

# 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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# 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?

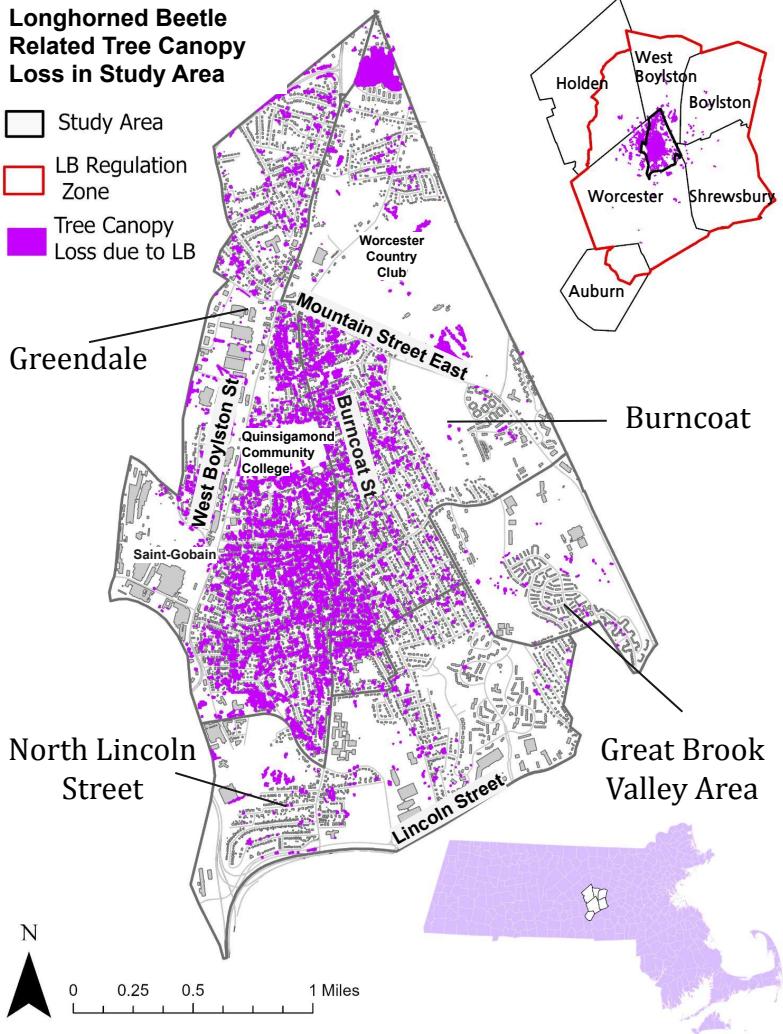
How does the tree health and structure compare to the past HERO tree survey?

## 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?



# 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

## 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

Greendale

Mountain Street East

West Boylston St

Saint-Gobain

Burncoat St

Quinsigamond Community College

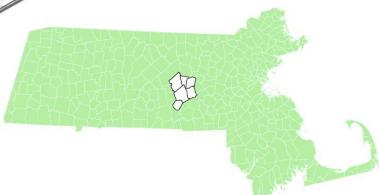
North Lincoln Street

Great Brook Valley Area

Lincoln Street

N

0 0.17 0.35 0.7 Miles



# DCR Tree Planting Program

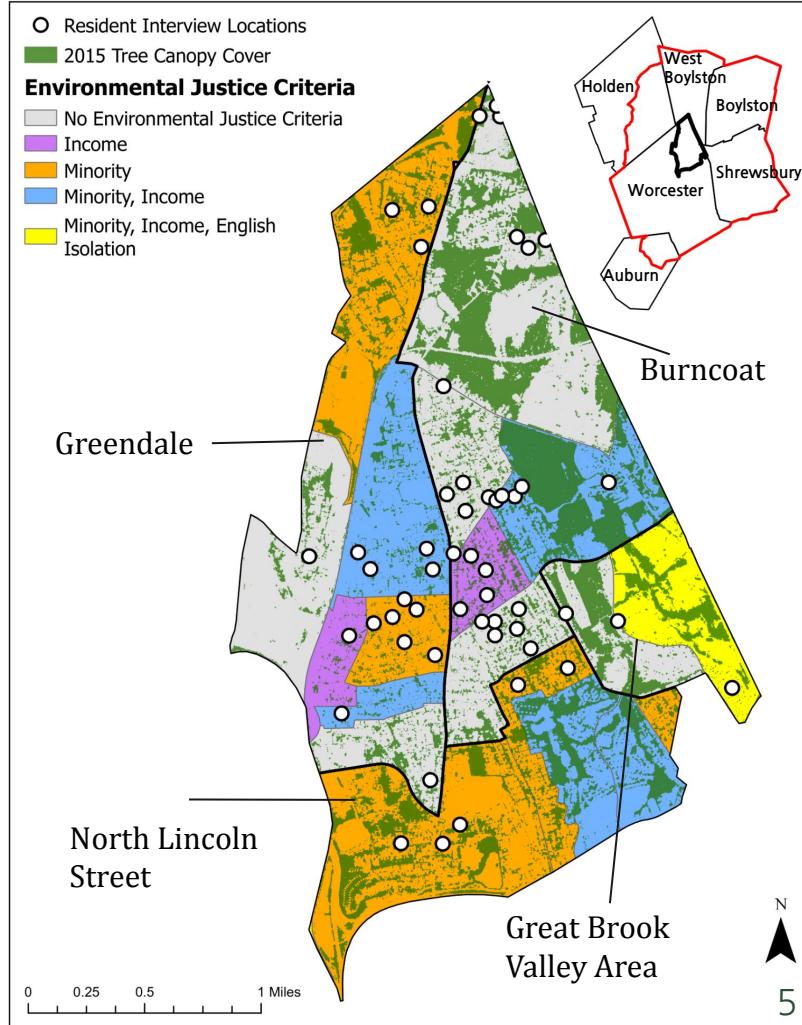
- The DCR's tree planting program planted 17,000 trees to rebuild the region's urban canopy
- ~7000 trees planted in our study area
- Tree planting began in spring 2010 and continued until 2017 - first trees were planted in study area
- Funded by the American Recovery and Reinvestment Act (ARRA)
- High 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”



# 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?

# Baseline HERO Survey

## Sampling:

Street trees were selected along transects in a randomly selected area

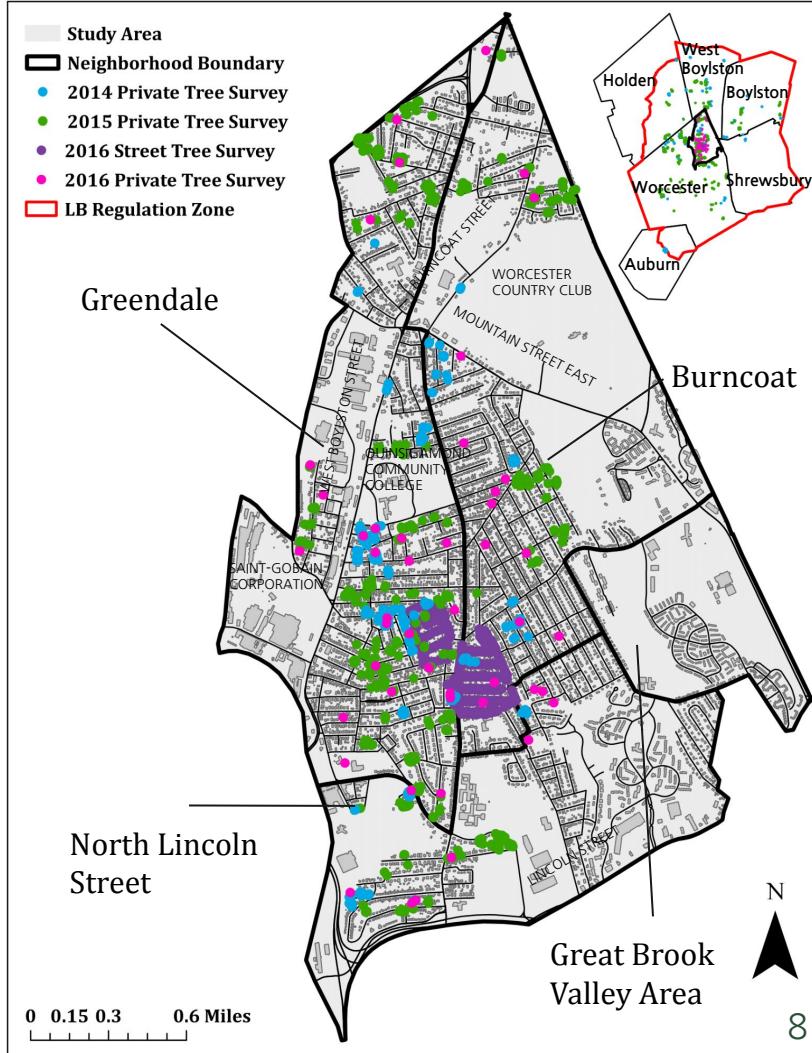
17,000 Total

9,000 tree stratified sample by species

1,516 in baseline sample

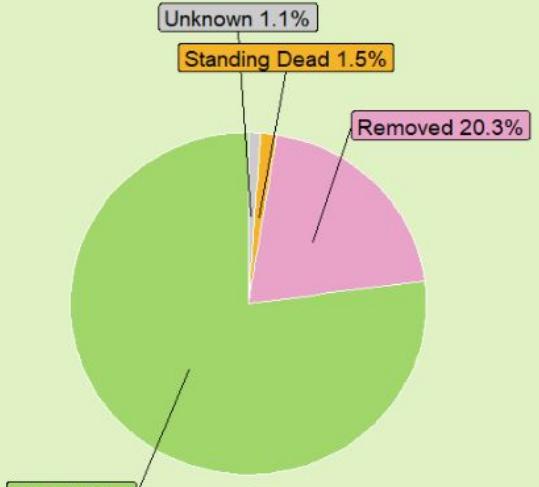
800 private trees surveyed in study area from 2014-2016

- 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

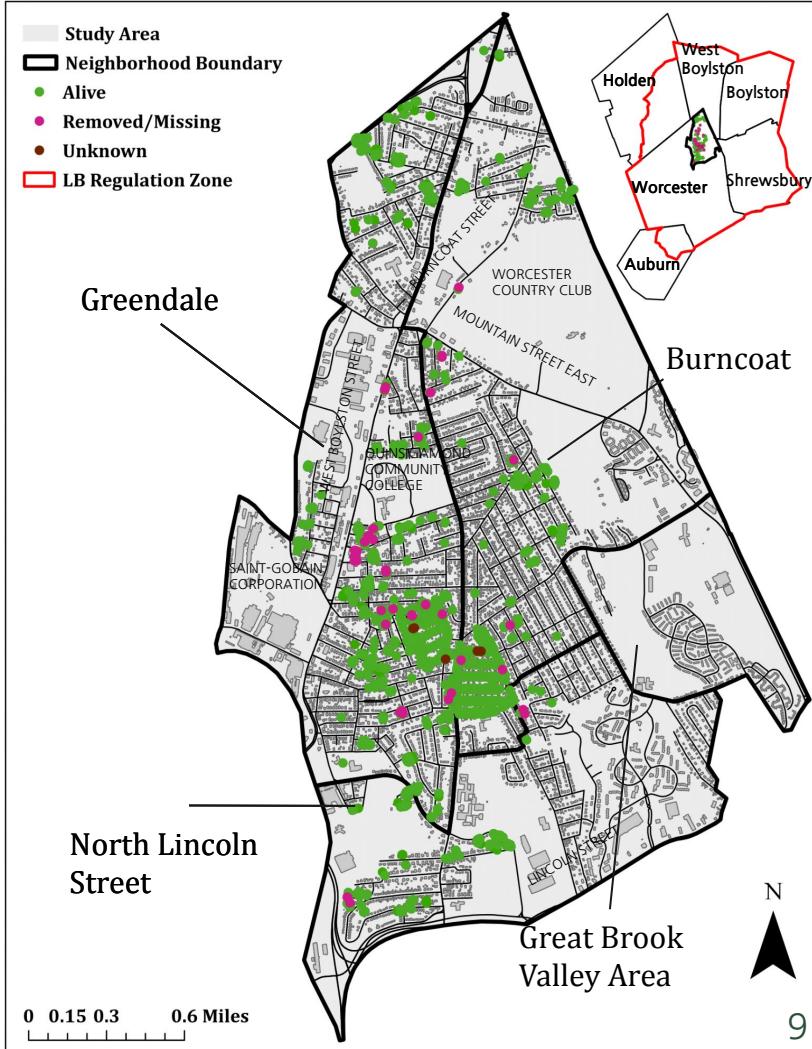
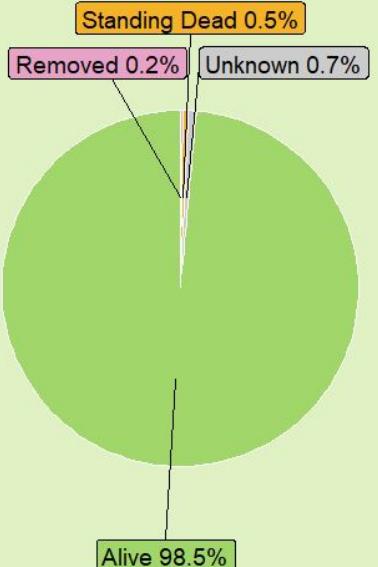


# Baseline HERO Survey Findings

Private Tree Survivorship



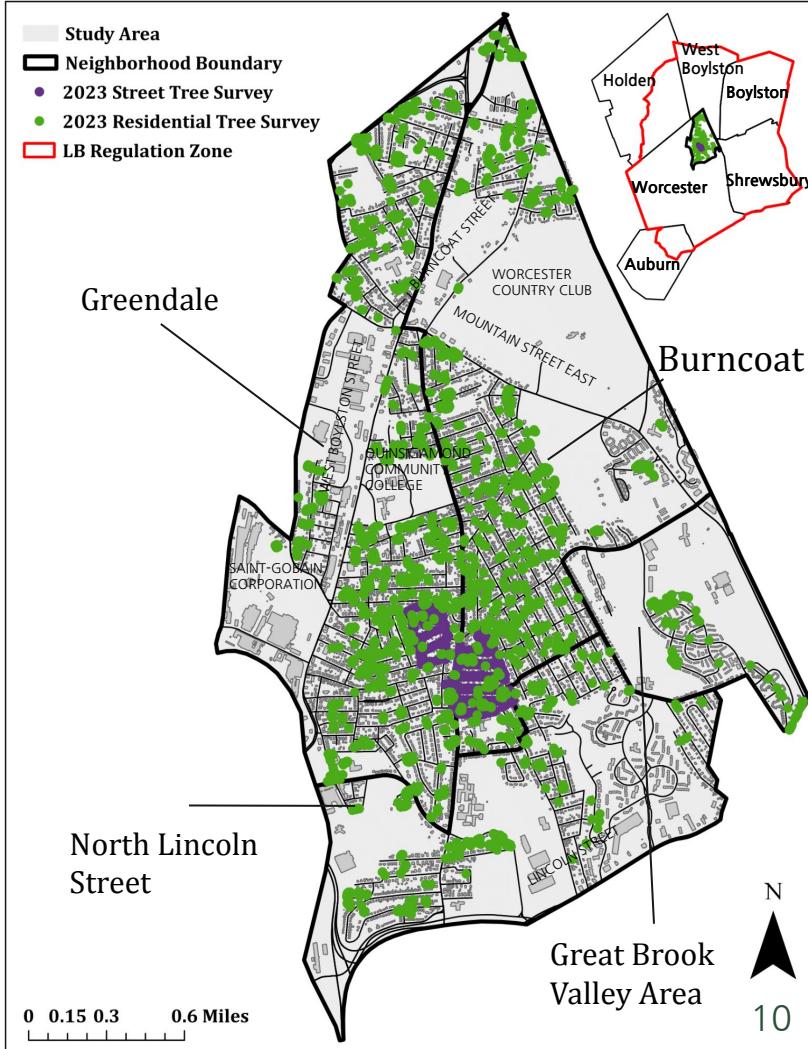
Street Tree Survivorship



# 2023 HERO Survey

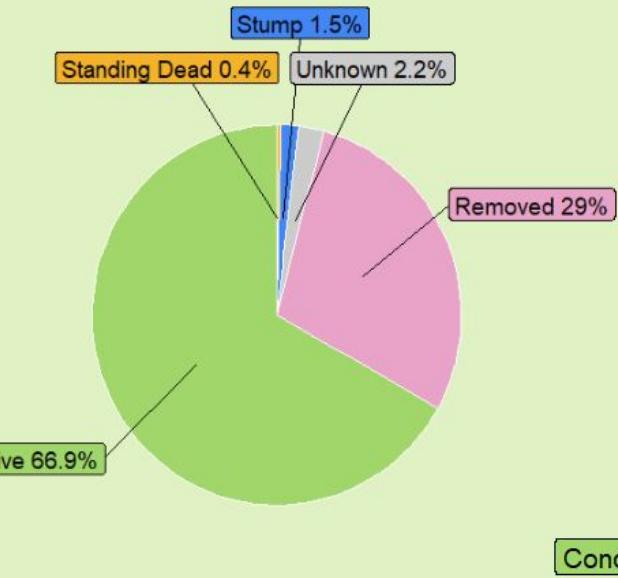
## Trees Surveyed in Study Area

- 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

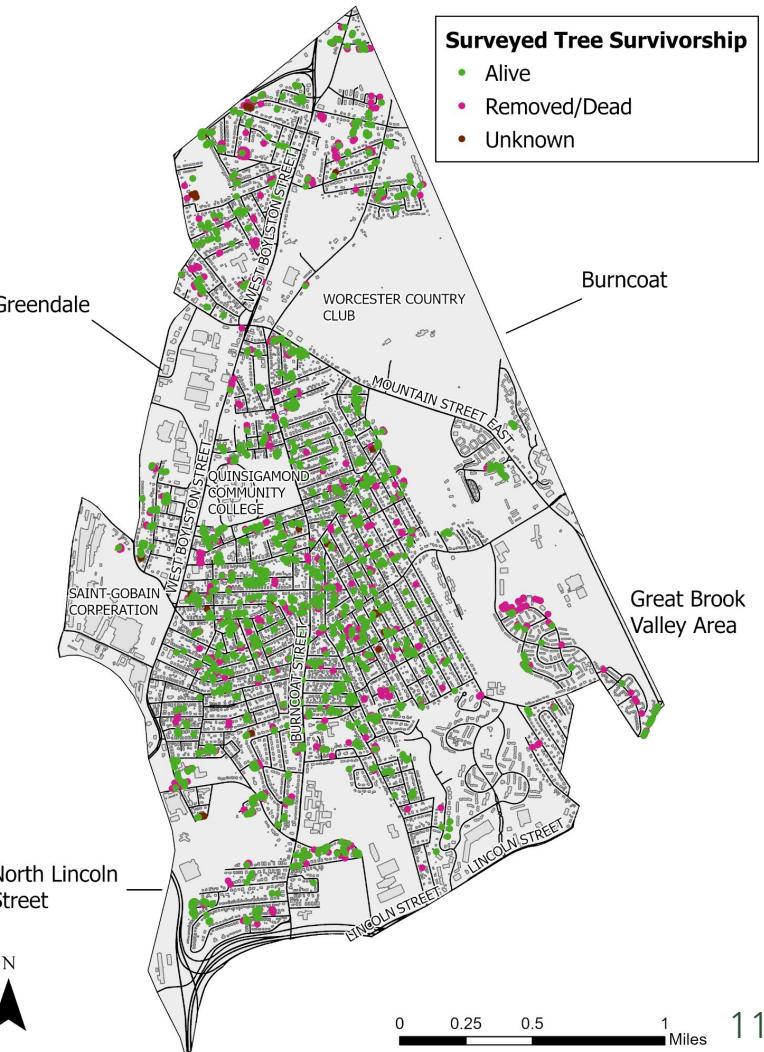
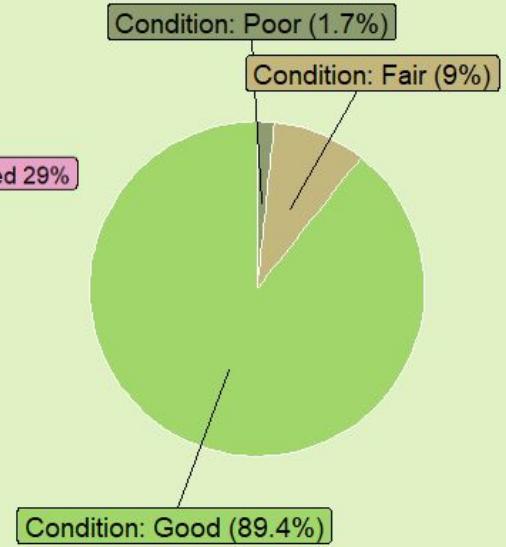


# 2023 Survey of Private Trees

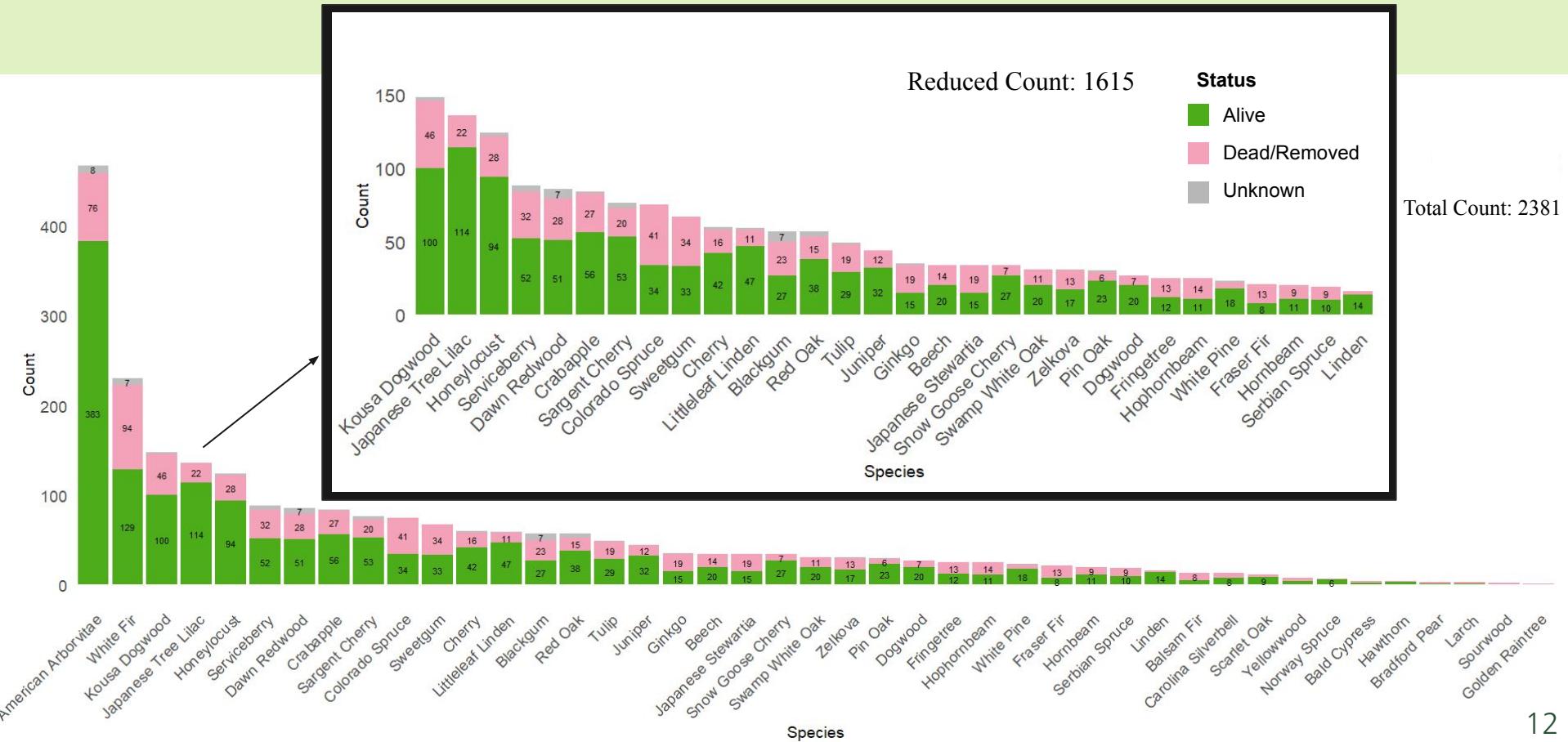
## Survivorship



## Condition



# Private Tree Species' Status by Count



# 2023 Survivorship



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



Right: White pine (*Pinus strobus*) 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



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

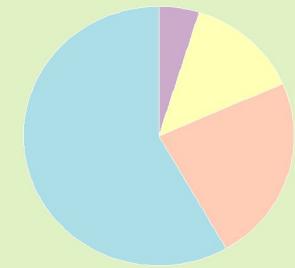
Below: Ginkgo (*Ginkgo biloba*) in a backyard



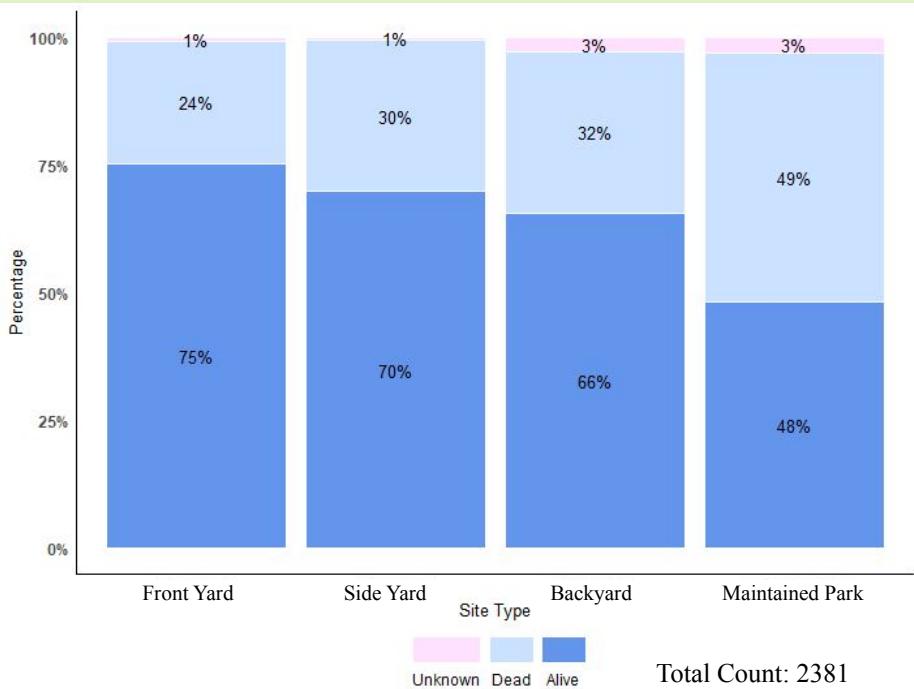
# Health By Site Type

## % Trees Surveyed (2023)

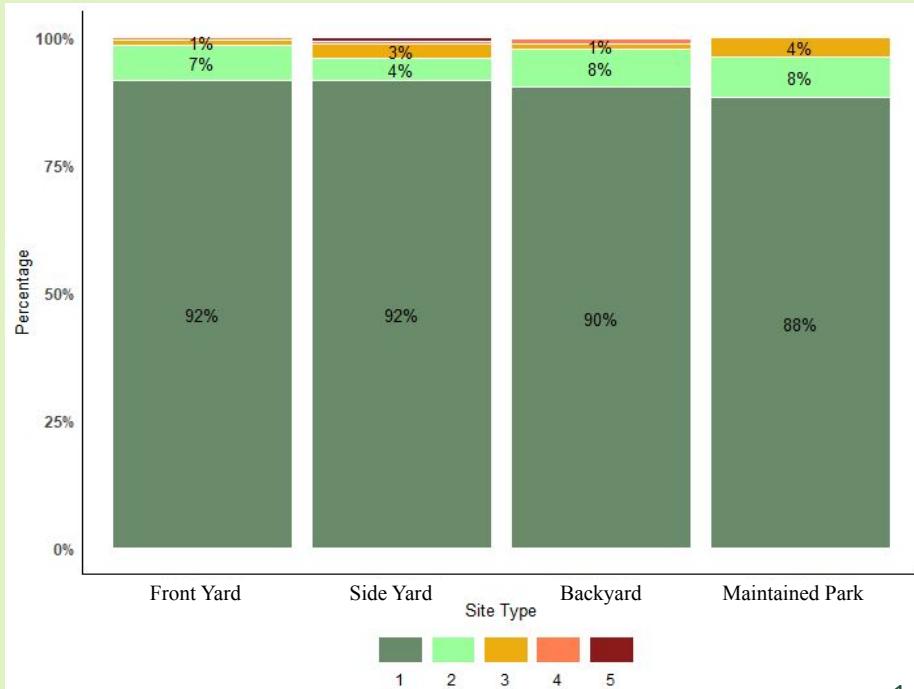
- Backyard (58.3%)
- Front Yard (23.3%)
- Side Yard (13.6%)
- Maintained Park (4.8%)



## Survivorship



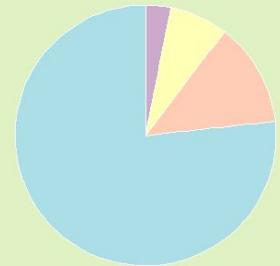
## Vigor



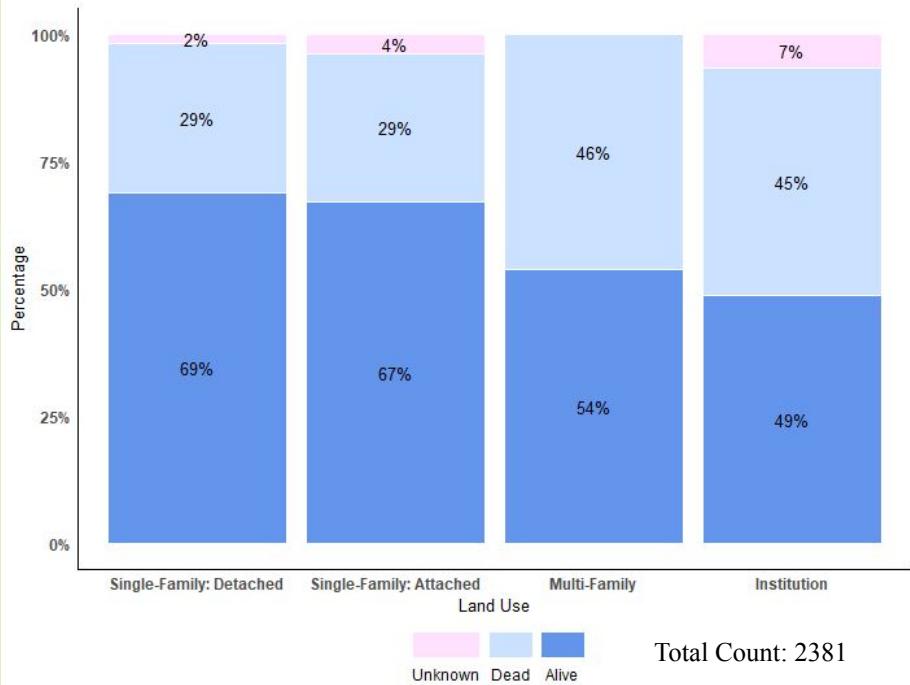
# Health By Land Use

## % Trees Surveyed (2023)

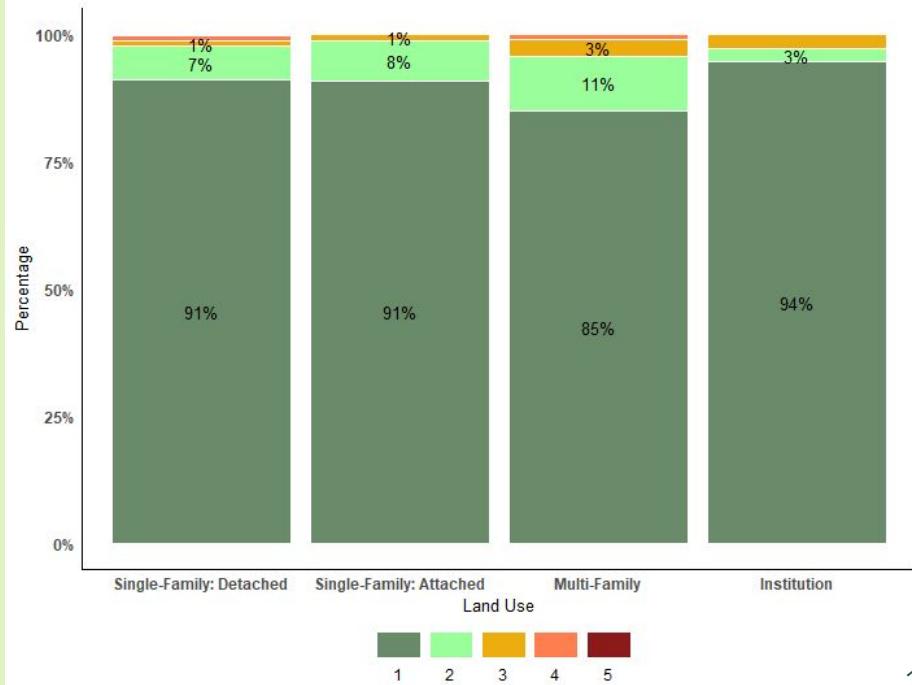
- Single-Family: Detached (76.7%)
- Single-Family: Attached (12.9%)
- Multi-Family (7.3%)
- Institution (3.1%)



## Survivorship



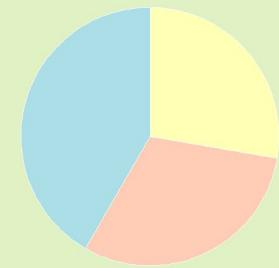
## Vigor



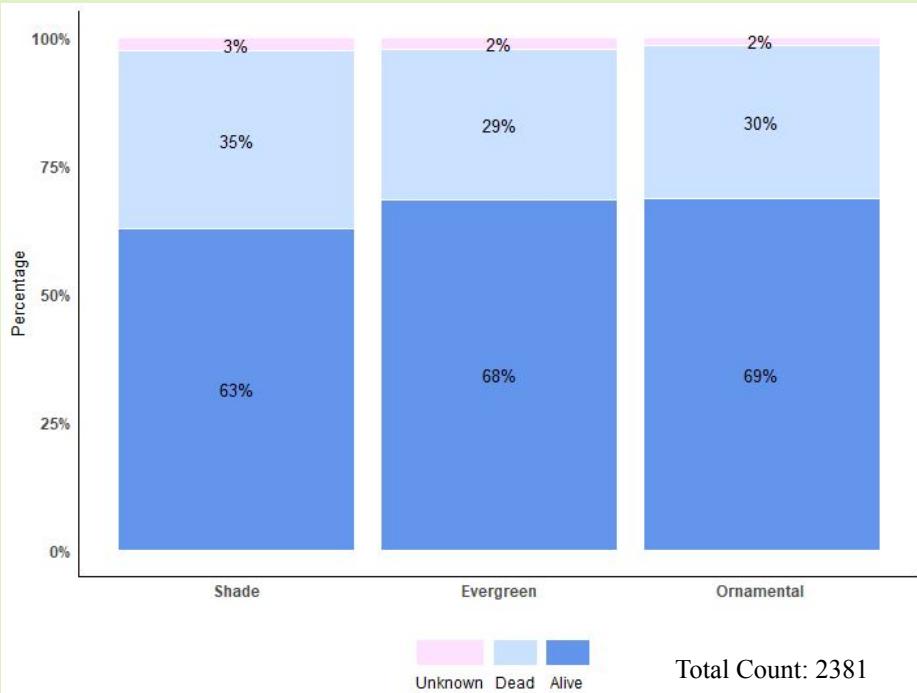
# Health By Tree Type

% Trees Surveyed (2023)

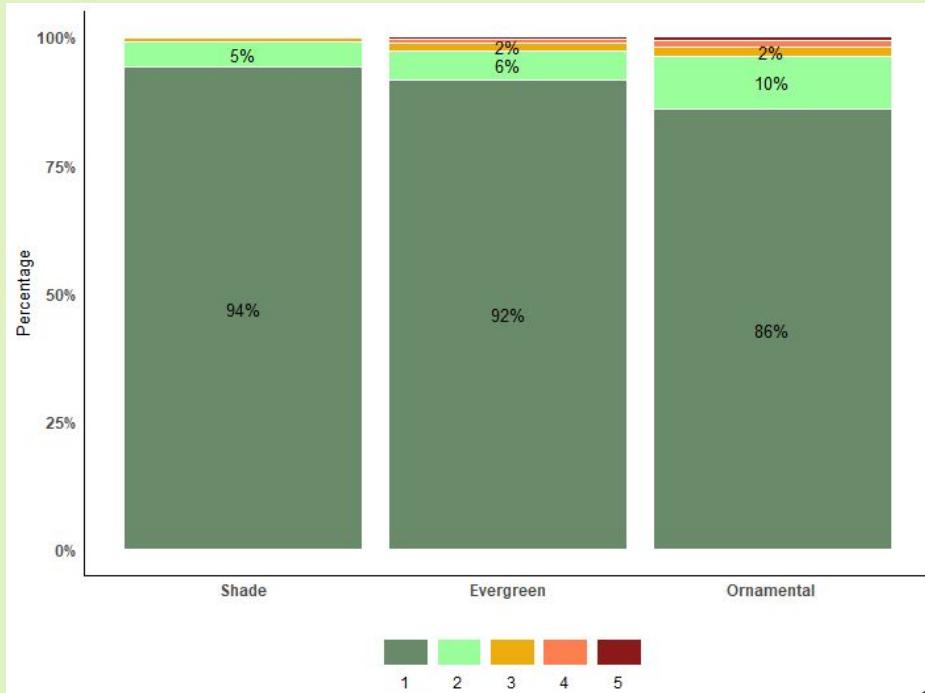
- Evergreen (41.7%)
- Shade (27.7%)
- Ornamental (30.6%)



## Survivorship



## Vigor



# 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



*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 vigor**
- **Native trees** do better in both **vigor and survivorship**



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

# 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

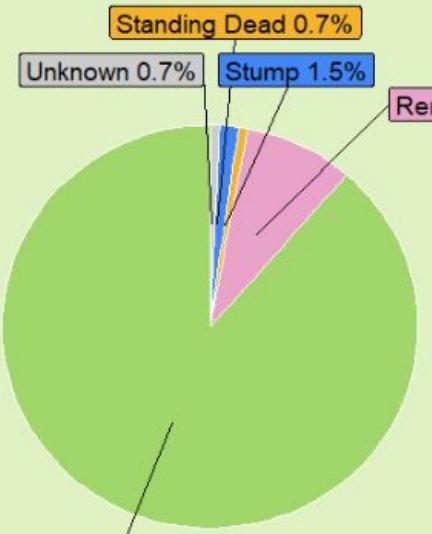
1. Compare street tree survivorship and growth to private trees
2. Analyze changes in survivorship over time



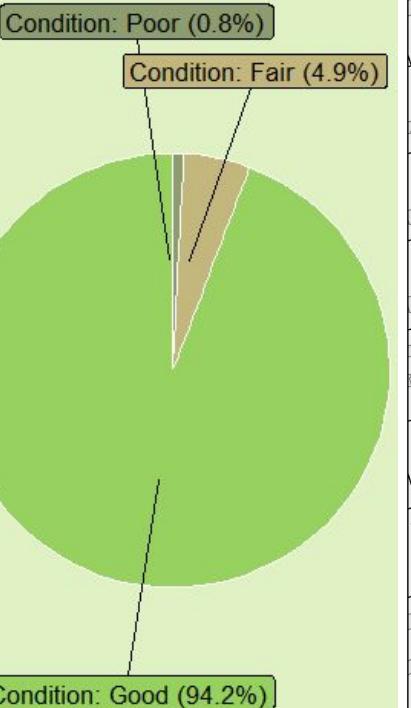
Tanner and Ksenia, next to our tallest street tree, a tulip tree (*Liriodendron tulipifera*), measuring 49.6 ft

# 2023 Worcester Tree Initiative Street Tree Survey

## Survivorship

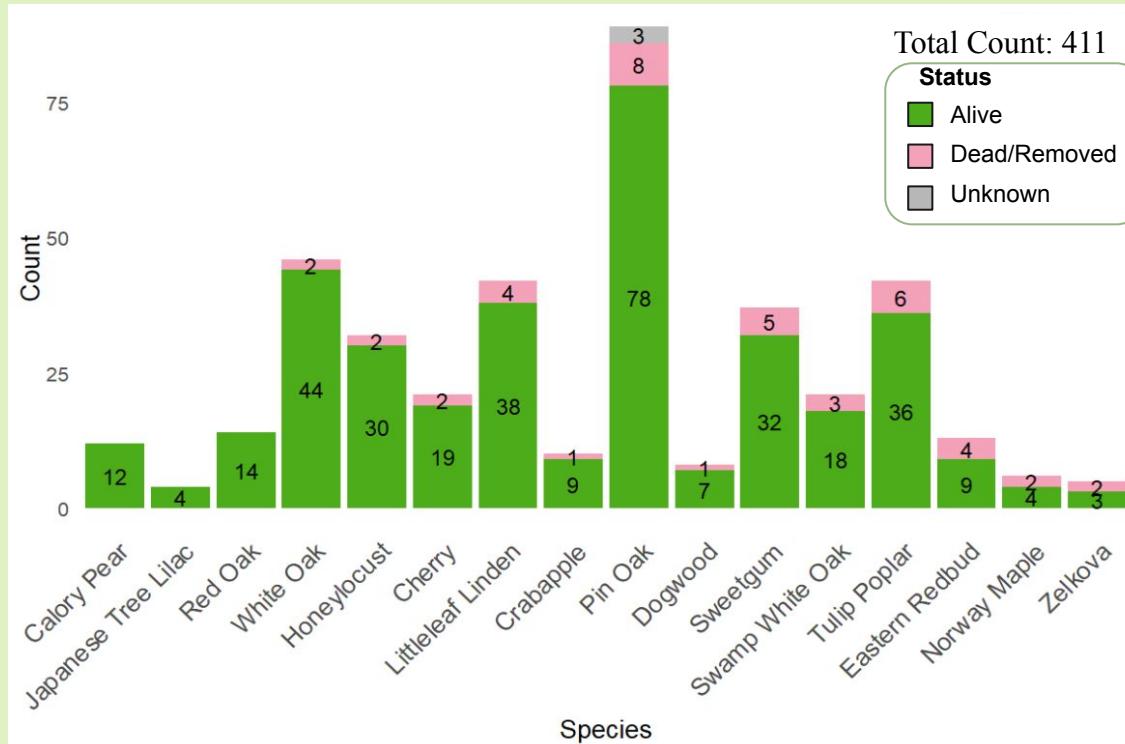


## Condition



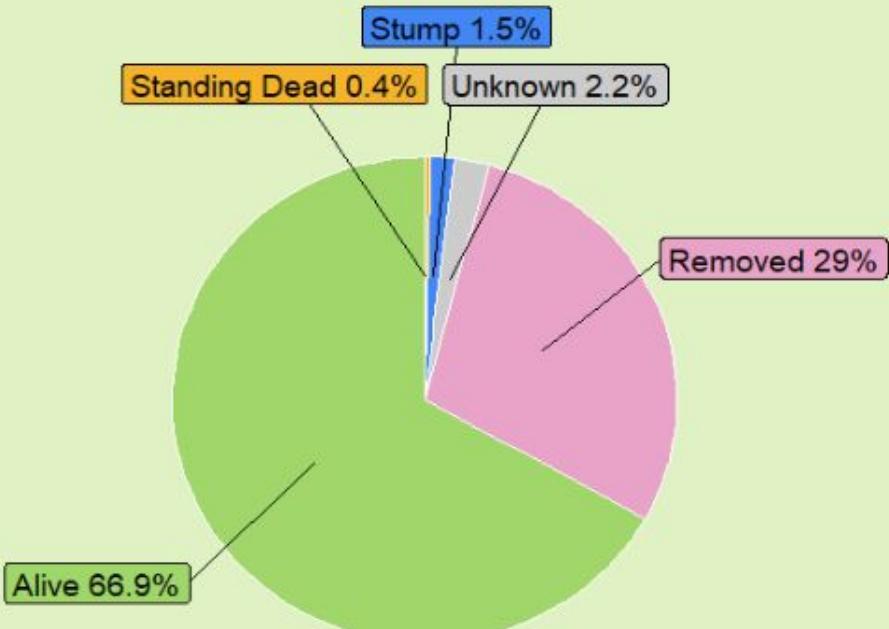
# Street Tree Survivorship by Species

Showing species with four or more trees planted

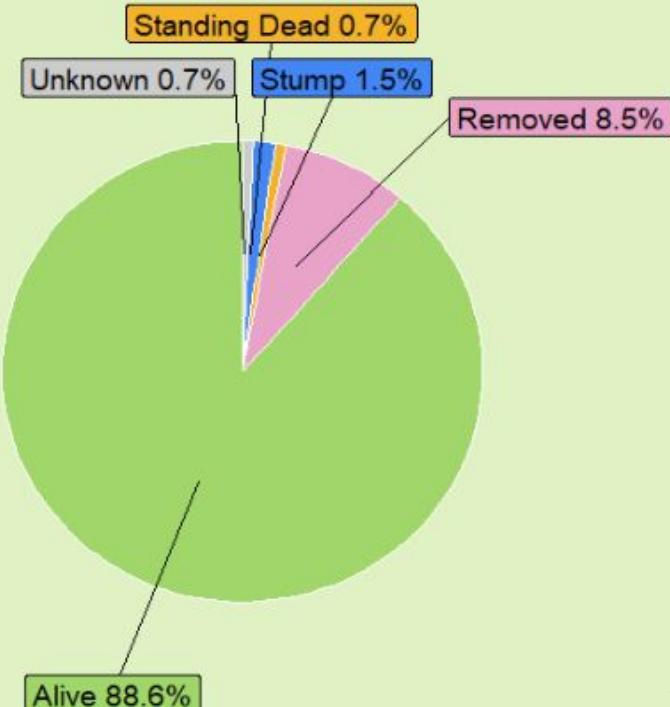


# Private Trees Compared to Street Trees: Survivorship

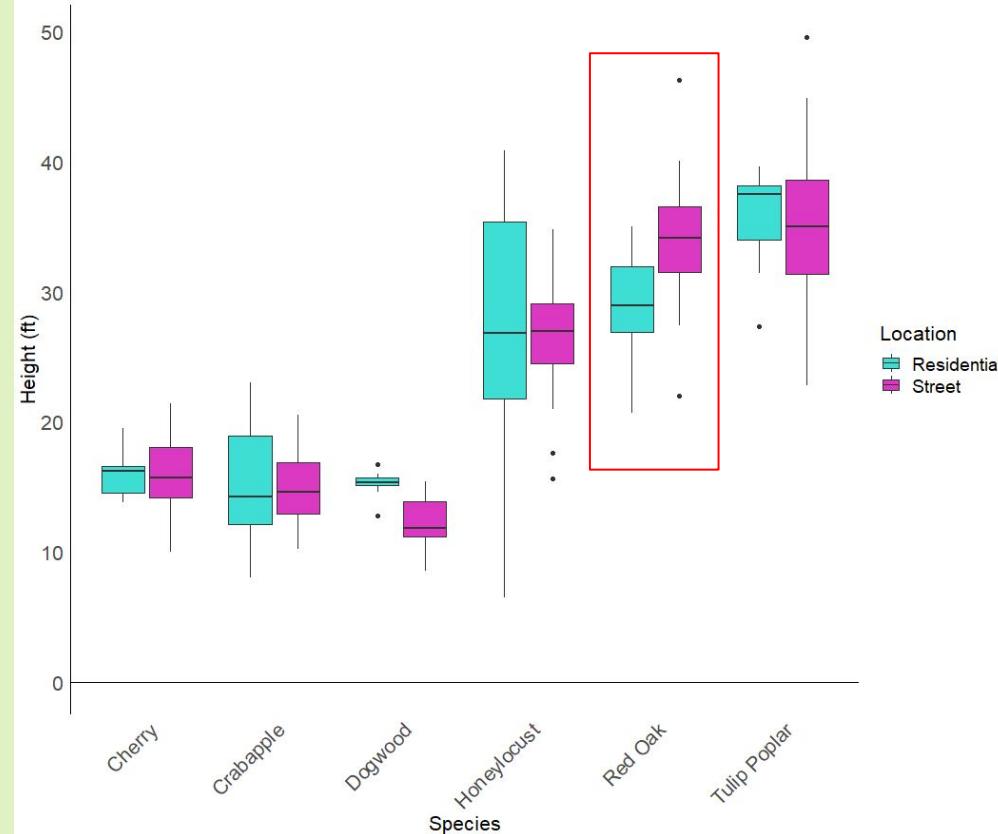
Private Trees



Street Trees



# Private Trees Compared to Street Trees: Height



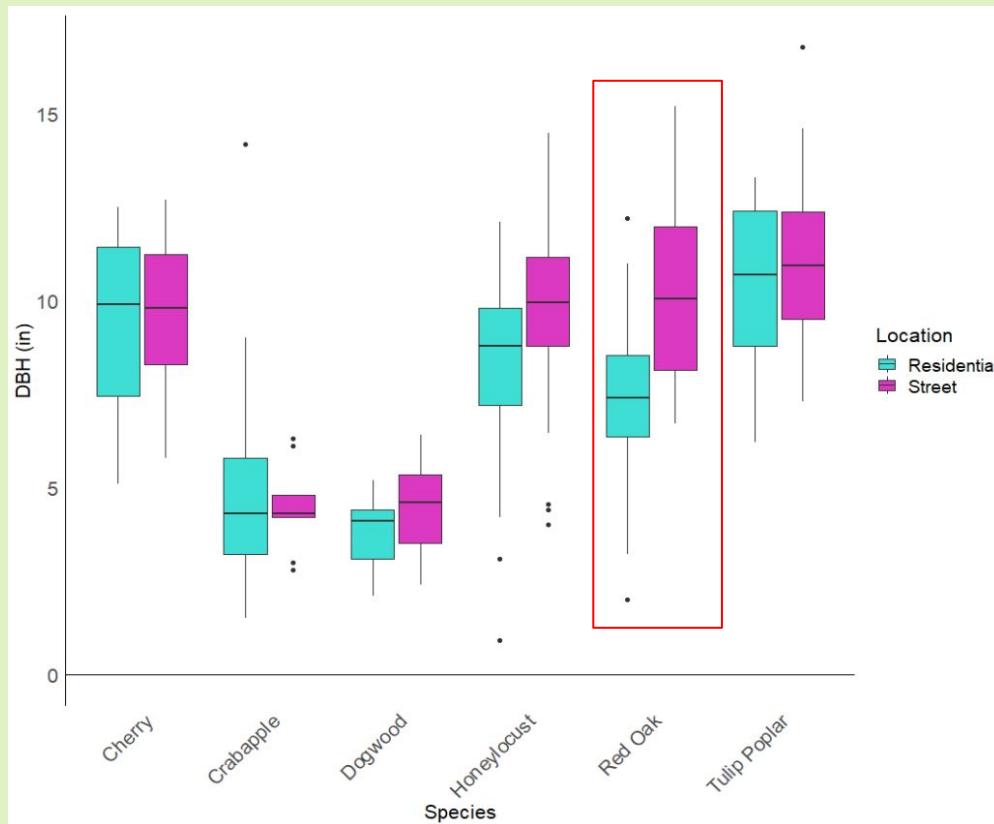
Red Oak Residential and Street



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

# Private Trees Compared to Street Trees: DBH

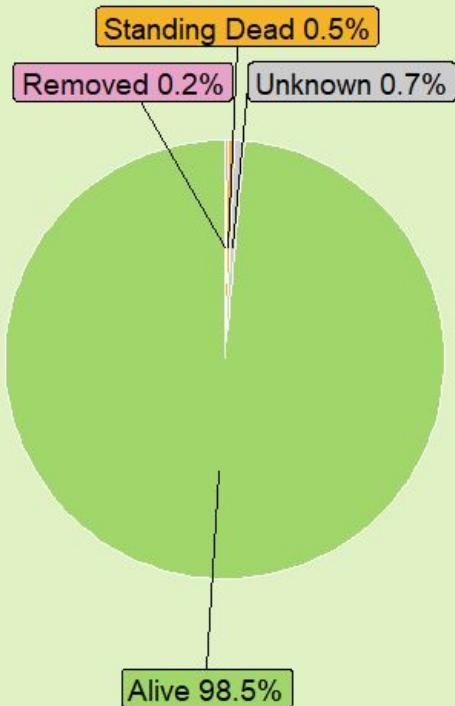
Honeylocust Residential and Street



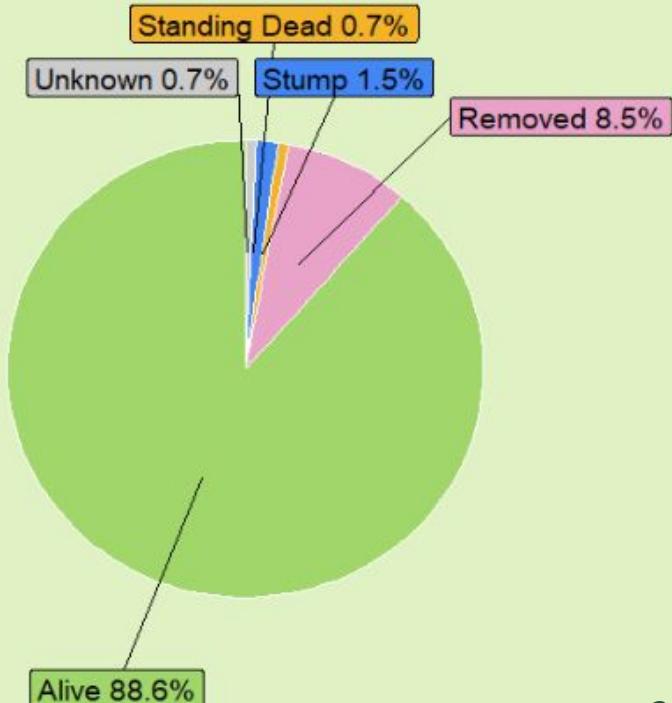
A Honeylocust (*Gleditsia triacanthos*) on a private property (pictured left) and next to the street (pictured right)

# 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 Adult 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 their 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

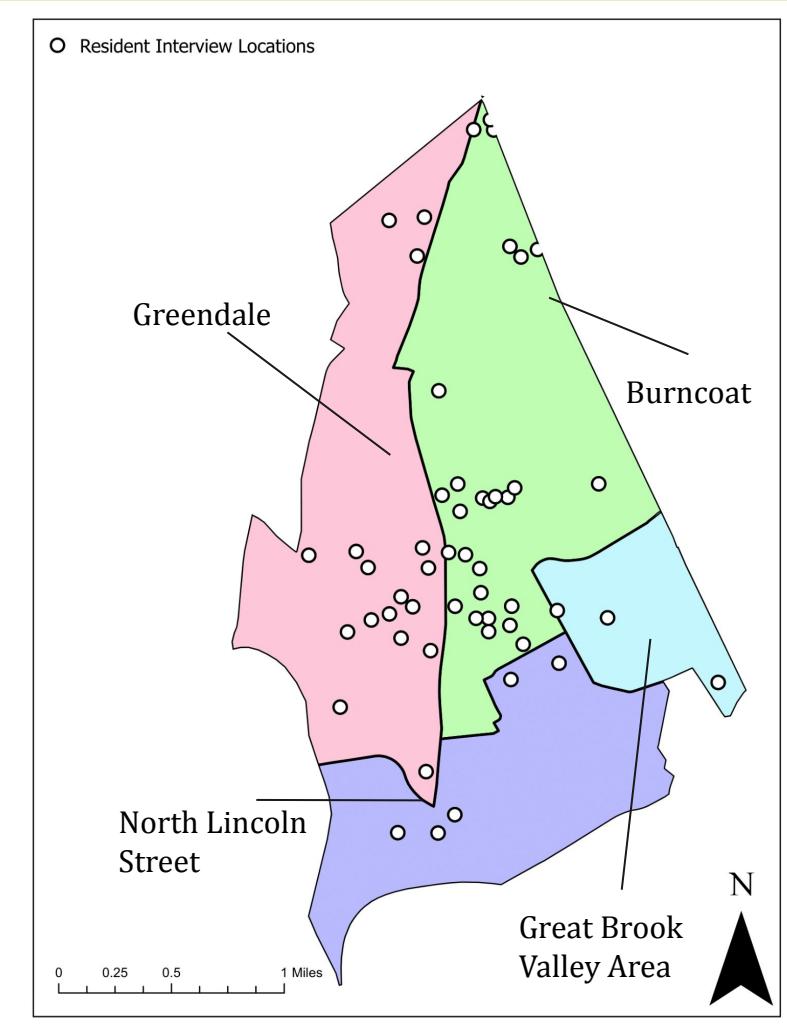
- 582 residents called
  - 40 interviews scheduled
- 12 additional interviews conducted based on interactions during data collection

## 52 Interviews Conducted

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

## Planted Trees Associated with Interviews

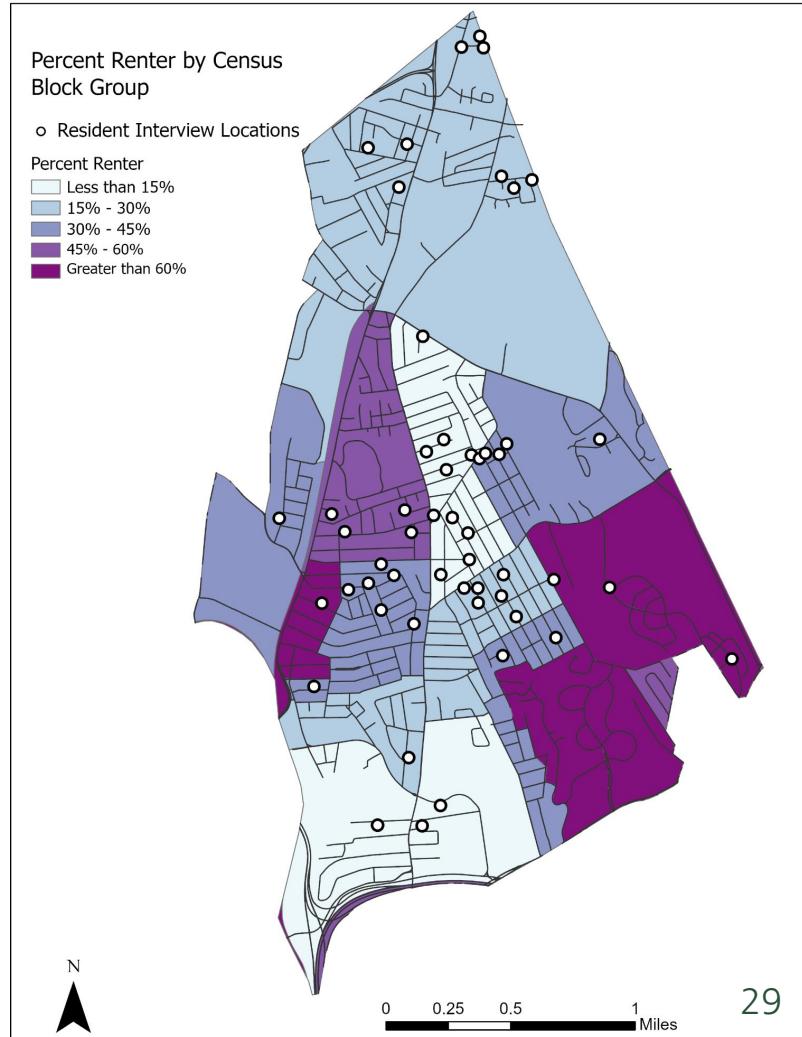
- 233 trees
- Average of 6 trees per property
- Average survivorship was 77%



# 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



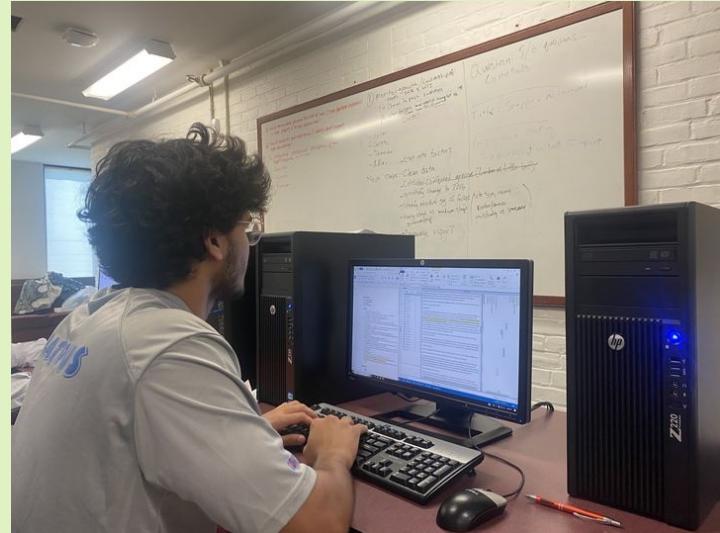
# Methods

## Interview Categories

1. Background: Personal History & Experience with DCR
2. Tree Stewardship
3. Perception of Trees
4. Perception of Neighborhood
5. Environmental Concerns

## Procedure

- Conduct 20-40 minute interviews
- Transcribe interviews manually and using AI
- Code interview transcripts using the Nvivo software
- Assign attributes to understand impact of demographics
- Assess emerging themes based on fully coded interview dataset to answer research questions



Ramón uses Nvivo software to code interviews

# Perceptions of Tree Benefits

*What are benefits of having trees on your property?*

"It throws beautiful shade for my tenant"

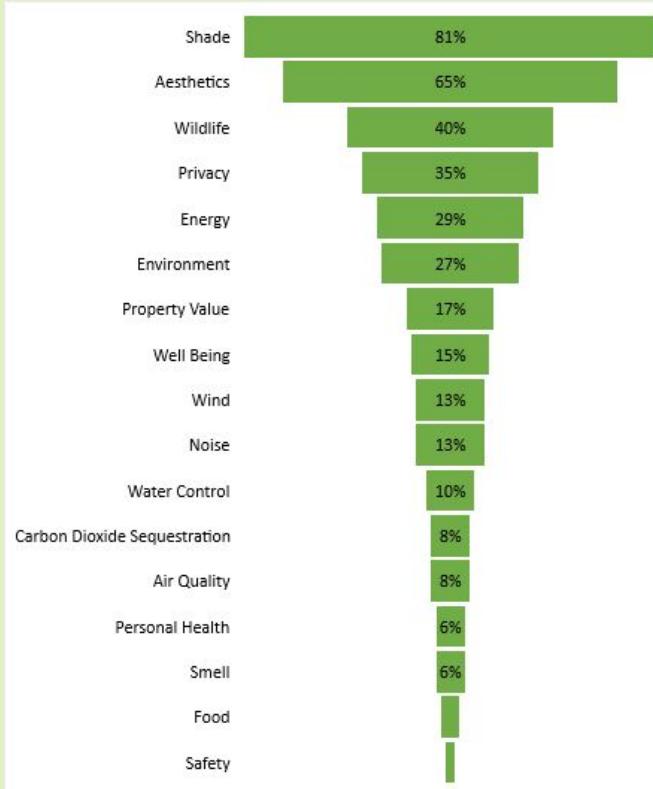
"I just find trees beautiful"

"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"



## 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

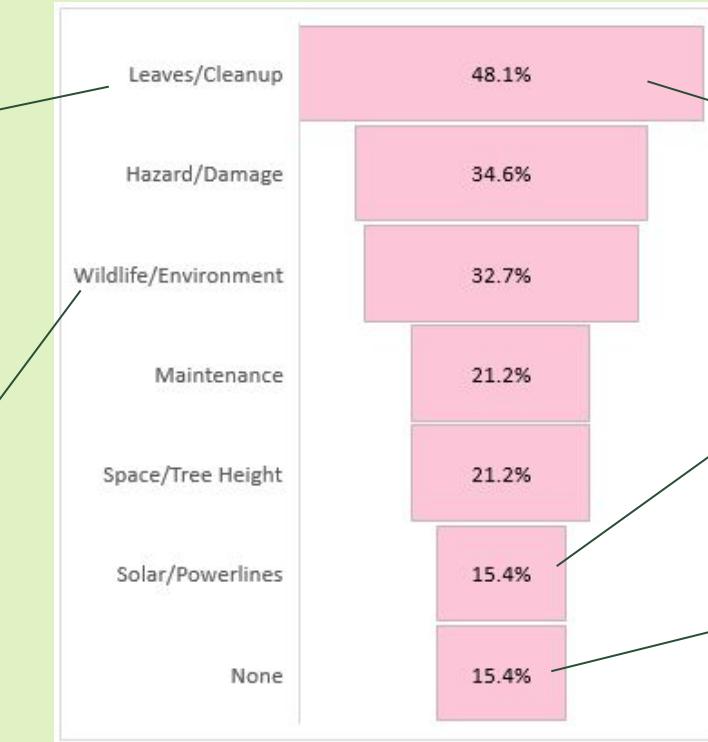
# Perceptions of Tree Challenges

*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."



"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 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

*Does your neighborhood feel similar to before the Longhorned Beetle outbreak?*

**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.**"

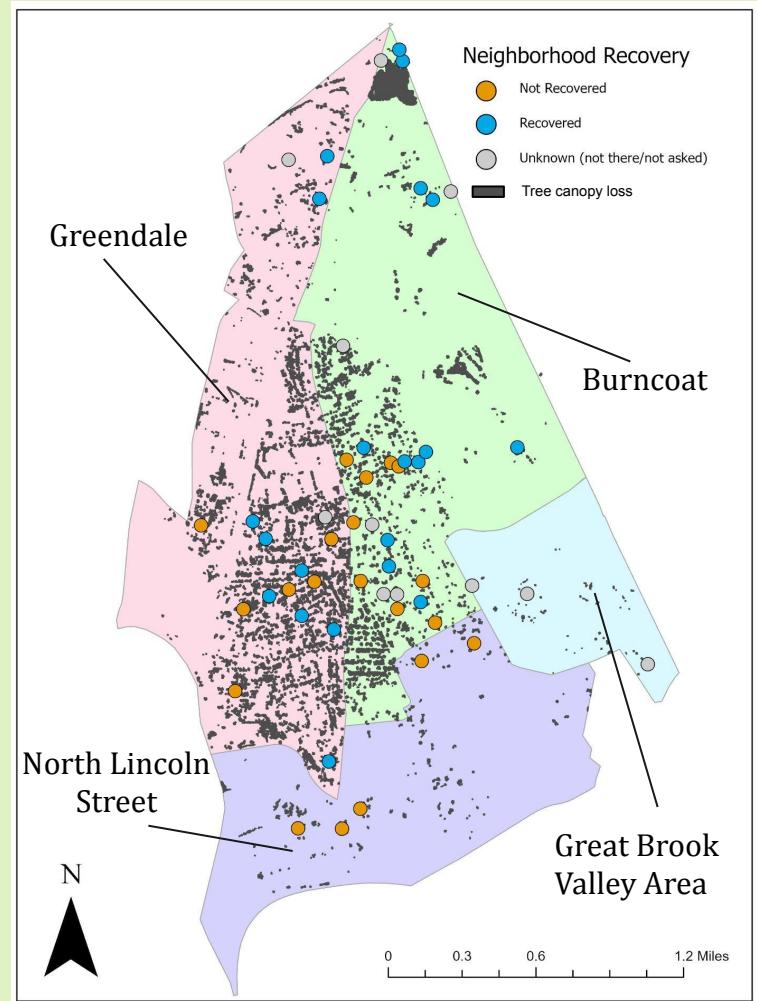
"No, no, **definitely not.** Like I said, the canopy that we had with all the trees was, I mean, something out of a Robert Frost poem or something out of storybook. Yeah. **It'll never be the same.**"

# 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



# Tree Stewardship

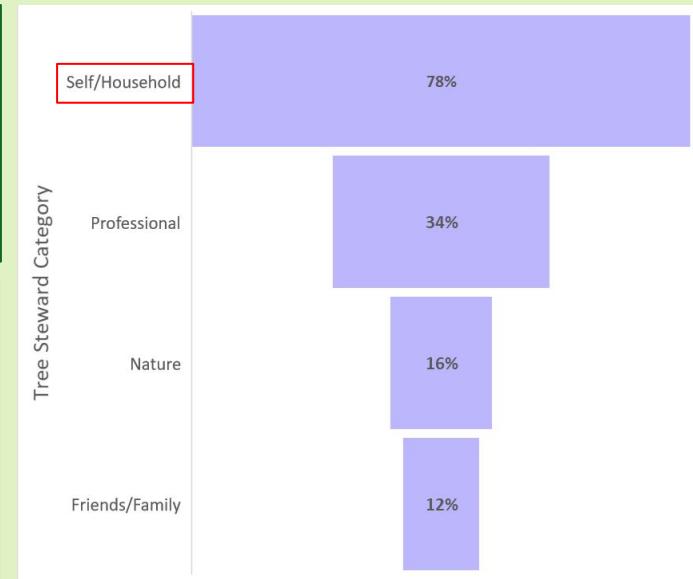
*Who maintains the trees on your property, if anyone?*

"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%

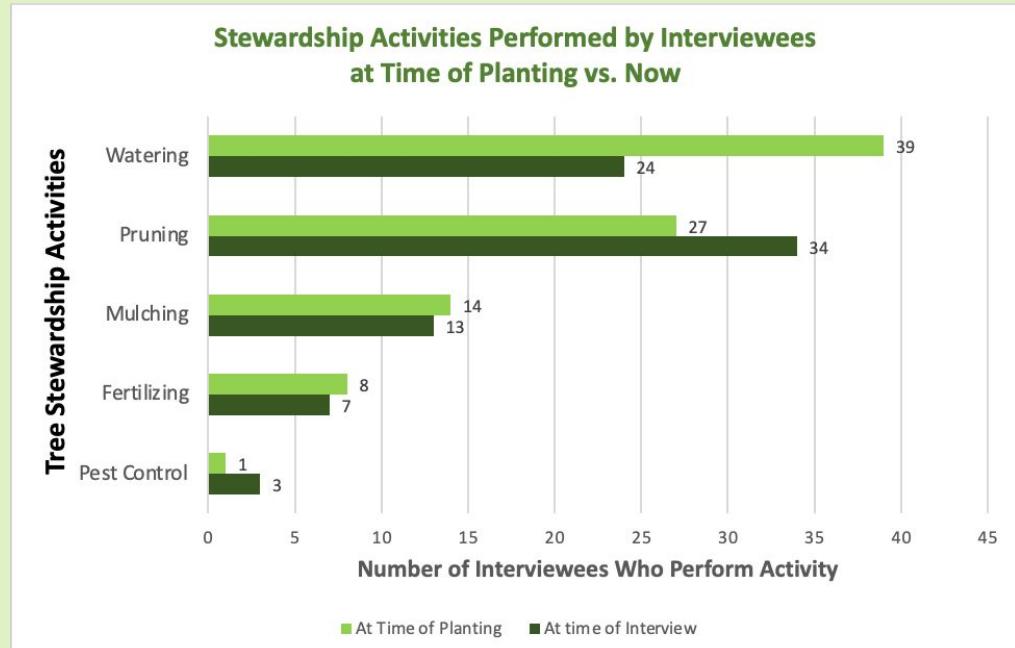
Who is stewarding trees



# Stewardship Activities

*What are the ways your trees are taken care of? (prompts: watering, pruning, mulching)*

- 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 encroaches near property, 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**.”

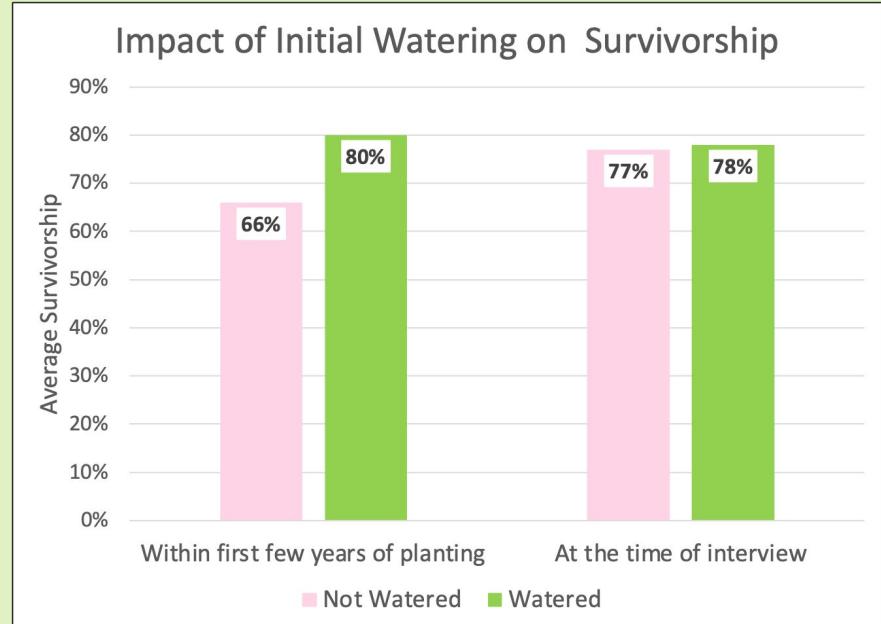


# The Difference Initial Watering Makes

*How has the maintenance of your trees changed over the last 10 years?*

- Trees watered in initial 1-2 years of planting have much higher survivorship
- Watering more mature trees is not associated with higher average survivorship

“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.”



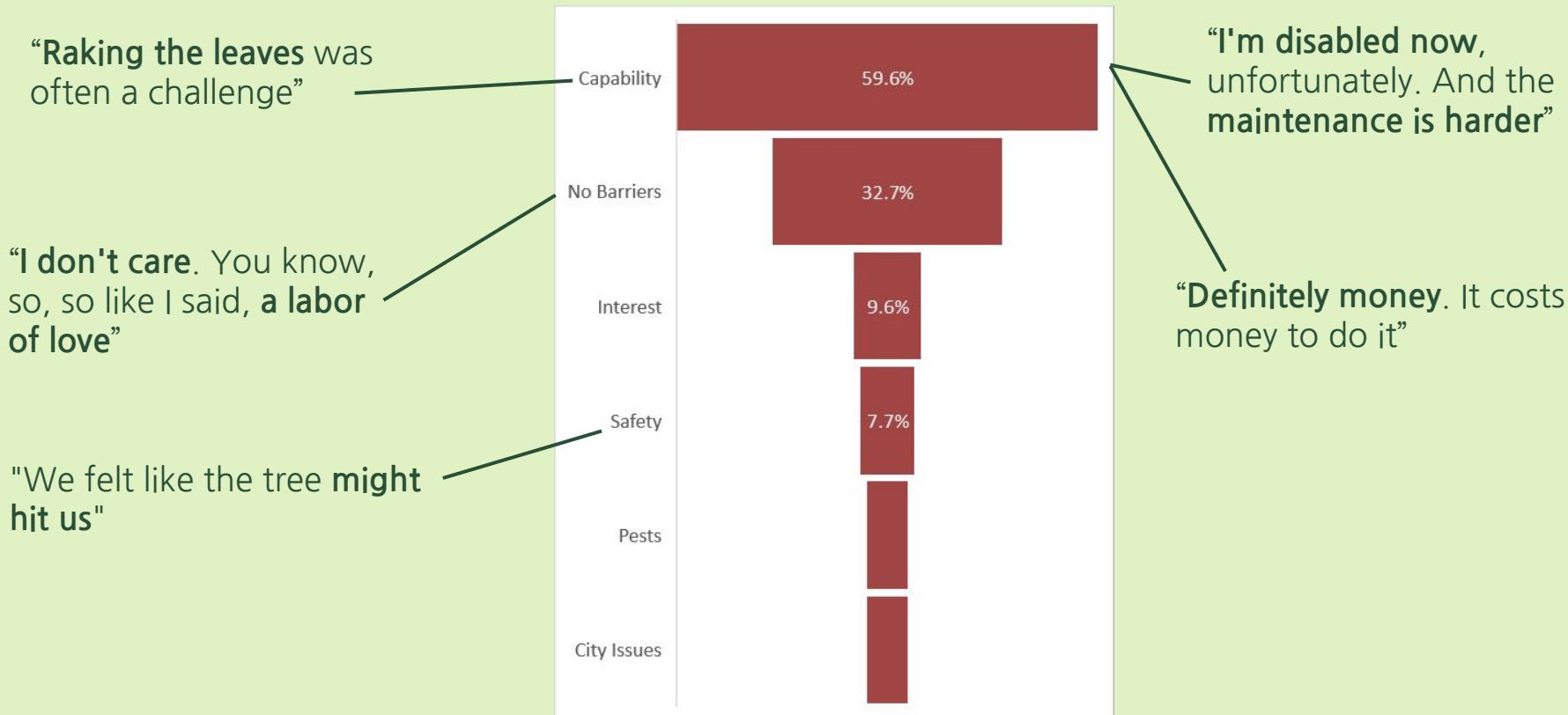
# Past Experience and Stewardship

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)?*



# Summary of Interview Analysis

## Major takeaways

- Residents value **shade, 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 planting experience



Amritha and Ksenia conducting an interview on resident's lawn



Ksenia and Caleb conducting an interview

# Tree Planting Outcomes and Conclusions



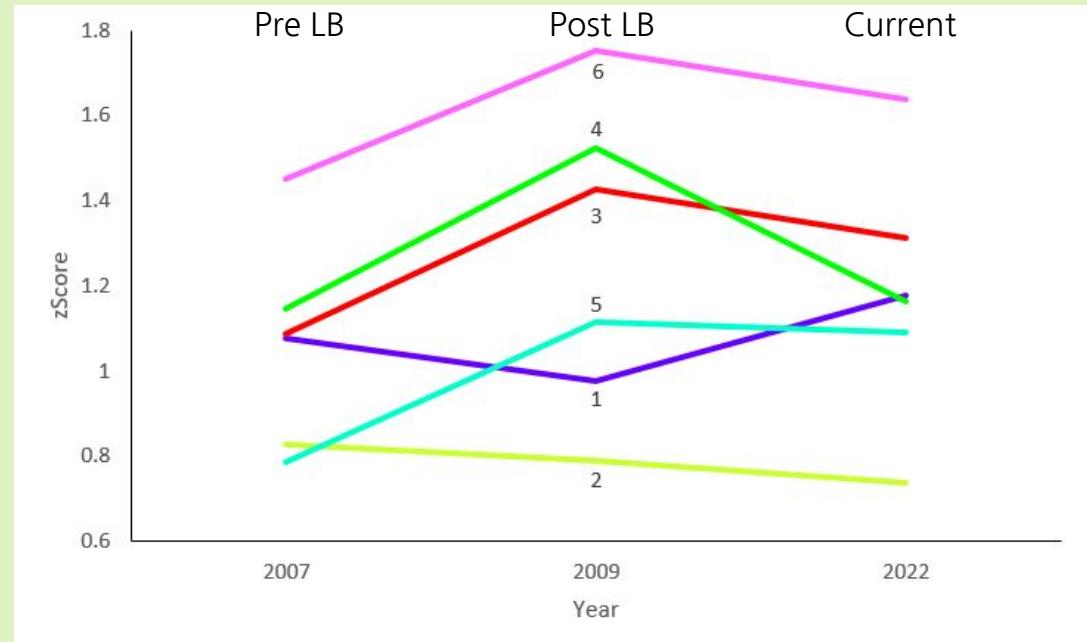
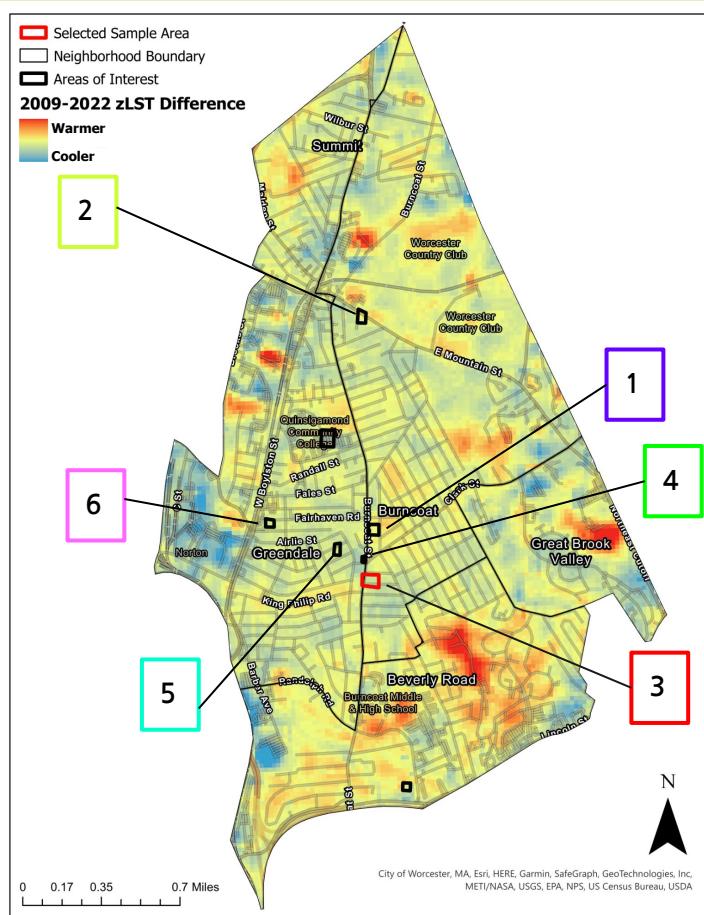
## Outcomes

What are the impacts of tree planting on temperature?

## Conclusions

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

# Tree Planting Impact on Surface Temperature



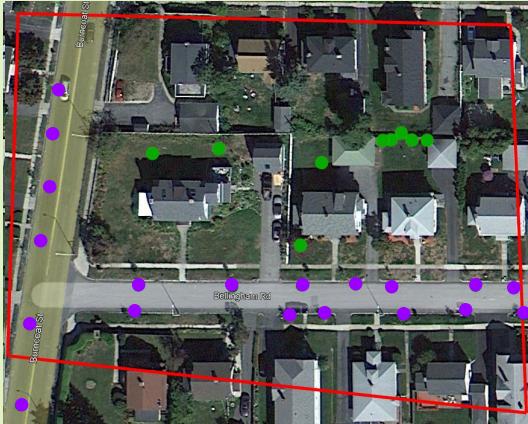
Residential areas with lots of removals get sharply warmer from 2007-2009, slowly cool following replanting

# Satellite Images of Selected Sample Area 3

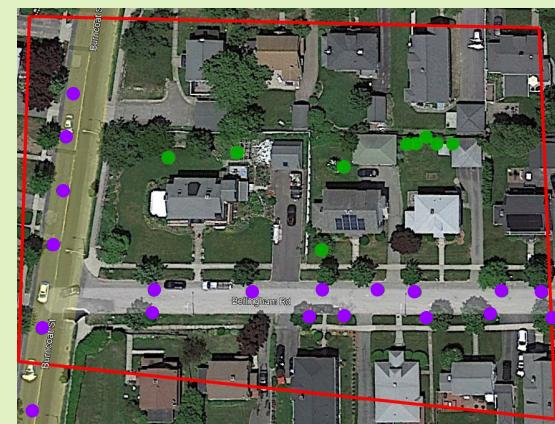
7/2007 Pre-LB



9/2010 - During Planting

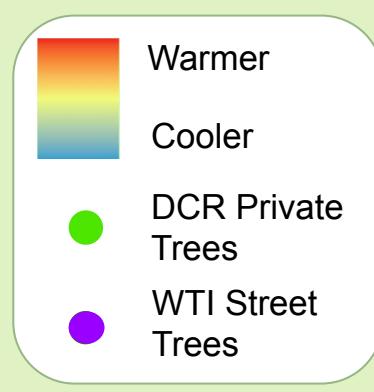


6/2022 - 13 years post LB

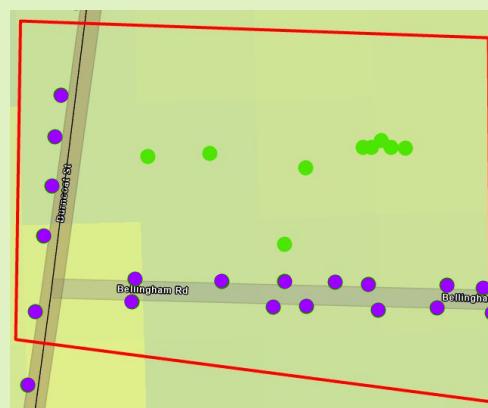


## Land Surface Temperature (zLST) Difference

Between 2007 - 2009



Between 2009 - 2022



# 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



255

# 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



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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

Danko III, J. J., Delauer, V., Martin, D. G., & Rogan, J. (2016). Worcester, Massachusetts: A History of Urban Forestry Practices. *Northeastern Geographer*, 8.

Bond, S. and Harless A., 2008, USDA announces Asian Longhorned Beetle survey in Massachusetts. *USDA-APHIS Newsroom*.  
<http://www.aphis.usda.gov/newsroom/content/2008/09/albinma.shtml>

Elmes, A., Rogan, J., Williams, C., Ratnick, S., Nowak, D., & Martin, D. (2017). Effects of urban tree canopy loss on land surface temperature magnitude and timing. *ISPRS Journal of Photogrammetry and Remote Sensing*, 128, 338-353.

Moody, R., Geron, N., Healy, M., Rogan, J., & Martin, D. (2021). Modeling the spatial distribution of the current and future ecosystem services of urban tree planting in Chicopee and Fall River, Massachusetts. *Urban Forestry & Urban Greening*, 66, 127403.

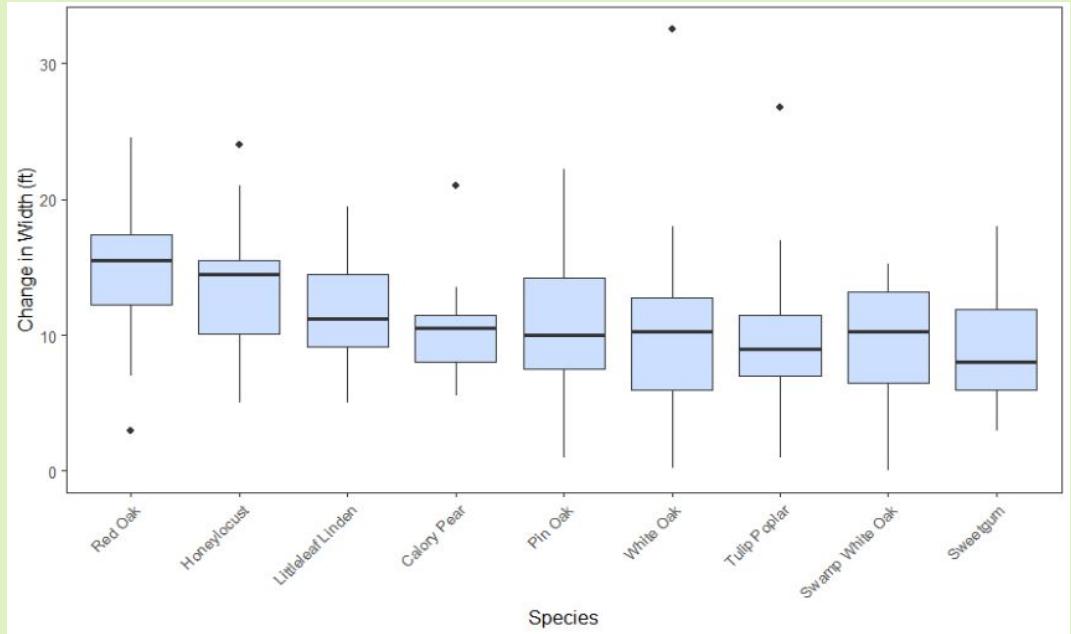
Rogan, J., Ziemer, M., Martin, D., Ratnick, S., Cuba, N., & DeLauer, V. (2013). The impact of tree cover loss on land surface temperature: A case study of central Massachusetts using Landsat Thematic Mapper thermal data. *Applied Geography*, 45, 49-57.

Roman, Lara A.; van Doorn, Natalie S.; McPherson, E. Gregory; Scharenbroch, Bryant C.; Henning, Jason G.; stberg, Johan P.A.; Mueller, Lee S.; Koeser, Andrew K.; Mills, John R.; Hallett, Richard A.; Sanders, John E.; Battles, John J.; Boyer, Deborah J.; Fristensky, Jason P.; Mincey, Sarah K.; Peper, Paula J.; Vogt, Jess. 2020. Urban tree monitoring: a field guide. Gen. Tech. Rep. NRS-194. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 48 p.  
<https://doi.org/10.2737/NRS-GTR-194>.

Palmer, S., Martin, D., DeLauer, V., & Rogan, J. (2014). Vulnerability and adaptive capacity in response to the Asian longhorned beetle infestation in Worcester, Massachusetts. *Human Ecology*, 42, 965-977.

Wilkens, G. (2018). A Hedonic Measure of the Effect of Tree Canopy Cover on Real Home Prices.

# 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