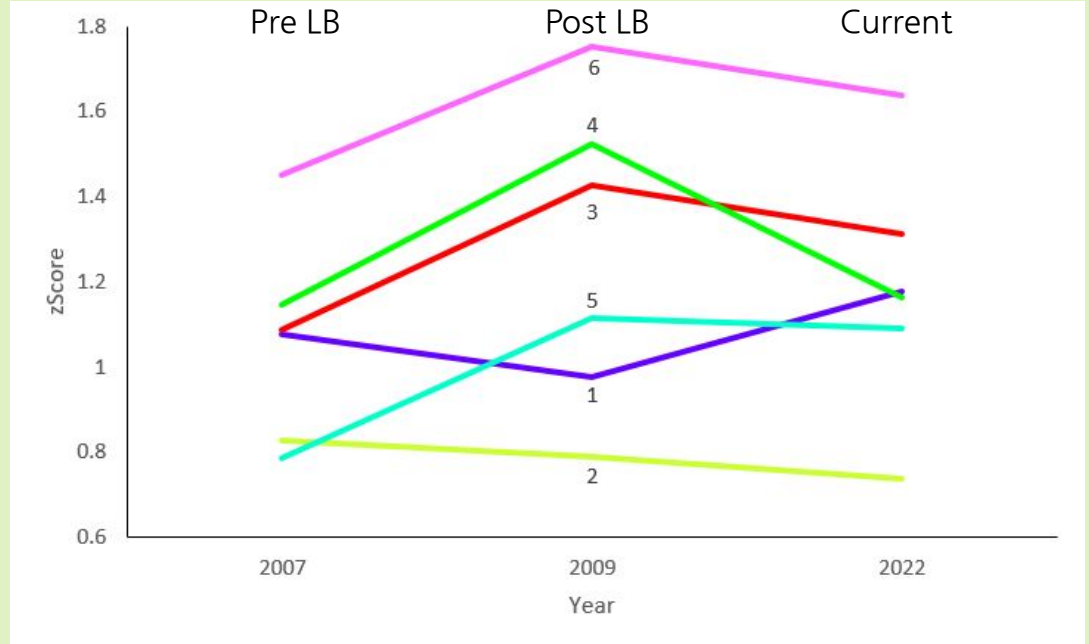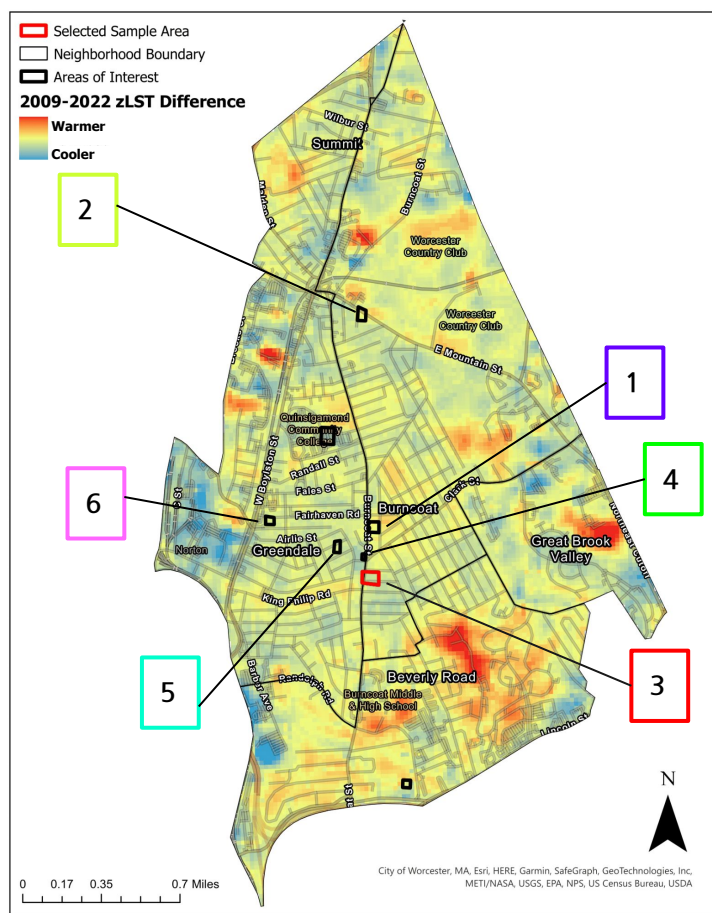
Residential areas with lots of removals get sharply warmer from 2007-2009, slowly cool following replanting

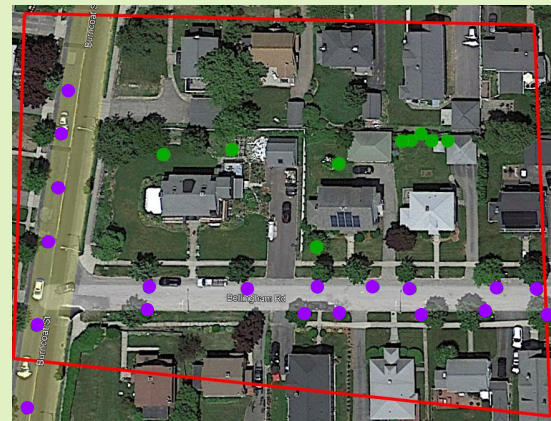# Satellite Images of Selected Sample Area 3
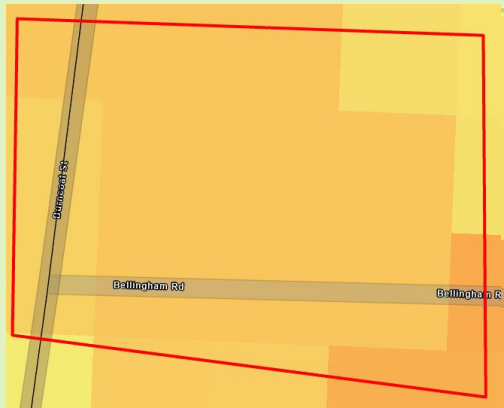
7/2007 Pre-LB   9/2010 - During Planting   6/2022 - 13 years post LB
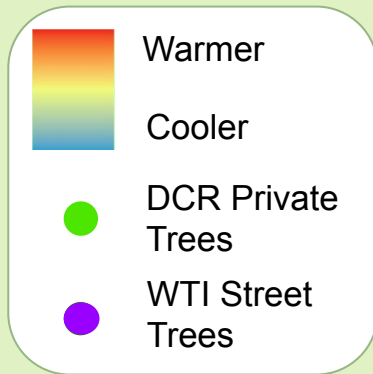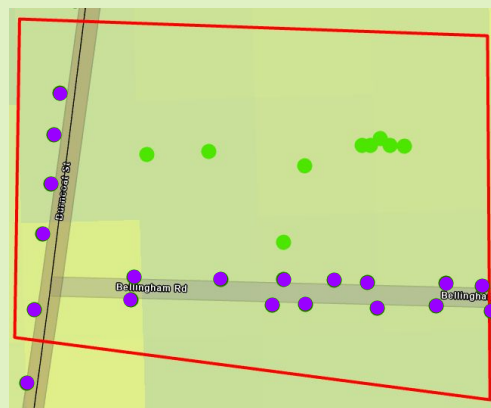

Land Surface Temperature (zLST) Difference

Between 2007 - 2009   Between 2009 - 2022

Warmer

Cooler

● DCR Private Trees

● WTI Street Trees

Lessons from Our Study

- **Linden, littleleaf linden**, and **honeylocust** have the **highest survivorships** of private shade trees

- **Japanese tree lilac** and **snow goose cherry** have the **highest survivorships** of private ornamental trees

- **Troubling** results were seen with **gingko** survivorship

- **Street trees** have **higher survivorship** than private trees

  - 66.9% private tree survivorship, 10.2% less than baseline

  - 88.6% street tree survivorship, 9.9% less than baseline

- **Residents** perceived that the **largest benefit** from trees was **shade**, despite **shade trees** having **lower survivorship** than evergreen and ornamental trees

  - Shade trees provide the most ecosystem services as quantified by iTree

  - Residents want shade trees, but not on their property

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Ksenia measures the DBH of a Pin Oak (Quercus Palustris)

Recommendations for Tree Planting

Tree Species Selection
- Shade and ornamental (see list)

Site Selection
- Front yards of single family homes/duplexes have highest survivorship and vigor
- Extra coordination and stewardship needed in multi-family residence properties

Communication
- Enhanced and sustained communication with residents is required to ensure tree survivorship
- Tree retention contract required when planting a tree in private yard

Long Term Monitoring
- Ongoing health assessments can promote intervention

Coordinated watering
- Private and Street trees

Shade Species
Littleleaf linden
Tulip
Pin oak
Honeylocust
Red oak

Ornamental Species
Snow goose cherry
Japanese tree lilac
Dogwood
Dawn redwood

Ksenia and Tanner measure a tulip (Liriodendron tulipifera)

Future Research

- Expand analysis to full LB regulation zone

- How can the likelihood of future removals of healthy trees be reduced?

- How do private tree survivorship factors change in the short and medium term?

- Optimizing configuration and density of tree species to maximize environmental system services and residential happiness

- What is the impact of shifts in home ownership on tree survival rates and overall health?

A view of Granville Ave in 2023

Thank you

DCR Foresters
US Department of Agriculture
Worcester Tree Initiative (New England Botanical Garden)
Worcester Technical High School (Environmental Science and Technology Program)
City of Worcester
Clark Geography - Aidan Giasson and Yaa Poku
Clark Marsh Institute Staff - Pamela Dunkle

Questions?

Sources Cited

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Change in Tree Crown Width
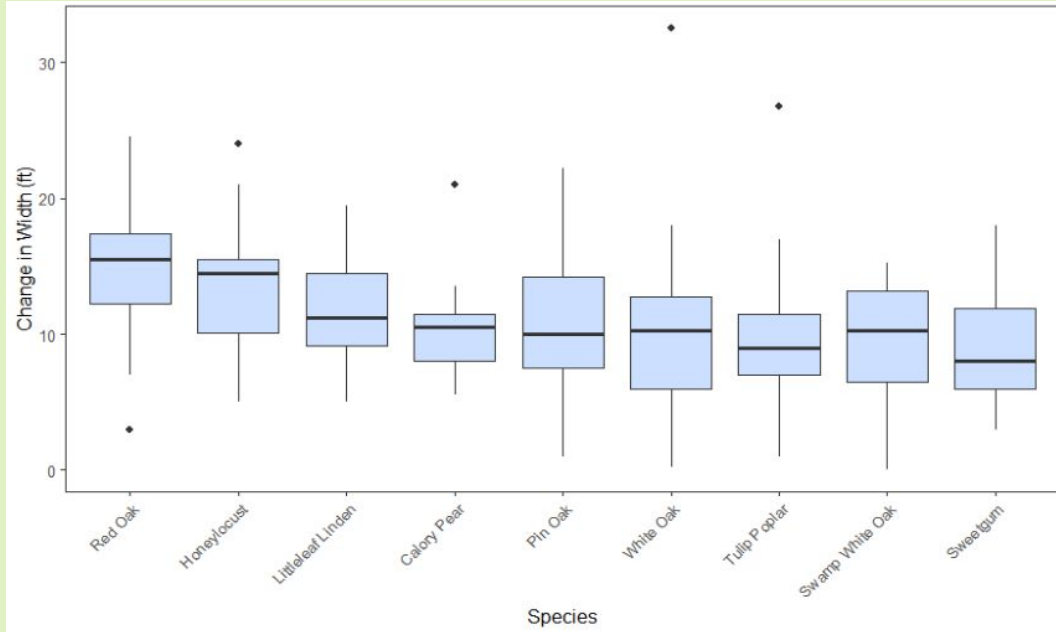
38 ft width Honeylocust (Gleditsia triacanthos)

Species	Width in 2023 (ft)	Change in Width (ft)
Red Oak	29.6	14.8
Honeylocust	32.0	13.4
Littleleaf Linden	22.8	11.9
Pin Oak	25.6	10.0
White Oak	21.0	10.0
Callery Pear	24.8	9.3
Swamp White Oak	21.7	9.3
Tulip Poplar	22.0	9.2
Sweetgum	20.6	9.1