

Young Street Tree Survival and Mortality Survey with City of Columbus Tree Subcommission

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ENR 4900.01 Capstone
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Executive Summary

Young Street Tree Survival and Mortality Survey with City of Columbus Tree Subcommission

PROJECT CONTEXT

The City of Columbus Tree Subcommission, in partnership with Columbus Recreation and Parks and the Ohio Division of Forestry, collaborated with SENR Capstone students to evaluate long-term survival rates of recently planted street trees. The project addresses a critical gap in urban forestry management, as thousands of trees are planted annually but survival beyond the first few years is not systematically monitored, leading to potential losses in canopy cover and public investment. This work is especially timely as Columbus advances its Urban Forestry Master Plan goals for canopy expansion and tree equity, making it essential to ensure that new plantings successfully establish and deliver long-term environmental and community benefits.

SCOPE OF WORK

This project evaluates the long-term survival of street trees planted in Columbus to identify patterns of mortality and factors influencing tree success. The team develops and applies a standardized field data collection protocol using ArcGIS to assess indicators such as tree condition, planting practices, and site characteristics.

Data are analyzed to estimate survival rates and identify key drivers of early and late-stage tree loss. Findings are synthesized into a partner-focused brief with actionable recommendations to improve planting outcomes and support implementation of the Urban Forestry Master Plan.

KEY FINDINGS OR PROJECT OUTCOMES

- A majority of trees are observed having issues with planting quality and maintenance, as opposed to site conditions
  - Of the trees with planting issues, 57% overall are planted too deep and 70% of contractor-planted trees are planted too deep
- The financial burden of investing more into planting quality will be offset by better survival rates.
- Continued investigation from future capstone groups will broaden the perspective and dig deeper into what underlying issues may be.

CORE RECOMMENDATIONS AND EXPECTED IMPACT

The core recommendations focus on improving planting quality and consistency across all crews by enforcing existing standards, strengthening contractor training and oversight, and implementing routine inspections and accountability measures, while also addressing existing issues through corrective actions like exposing root flares and removing excess mulch. Additional emphasis is placed on targeting simple, high-impact maintenance practices and incorporating planting quality into long-term performance tracking to better inform future decisions. Together, these actions are expected to significantly reduce preventable early tree mortality, protect the city's substantial financial investment, and improve long-term canopy outcomes, potentially saving hundreds of thousands of dollars annually while ensuring more trees survive to deliver ecological and community benefits.

Background

Project Partner Background

City of Columbus Tree Subcommission

The City of Columbus Tree Subcommission serves as an advisory body supporting urban forestry policy, planting strategy, and long-term canopy goals within the City of Columbus.



Figure 1. Photo of Alistair Reynolds, Vice Chair of City of Columbus Tree Subcommission.

Working in collaboration with Columbus Recreation and Parks, the City Forester, and the Ohio Department of Natural Resources (ODNR) Division of Forestry, the Subcommission plays a key role in guiding implementation of the Columbus Urban Forestry Master Plan (UFMP). The UFMP establishes long-term goals for canopy expansion, tree equity, and improved management of public trees across the city. Columbus plants several thousand street trees annually in public rights-of-way using both city crews and private contractors.

While planting numbers are carefully tracked, long-term survival rates have not been systematically evaluated. Members of the Sub-Commission have observed recurring patterns of mortality among young street trees, including early failures within the first two to three years and later losses around year nine, just as trees begin providing measurable canopy benefits. These losses represent not only ecological setbacks but also financial inefficiencies in public investment and labor (“Columbus Tree Subcommission | Columbus Recreation and Parks Department”, 2025; “Urban Forestry Master Plan | Columbus Recreation and Parks Department”, 2025).

As Columbus prepares for expanded planting efforts to address tens of thousands of vacant planting sites citywide, the Sub-Commission identified a need for data-driven insights to improve survival outcomes. This project was developed in direct response to that need.

Working with Alistair Reynolds (ODNR Division of Forestry; Vice Chair of the Tree Subcommission), Rosalie Hendon (Columbus City Forester), Chad Hoff (Columbus Assistant City Forester), and in coordination with city forestry staff, our team conducted a focused survival and condition assessment of recently planted street trees. The results are intended to inform planting standards, contractor oversight, maintenance priorities, and future monitoring protocols.



Figure 2. Photo of downtown Columbus Scioto Mile

Problem Statement; Project Goals & Objectives

Problem Statement and Context

Disparities in tree distribution in cities have become a growing emphasis for urban tree planting programs. Urban trees provide cities with many positive effects such as ecological benefits, mitigating climate effects, and social value (Myers et al., 2023). With the city of Columbus planting several thousand street trees each year, there is a question in how many of those trees are actually surviving. Urban trees are most likely to die within the first few years after planting (Lu et al., 2010). Places like New York City and Chicago have completed tree mortality surveys.

Columbus has completed a tree canopy assessment but has yet to complete an urban tree mortality survey. This case study is an opportunity to look at the young tree mortality in both high and low tree equity sites. A literature review of urban tree mortality states that this is a topic that needs to be further studied (Hilbert et al., 2019). This project takes the opportunity to study tree mortality, which is not a well-researched topic, and applies the topic to Columbus specifically. The data collected also uncovers if there is a difference between city crew versus contractor planted trees within Columbus, which is under-researched as well.

Project Goals and Objectives

The overarching goal of the street tree mortality project is to gain an understanding of the factors associated with young tree mortality in Columbus to improve future success rates. By relating planting and maintenance issues with measures of tree stress and mortality, the project should be able to correlate tree condition with a list of predictor variables.

This process should highlight major threats to the urban street trees of Columbus, allowing the tree subcommission to improve future planting success and efficiency by updating guidelines. This is especially relevant considering Columbus's plan to fill tens of thousands of vacant sites, which represents a major investment of time and money. To achieve the best results, it is helpful to understand why current trees are dying.



Figure 3. Photo of young cherry spp. tree with intense sprouting, a sign of stress

Sample a representative group of street trees to obtain informative data

Two sample zones representing high and low tree equity scores respectively were selected for sampling. The high equity zone is just south of the OSU campus (zone 13B), and the low equity zone is in the Woodland Park area (zone 19A). Collecting data in both zones allows for analysis of tree success and mortality factors between them.

Relate contractor vs city planting with tree mortality

By relating planting entity with tree mortality, the results of this study will guide future decisions of the subcommission regarding the outsourcing of labor. This information will allow the city of Columbus to use resources more effectively in the future, reducing the amount of time, money, and labor lost to unsuccessful plantings. Additionally, the data may be used to update contractor guidelines if any specific planting metric is found to be troublesome.

Identify planting methods and site factors associated with tree mortality

Correlating tree success with specific site factors and planting methods, such as mulching practice, planting depth, and tree lawn width, will identify specific stressors associated with mortality. This information can inform future planting guidelines and predict



Figure 4. Tree mulched with preferable "donut" technique



Figure 5. Street tree planting tag

possible mortality of trees. This data will give the tree subcommission an idea of why their young trees are dying, allowing them to take steps to prevent this in the future. With the number of trees they are planning on planting in the near future, avoiding preventable losses will add up.

Create an informative report to summarize and communicate our results with the Tree Subcommission

Major takeaways are written in a thorough report and shared with the tree subcommission. This document can be referenced in the future and contains data analysis, discussion, and conclusions of the study. This report goes into more detail than the in-person presentation of results, outlining specific findings for each variable of interest. With this report, the raw data will be shared from sampling efforts, allowing the Subcommission to conduct any analysis of their own.

Create a project that sets up future capstone projects to seamlessly continue the study

As part of the outputs of the study, a handoff to future capstone groups is included. This includes information to guide their data collection process, including guidelines about what to collect, things that worked well, and things that could be improved upon. Part of this is the raw dataset collected this year, which can serve as a format for later years to allow for the seamless continuation of the project.

Evidence Base and Application



Figure 6. USDA Forest Service Logo

Justification and application of data collection

Past studies tend to examine a suite of conditions relating to tree stress and mortality, with the same variables commonly repeating. Mortality, DSH, crown vigor, and planting site attributes such as lawn width and zoning were all specifically mentioned by Ordóñez et al. (2018) and the US Forest Service urban tree monitoring field guide. The former also included mechanical damage as a contributing factor, providing guidelines on how to sample it. Specifically, they say to look for "appreciable torn limbs, trunk scars, missing canopy, pruning scars, cracks, and peeling bark," (Ordóñez et al., 2018).

Additional metrics were included in work by Arnold et al. (2005), who focused on the impacts of over-mulching. Their work pointed out that planting too deep or mulching too high up the trunk can cause tree decline and mortality, justifying these as data points in our study. These sources also mention a key point regarding tree mortality: tree death is the result of many compounding factors, not a single event (Ordóñez et al., 2018). During data analysis, this fact must be kept in mind and may be used to more effectively associate tree mortality and decline with contributing factors.

While most variables were suggested to us by the tree subcommission, these sources justify why such things are necessary to look at and guide their collection. The explanation of mechanical damage by Ordóñez et al. (2018) allowed for consistent identification of damaged trees, which could have been subjective otherwise. Crown vigor was consistently pointed to as an assessment of tree health; however, due to our winter sampling, the protocol had to be adjusted. Instead of reporting a lack of leaves or canopy dieback (Ordóñez et al., 2018; USFS, 2020; Arnold et al., 2005), we looked for dead main canopy branches, missing gaps, or a lack of fine twigs. This acts as a surrogate for canopy dieback that can be seen in winter. Overall, the range of variables also supports the idea that tree mortality is a result of compounding stressors rather than a single cause.

Collection protocols and standardization

Standardized collection protocols are essential for producing reliable, comparable, and decision-relevant urban tree data. The Urban Tree Monitoring Field Guide (U.S. Forest Service, 2020) emphasizes that long-term monitoring depends on clearly defined variables, repeatable measurement procedures, and consistent documentation practices. It outlines a structured Minimum Data Set (MDS) including unique tree identifiers, location information, species, site type, mortality status, condition or vigor indicators, and trunk diameter measurements. The guide also stresses the importance of recording height, maintaining consistent units and precision across crews, and incorporating quality control steps such as supervisory review notes and documentation of data collectors. These practices are framed as necessary safeguards to hopefully reduce our observer bias and ensure that repeated measurements over time remain comparable.

Municipal and empirical research reinforces this emphasis on consistency and structured data management. The City of Columbus Tree Technical Manual (City of Columbus, 2024) standardizes diameter measurement at 4.5 feet above grade (Diameter at Standard Height, DSH; also known as Diameter at Breast Height, DBH) and requires trees to be referenced

using an inventory ID or field-applied tag number, alongside clearly documented species names, condition ratings, and measurement values. This creates alignment between field data and the city's broader inventory system. Elmes et al. (2018) similarly demonstrate the importance of standardized baseline planting records, including geospatial coordinates, unique IDs, caliper measurements, and irrigation status, to enable accurate matching with subsequent field assessments of mortality and condition. Their structured geodatabase approach illustrates how standardized identifiers and categorical condition classifications support longitudinal survival analysis. Jin and Yang (2020) extend the discussion of standardization to sampling design, distinguishing probability from non-probability sampling and highlighting that only probability-based approaches allow for estimation of sampling error and defensible inference. They also show that sample size decisions significantly affect accuracy, cautioning against arbitrary or insufficient plot numbers. Taken together, these sources show that effective urban tree monitoring requires standardized variables, consistent measurement conventions, integrated data systems, and statistically justified sampling frameworks.

Guided by the U.S. Forest Service (2020) Field Guide and the City of Columbus (2024) Technical Manual, our team implemented a standardized data sheet that includes unique tree identifiers, consistent condition and mortality classifications, and trunk diameter measurements taken at DSH using consistent units and precision. We incorporated structured notes and internal review procedures to strengthen quality control, as recommended in the Field Guide. Following Elmes et al. (2018), we ensured that each tree record includes spatial information and unique identifiers in the form of individual Tree ID numbers assigned by City of Columbus and associated GPS locations to support longitudinal analysis and consistency with the city's existing databases. Finally, consistent with Jin and Yang (2020), we adopted a random sampling approach with a justified sample size to allow for defensible statistical interpretation of early mortality patterns. These decisions ensure that our data collection process is replicable, comparable, and aligned with professional and research-based standards.

Justification of random sampling and sample size

Urban tree mortality research consistently emphasizes that reliable survival estimates depend on systematic, representative sampling designs. Work by Nowak et al. (2004) in Baltimore demonstrated the importance of citywide sampling across different land uses to capture potential variation in mortality patterns. Similarly, Lu et al. (2010) used a stratified random sampling framework to assess over 13,000 street trees in New York City and noted that factors including land use and time since planting influenced survival rates. Their use of random sampling within a defined population allowed them to produce generalizable mortality estimates across different urban conditions. A literature review by Hilbert et al. (2019) shows that reported mortality rates can vary widely depending on factors such as study design, tree age class, and observational approach, further supporting the need for a clearly defined population and a statistically defensible sampling method.

The literature also emphasizes the importance of statistically significant sample sizes when researching urban tree mortality and generalizing from those findings. Research from Roman et al. (2014) shows that small deviations in generalized survival rates can significantly alter projected outcomes, especially during the establishment phase (the first five years after planting) when mortality rates are highest.

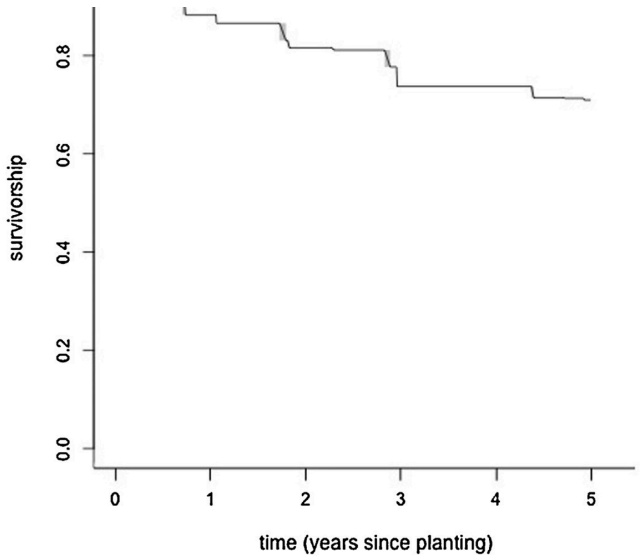


Figure 7. Figure from Roman et al. (2014) "Overall survivorship for all planted shade trees (n = 370). Survivorship was assessed from Kaplan–Meier survival analysis with Turnbull (1976) estimator for censored observations (Fay & Shaw, 2010). The gray rectangles indicate the range of possible values given censoring."

Hilbert et al. (2019) also found that annual mortality rates in studies typically range from 3-9% during early establishment but can vary widely depending on other factors. Because mortality is influenced by species, site conditions, land use, stewardship, and other factors, studies need to include enough observations to detect meaningful differences and produce narrow confidence intervals. Guidance from New York City's Urban Street Tree Mortality Study (2010) also recommended random sampling frameworks and defensible mortality calculations to ensure that findings could support management decisions. Overall, this research suggests that our mortality estimates should be based on randomly selected trees within a clearly defined population, and that our sample size should be determined using statistical confidence levels to ensure accurate results.

For our project, the population was defined as all trees planted on or after January 1, 2026, within Zone 19A (N=356) and Zone 13B (N=403). These population sizes were based on data provided by the Columbus Recreation and Parks Department. Consistent with the sampling approaches used in our research, we used a probability-based random sampling design to ensure an unbiased representation of conditions within each zone. To ensure reliable estimates of mortality rates and health indicators, we calculated our sample sizes using a 95% confidence interval and a ±5% margin of error, with a finite population correction. This resulted in target sample sizes of 186 trees in Zone 19A and 197 trees in Zone 13B.

Defining Tree Mortality

Within literature about tree mortality, there are different definitions of what tree mortality is and which trees are counted toward tree mortality within each study. Hilbert et al. (2019) states that it clearly defining mortality and survival of urban trees is imperative to a study. A 2022 study by Jack-Scott did not include tree removal in their tree mortality study. This contrasts Nowak et al. (2004) which noted and counted removal of tree in New York City as tree mortality. Almost all of the studies included in the scope of the 2019 literature review by Hilbert et al. defined tree mortality as both death of the tree and removal of the original tree planted. This makes the study by Jack-Scott (2022) an outlier in not including removal of trees towards mortality rates.



Figure 8. City of Chicago 1905 Seal

Within our study, this highlights the importance of defining tree mortality. Along with the definition that most studies use, we are including both dead trees and removed trees in our analysis of mortality. This means within data collection, if a tree that is included in our sampling plan is removed, that is noted on the data sheet. We are including this definition of mortality so that it is well understood what trees are being analyzed.

Chicago Urban Forest Management Plan – Chicago, Illinois

The Chicago Urban Forest Management Plan (2023) provides a comprehensive framework for assessing, maintaining, and extending the lifespan of the city's urban forest. The plan outlines how Chicago evaluated its existing tree inventory, identified patterns in tree condition and mortality, and created performance metrics connected to canopy equity, planting standards, maintenance cycles, and contractor oversight. Instead of focusing solely on planting targets, the plan focused on long-term survival, proactive maintenance, and standardized practices to reduce tree mortality rates. It used a combination of technical standards, data-based decision-making, and policy reforms to ensure that investments in urban forestry produce lasting benefits for the city.

Chicago's approach was used as a benchmarking example because of its integration of assessment findings into actionable management changes. Chicago's plan used survival rate data to revise planting specifications, inspection protocols, species selection, and maintenance standards. It also focuses on contract language changes and performance monitoring, supporting other research showing that planting practices and follow-up care are key to reducing mortality rates. Their emphasis on measurable outcomes and using findings to shape future planting and management practices is relevant for an urban forestry approach aligned with the goals of the Columbus Tree Subcommission, which is looking to increase long-term survival rates rather than solely focusing on increasing tree planting numbers.

The Chicago Urban Forest Management Plan informed our project by demonstrating that findings from survival assessments can be used to directly inform changes to planting standards, contractor oversight, and management practices. Based on this benchmarking example, our analysis was designed to both quantify tree condition and mortality rates within our selected zones, and to identify potential patterns that could inform future updates to City of Columbus planting standards, inspection practices, or contract language.

Physical Neighborhood Factors

Data collected	May Indicate
Median strip, number of traffic lanes, and traffic volume	Traffic patterns, air pollution levels and potential for mechanical damage from vehicles
Parallel or perpendicular street parking and pit location (on or off curb)	Tree's proximity to vehicular traffic
Sidewalk width	Increased pedestrian impacts in tree pit
Pit type and cutout size	Amount of available soil, soil moisture, and rooting space
Slope	Drainage and potential for soil erosion.
Proximity to driveway or bus stop	Potential for mechanical damage from vehicles
Presence and condition of a walled tree well, perimeter pit guard, or tall, narrow pit guard indicates	Protection of the tree
Block paving, gravel, mulch, or plantings in the pit	Protection from soil compaction and tree root damage.
Choking guards, grates, or wires	Negative impact on tree health
Electrical outlet in the pit	Tree lights are used.
Bike locked to tree	Source of trunk damage
Telephone wires, awnings, and scaffolding	Limited above growing space
Building height	Available light

Figure 9. Table of Physical Neighborhood Factors collected in the New York City Young Street Tree Assessment

Urban Street Tree Mortality Study – New York City, New York (NYC)

New York City's Young Street Tree Mortality Study was conducted by NYC Parks & Recreation in collaboration with researchers from the United States Department of Agriculture Forest Service (USFS), Rutgers University, and Parsons School of Design. The study examined approximately 45,000 street trees that were planted between 1999 and 2003 putting them all at 5-10 years of age at the time of sampling in 2006 and 2007. 14,000 street trees were sampled and had 40 pieces of data collected including characteristics of the tree itself and the surrounding area. The aim of this study was to identify biological, physical, and social factors influencing early tree mortality during the early 5-10 year period of establishment (NYC Parks & Recreation, 2010).

This study was unique, as integrated biophysical indicators, site design characteristics, and social variables into the study design. The sampling methodology used stratified random sampling by land use and the time the trees have been in the ground. What makes this study valuable is that it identified the real-world conditions influencing young street tree survival. NYC grouped their field observations into biological, physical, and stewardship-related categories, capturing factors such as soil compaction, planting depth, infrastructure conflicts, and visible signs of care or neglect. They also stressed standardized protocol, allowing the study to be replicated and adapted by other cities. This combination of practical field guidance and defensible sampling design makes it a strong model for municipalities looking to improve accountability, planting quality, and long-term survival outcomes (NYC Parks & Recreation, 2010).

The NYC study directly informed our study with the Columbus Tree Subcommission by demonstrating how a defensible sampling strategy can be paired with standardized field indicators to assess early street tree survival. We adapted elements of their sampling approach and site condition variables to ensure our survey captures planting quality, maintenance factors, and neighborhood context. Their integration of biological, physical, and social indicators reinforced our decision to move beyond simple "alive/dead" tracking and instead analyze patterns that may explain early mortality trends in Columbus.

Description of Products

Study Design and Field Protocol



Figure 10. Liam taking tree DSH while Joan records measurements and condition

Description

When deciding what age range of trees to include in our study, we referenced literature to find when urban trees are at the greatest risk of mortality. Two separate studies found that trees had a harder time surviving during their younger years, informing our decision to measure trees planted in the last 10 years (Koeser et al., 2013; Nowak et al., 1990).

When exploring the different urban tree regions in Columbus, we found Region 13B, which had an average score of 72.4, and Region 19A, which had an average score of 87.5. Tree equity scores allow a number to be attached to locations to indicate the amount of need they have for more trees, which are essential to public health and well-being (Tree Equity Score, n.d.).

Using these two regions and their differing equity scores gives insight into how urban tree mortality plays a role in different parts of Columbus.

The Columbus Tree Sub-Commission provided a GIS map of the different regions and the tree planting data in each of them. These were converted into a map of just the regions we were measuring and trees planted in the last 10 years. An ArcGIS function was then used to create a random sampling plan with a 95% confidence interval. Using the benchmarking example of New York City's Urban Street Tree Mortality Study (2010), random sampling proved to be the correct choice for our study and ensures an unbiased representation of Columbus's urban trees within the regions that were chosen.

Design Methodology

When deciding what age range of trees to include in our study, we referenced literature to find when urban trees are at the greatest risk of mortality. Two separate studies found that trees had a harder time surviving during their younger years, informing our decision to measure trees planted in the last 10 years (Koeser et al., 2013; Nowak et al., 1990). This, however, does not include trees that were removed in during their first year warranty as those trees were not included in the mapping data provided to us.

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Stakeholder Guidance

It is our suggestion that this output helps our partner understand the steps we took in choosing the regions that we sampled. This output lays the framework for a continuation of studying Columbus's urban trees and the choices of where to sample. Our study includes a small portion of Columbus, and there will likely be stronger results if more regions are sampled.

Both of the regions that were chosen for our case study were residential areas that have a high turnover rate in terms of residents. In the future, the study would benefit from different zoning areas being sampled. Continuation of this study will provide a more comprehensive view of tree mortality in Columbus and the stressors that are linked to tree mortality.

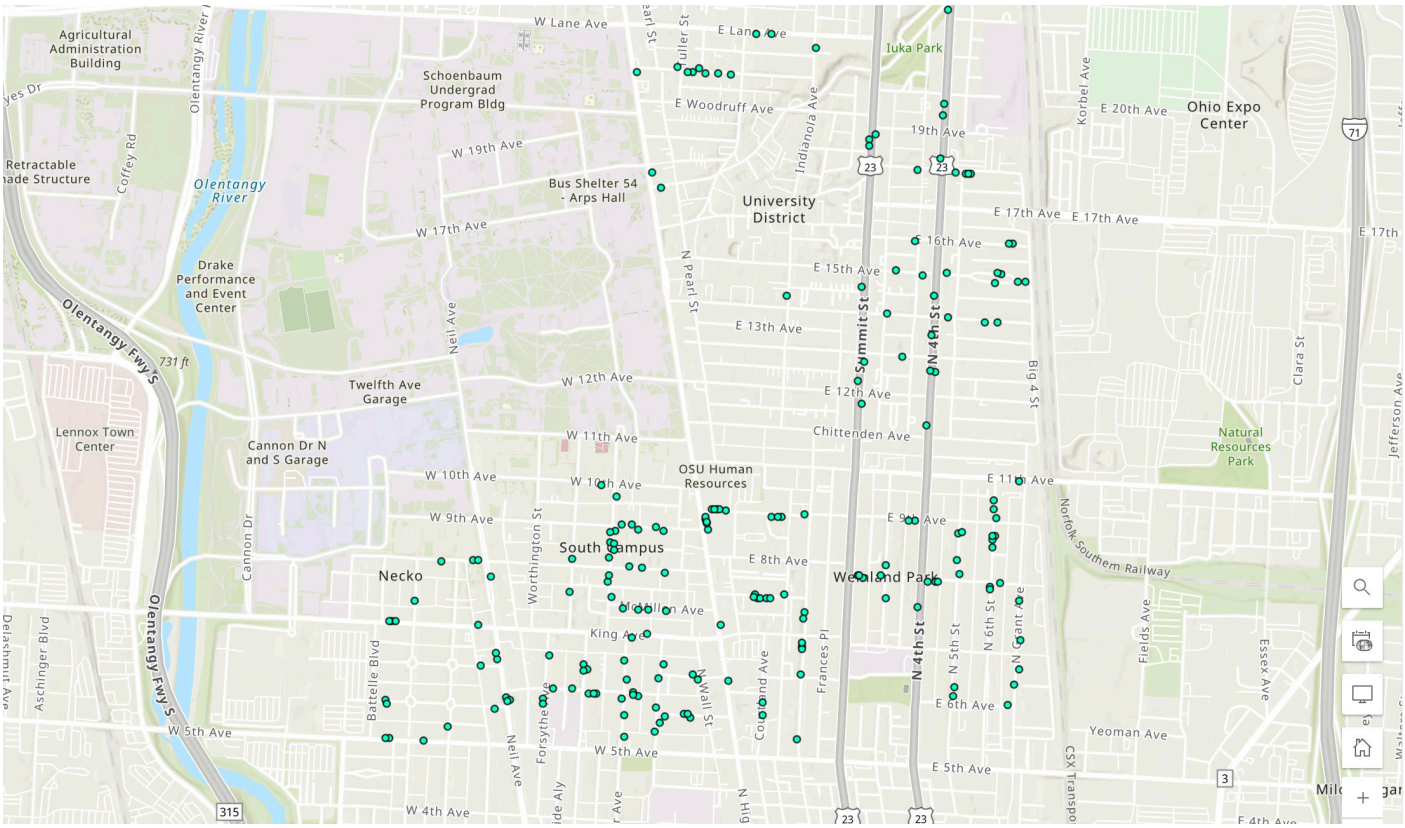


Figure 11. Map of randomly sampled trees in zone 13B. Map created by Liam Ott via ArcGIS in 2026.

G	H	I	J	K	L	M	N	O	P	Q	R	S	T
						Sampling data							
Sampler initials	Dead/Live	Mechanical Damage?	Root flare visibile?	Volcano mulch?	Distance to curb (CM)	Distance to curb (in)	Distance to sidewalk (CM)	Distance to sidewalk (in)	DBH(CM)	DBH (in)	Fungus/main stem decay?	Large dead branches?	Sprouting?
NY, JH, JS	L	Y	N	N	125	49.2	135	53.1	5.1	2.0	N	N	N
	L	N	N	N	130	51.2	127	50.0	4.5	1.8	N	N	N
	L	N	N	N	125	49.2	145	57.1	9.2	3.6	N	N	Y
	D (REMOVED)					0.0		0.0					
	L	N	Y	N	120	47.2	115	45.3	11.1	4.4	N	N	N
	D	Y	N	Y	135	53.1	135	53.1	3.2	1.3	N	N	N
	L	N	Y	N	190	74.8	N/A		3.8	1.5	N	N	N
	D (REMOVED)					0.0		0.0					
	L	N	N	N	100	39.4	80	31.5	4.8	1.9	Y	N	N
	L	N	Y	N	90	35.4	100	39.4	3.5	1.4	N	N	N
	L	N	N	N	75	29.5	73	28.7	4.1	1.6	N	N	N
	L	Y	Y	N	91	35.8	88	34.6	5.7	2.3	N	N	N
	L	Y	Y	N	104	40.9	85	33.5	5.1	2.0	N	N	Y
	L	N	Y	N	107	42.1	46	18.1	5.7	2.3	N	N	N
	L	N	N	Y	84	33.1	90	35.4	2.2	0.9	N	N	N
	L	N	N	N	N/A		200	78.7	4.8	1.9	N	N	N
	L	N	N	N	N/A		154	60.6	3.2	1.3	N	N	N
	L	Y	Y	N	N/A		85	33.5	8.3	3.3	N	N	Y
	L	Y	N	N	N/A		96	37.8	8.9	3.5	N	N	N
	D (REMOVED)					0.0		0.0					
	L	Y	Y	N	87	34.3	49	19.3	2.2	0.9	N	N	N
	L	N	N	N	58	22.8	85	33.5	4.1	1.6	N	N	N

Figure 12. Screenshot of digitized dataset from collected data used for analysis

Field Dataset

Description

This output presents an excel file with the raw data collected in the field for future reference by our project partner, further analysis, and guidance for later capstone groups. It contains a neat collection of all the data we collected over both sampling zones. Pre-sampling data includes tree ID number, species, planting year, and planting entity. Sampling data includes sampler initials, mortality status, mechanical damage presence, root flare visibility, volcano mulch status, distances to curb and sidewalk, DSH, main stem decay presence, large dead branch presence, and sprouting presence.

This data serves as the fundamental information we will provide to our project partner. It will quantify stress levels, tree mortality, and which stressors are most prevalent in the landscape while revealing patterns that may inform future management decisions. With this information, our partner will be able to assess the condition of Columbus's young street trees and the factors associated with their declines.

Design Methodology

Specific data we recorded for this output was informed by our project partners and a review of literature regarding tree stress metrics. Mechanical damage and planting depth (indicated by root collar visibility and volcano mulching) were highlighted in early project partner meetings as important metrics to record due to their association with mortality or tree stress. Further investigation into literature agrees with this, further justifying these data points (Arnold et al., 2005). The definition of mechanical damage was informed by Ordóñez et al. (2018), who suggest looking for appreciable torn limbs, trunk scars, missing canopy, cracks, peeling bark, and open wounds. Additionally, the US Forest Service urban tree monitoring field guide mentions DSH, crown width, and tree lawn size as influential variables (2020).

Main stem decay, large dead canopy branches, and sprouting were chosen to reflect the stress level of a tree. Rather than only recording if a tree is dead or alive, which leaves gaps in the data, these stress metrics will allow us to cover a range of steps in tree decline. Sprouting is a clear indication of tree stress (USFS, 2020) which can result from a variety of conditions. We looked for epicormic and basal sprouting, which is not normal growth and represents a tree in poor condition. Canopy condition is an extremely common way to measure overall tree health (Ordóñez et al., 2018; USFS, 2020; Arnold et al., 2005). Because we collected data in winter, we looked for dead main canopy branches, missing gaps, or a lack of fine twigs.

Recommendations for Use and Guidance

This dataset can be used by our project partner and future capstone projects. The sub-commission may reference this data to conduct their own analyses regarding tree stressors, add to existing databases, or compare with past or future data to uncover trends. Additionally, the raw data supports our analyses and conclusions. Future capstone groups who add to this project will be able to reference the datasheet to guide their collection. Of course, they will be able to add or change what they see fit as the project evolves over time. Ideally, however, long-term data collection will be consistent enough to draw comparisons between years.

Findings Brief

Description

The findings brief is the primary communication product, designed to synthesize our field-collected data on the condition of young street trees in Columbus, OH into a concise and visually supported format. The findings brief is intended to translate our detailed technical information into clearly interpretable patterns with key takeaways and actionable steps for the future of the Urban Forestry Master Plan in Columbus.

This product presents presents trends in tree condition, site characteristics, and mortality across the sampled regions, with attention on early establishment failure (0-10 years post-planting). This brief highlights the relationships between observed stress indicators and overall tree conditions or survival status.

The document will incorporate a combination of data visualizations and concise explanatory text to ensure accessibility for both technical and non-technical audiences. In addition to summarizing findings, the brief will include interpretation of results, management-relevant insights, and clearly stated limitations, including seasonal constraints (e.g., winter data collection) and potential sampling biases.

Ultimately, the Findings Brief is intended to function as a bridge between data collection and decision-making. By distilling complex analyses into a format that is both readable and actionable, this product supports the Tree Subcommission's ability to identify priority issues, evaluate current planting outcomes, and inform future urban forestry strategies.

Design Methodology

The design of the Findings Brief is grounded in the need to balance analytical rigor with clarity and usability. Because the intended audience includes both technical professionals and decision-makers, the structure prioritizes clear communication of key insights without sacrificing the integrity of the underlying data.

The development of this product begins with the organization and cleaning of the field dataset, followed by exploratory and statistical analyses to identify patterns in tree condition and mortality. Analyses include summary statistics, comparisons across categorical variables to examine relationships between stress indicators and tree outcomes. These analyses are used not to establish definitive causation, but to identify meaningful trends and associations that can inform management, with an emphasis on readability and interpretability. Charts and maps will be paired with short, direct text summaries that explain what the data show, why it matters, and how it relates to broader

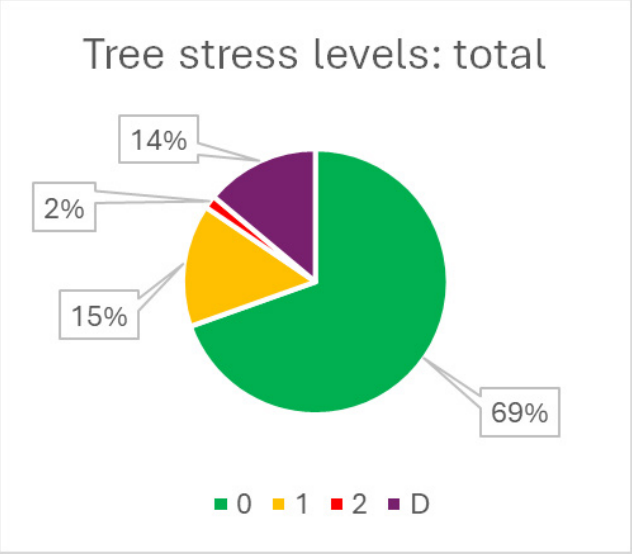


Figure 13. Tree stress level across both zones

project goals. Technical language is minimized or clearly defined to ensure accessibility.

The design of this product is informed by both literature and partner input. Previous urban tree mortality studies emphasize that tree decline is typically the result of interacting stressors rather than a single factor, which guides the interpretation framework used in the brief. Additionally, feedback from the Tree Subcommission has shaped the focus on contractor performance, planting practices, and early maintenance as key areas of interest. By integrating these considerations, the Findings Brief is intentionally designed to align with real-world management needs.

Recommendations for Use and Guidance

The Findings Brief is designed to support the Columbus Tree Subcommission and affiliated urban forestry staff in interpreting and applying project results to management decisions. Rather than functioning as a purely academic report, this product is intended to provide clear, actionable guidance that can inform planting strategies, contractor oversight, and long-term monitoring efforts.

Stakeholders should use the Findings Brief as a tool to identify patterns and potential risk factors associated with early tree mortality. For example, if certain stress indicators (such as improper planting depth or evidence of mechanical damage) are consistently associated with declining or dead trees, these patterns may point to areas where planting practices or maintenance protocols can be improved. Similarly, differences observed between planting entities (e.g., contractor versus city-planted trees) or across site conditions may highlight opportunities for targeted interventions.

It is important that stakeholders interpret the findings within the context of the study's limitations. Because data were collected during a specific time window and under winter conditions, certain indicators (such as canopy health or leaf condition) could not be assessed. Additionally, observed relationships should be understood as associations rather than definitive causal links. As such, the Findings Brief should be used as a starting point for further investigation, rather than as a standalone basis for major policy changes.

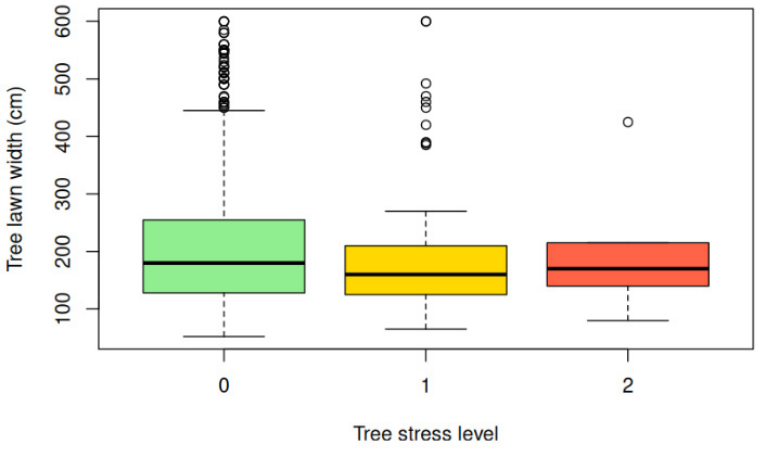


Figure 14. Tree stress levels correlated with tree lawn width

The brief is also intended to inform iterative improvement. Stakeholders are encouraged to use the findings in combination with future data collection efforts, contract evaluations, and additional research to refine urban forestry practices over time. In particular, this product can support the development of more effective planting specifications, improved contractor accountability, and enhanced post-planting care strategies.

Finally, the Findings Brief contributes to a broader, long-term monitoring framework. When used alongside the standardized protocol and dataset developed in this project, it enables comparisons across years and planting cohorts. This continuity is critical for identifying trends, evaluating the effectiveness of management changes, and ensuring that investments in urban tree planting result in sustained canopy benefits.

Future Capstone Handoff

Description

This output was designed to allow future capstone groups to continue and expand the street tree mortality study in Columbus. It directly addresses the project's long-term goal of improving urban tree survival. By ensuring data collection, analysis, and reporting can be replicated and built on over time, this output prevents the work from remaining a one-time assessment.

This output includes three primary components: (1) a clean and standardized dataset of sampled street trees, (2) a geospatial shapefile identifying all sampled tree locations, and (3) written documentation outlining data collection protocols, definitions of the tree health indicators we analyzed, and recommendations for future data collection and analysis. Together, these materials create a framework that future capstone groups and project partners, such as the Columbus Tree Subcommission, can use to monitor trends in tree health and mortality over multiple years.

This output is especially important given that urban tree mortality results from the accumulation of multiple stressors over time (Ordóñez et al., 2018). As a result, continued research is necessary to identify patterns, evaluate planting practices, and support evidence-based decision-making.

Design Methodology

The design of the materials included in the Future Capstone Handoff was created based on established best practices for urban tree monitoring, with a strong emphasis placed on standardization, repeatability, and integration among the different output components. The structure of the dataset and documentation were informed by the Urban Tree Monitoring Field Guide (U.S. Forest Service, 2020) and The City of Columbus Tree Technical Manual (City of Columbus, 2024), both of which emphasize the importance of consistent variables, measurement protocols, and documentation practices for long-term monitoring.

Standardized Data Structure

The dataset was developed using a minimum dataset (MDS) approach, incorporating variables identified in municipal guidance and academic literature, as well as specific condition indicators suggested by our stakeholders. These included unique tree identifiers, location information, species, site type, mortality status, condition or vigor indicators, and trunk diameter measurements, all of which are commonly used in urban tree mortality studies (U.S. Forest Service, 2020; Ordóñez et al., 2018).

DSH (Diameter at Standard Height) measurements were collected at 4.5 feet above ground, in line with City of Columbus standards. This ensures compatibility with preexisting municipal city tree inventory data (City of Columbus, 2024). The inclusion of consistent tree health identifiers and variables is also supported by Elmes et al. (2018). This emphasizes the importance of linking baseline data to future condition assessments for continued analysis.



Figure 15. Map of randomly sampled trees in zone 13B. Map created by Liam Ott via ArcGIS in 2026.

Replicable Sampling Framework

The handoff output includes documentation of the sampling framework used in this study, enabling future data collection efforts to be replicated or expanded. Following Jin & Yang's (2020) guidance, a probability-based sampling approach was used to support statistically defensible conclusions and reduce bias in site selection.

Additionally, sampling zones were selected to represent both high- and low-tree equity areas within Columbus, enabling comparative analysis of survival patterns across different socioeconomic and environmental conditions (Din & Krisko, 2022). This structure was included in the handoff materials to support future analyses of equity-related disparities in tree mortality.

Geospatial Integration

A geospatial shapefile was developed to accompany the dataset, linking each tree record to a unique tree ID and GPS coordinates. This approach followed recommendations from Elmes et al. (2018), which highlight the importance of linking spatial data with field observations to enable long-term monitoring and analysis. The inclusion of geospatial data enables future users to revisit specific trees, track changes over time, and add additional data layers to GIS platforms such as ArcGIS.



Figure 16. ArcGIS logo

Recommendations for Use and Implementation

Continuation of Data Collection

Future capstone groups should use the provided dataset and protocols as a baseline for continued data collection. This includes revisiting previously sampled trees to assess changes in condition or mortality, expanding the dataset to include additional planting zones or geographic areas, and maintaining consistent measurement techniques and variable definitions.

Repeating measurements over time enables longitudinal analysis, which is critical for identifying delayed mortality trends and evaluating the long-term success of planting practices.

Integration with City Decision-Making

As a part of the final project deliverables, the dataset and shapefile will be provided to the City of Columbus and can be integrated into their existing city forestry databases and GIS systems to support decision-making. This data can be used both by the city and in conjunction with future capstone groups to continue evaluating contractor versus city planting outcomes, identify recurring stressors associated with mortality, and inform updates to planting guidelines, inspection protocols, and contract language. As mentioned in the overall project goals, understanding these patterns can help reduce financial and ecological losses associated with unsuccessful tree plantings.

Data Accessibility and Management

The final project deliverables, including the dataset, shapefile, and documentation, will be submitted to the Columbus Tree Subcommission and The Ohio State University Knowledge Bank for future use. It is recommended that any additional work be stored in a centralized, accessible format to ensure continuity between capstone groups. Using clear file-naming practices and documentation is recommended to prevent data loss or inconsistency.

Future Enhancements

Using this output, future capstone groups can improve upon this project by increasing sample sizes or incorporating additional sampling zones, adding new variables related to maintenance practices or environmental conditions, conducting more advanced statistical or spatial analyses, and developing better tools and methods to communicate findings to stakeholders. Additionally, incorporating feedback from the Columbus Tree Subcommission and city forestry staff will help refine future projects and ensure they align with the city's needs.

Lessons Learned

The first important lesson that we learned, was that sampling takes a longer time than expected. When we started on sampling, we thought that both Regions were going to be completed within a two week period. Region 19A proved to take longer than expected due to unfamiliarity with both the area and data collection as this was the first region sampled. This was partially unavoidable for our project due to a large snow preventing data collection from starting earlier. We suggest that as this project moves into the future, that capstones delegate more time to sampling and set aside dates to sample early in the semester.

While reading literature, we also learned that there are many important tree metrics that can only be collected with the presence on leaves. While we were able to collect many tree metrics, without the presence of leaves, they would have been very helpful in collecting information about the tree's overall condition and the presence of disease. Another metric that we would do differently in the future is tree lawn width. We did not collect the width if the tree was removed. In many of the removed tree areas, the location of the tree was still visible and it would have been beneficial to still collect that information. Another small change that we would make in our data collection is ensuring our DSH tapes are using inches. The tapes used were in the metric system and our project partner requested that the data be given in inches. This is a simple change that we would implement in the future.

Another lesson we learned is that not including the trees that were removed in their first year warranty had an affect on our findings. The first year after planting is a critical time in a urban tree's life and the exclusion of this data does not given a holistic view into tree mortality of trees planted in the last ten years. We suggest that future capstones acquire this data from the Columbus Tree Sub-Commission and use it in data analysis.



Figure 17. Examples of tree canopy showing the overall condition of urban trees from New York City's Urban Street Tree Mortality (2010)

Group Member Bios

Meet the Team



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Study Design Lead

Major: Forestry, Fisheries, and Wildlife
Primary Contributions: study design, editing, outreach, data collection



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Future Capstone Handoff Lead

Major: Environmental Policy and Decision Making
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Major: Environmental Science
Primary Contributions: dataset, data analysis, editing, data collection

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