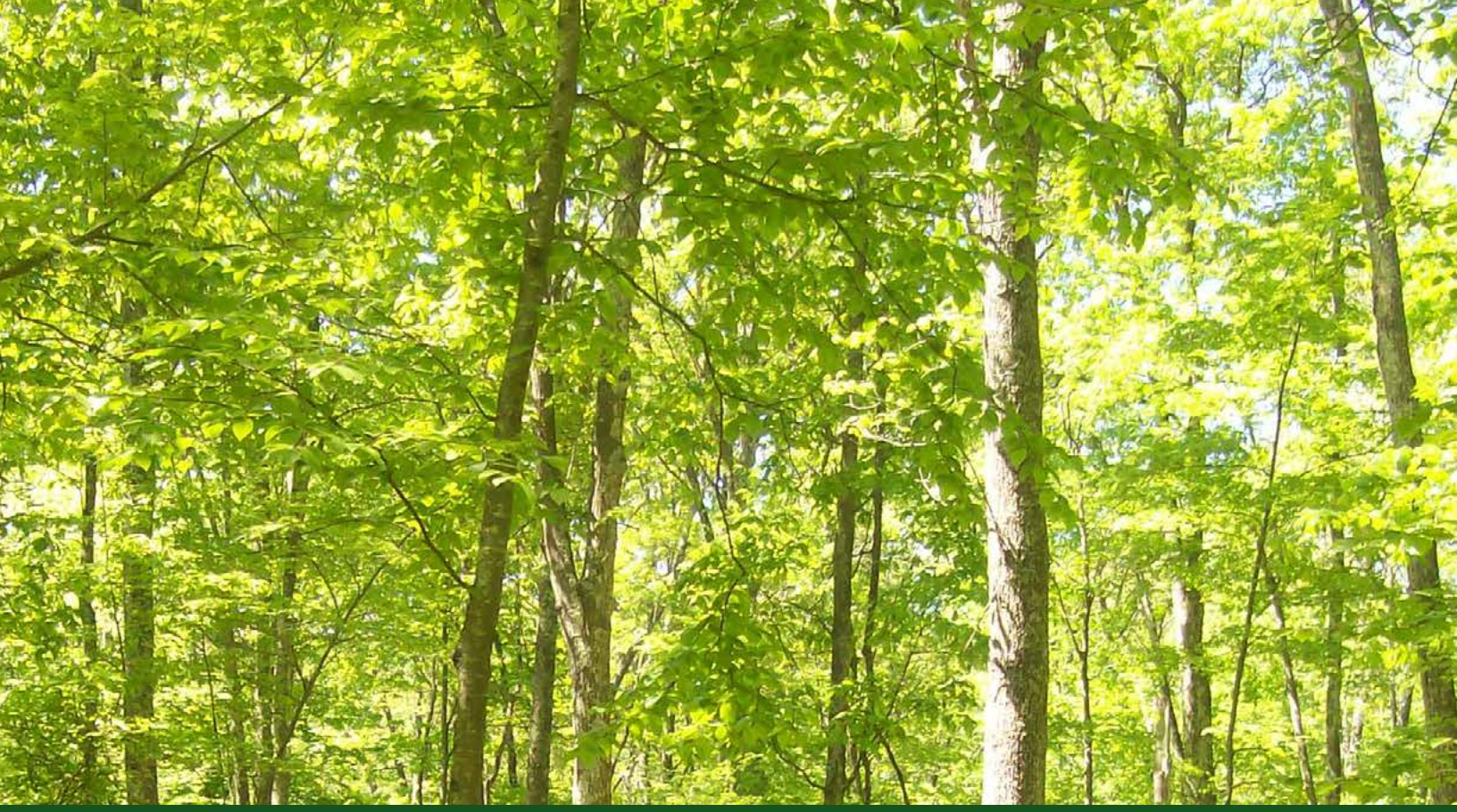

Spring 2023

URBAN FORESTRY

Advancing Climate Resilience and Health Through Urban Forestry

clf
Conservation
Law Foundation

CONSERVATION LAW FOUNDATION protects New England's environment for the benefit of all people. CLF uses the law, science, and the market to create solutions that preserve our natural resources, build healthy communities, and sustain a vibrant economy. To learn more, visit www.clf.org.

Acknowledgments

Conservation Law Foundation wishes to acknowledge the many partners and community stakeholders who supported this project. Without their participation, the project would not have been possible.

With Support From

Wells Fargo Foundation

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City of New Haven

Annie Mixsell, Tree System Coordinator/ Tree Warden

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Executive Summary

Conservation Law Foundation (CLF) conducted a multi-faceted research project to assess the current state of urban forestry in the New England region and elsewhere in order to promote and accelerate the creation, maintenance, and preservation of urban forests. Urban forests are made up of all trees and plant communities in cities. The trees of the urban forest, as well as the shrubs, herbaceous plants, and mosses that support them, exist in places commonly used by people, such as parks and residential yards, as well as other places like conservation areas and woodlands.[1] Urban forests support the health and wellness of city residents by contributing to mental and physical wellness, managing stormwater, and addressing extreme heat by reducing the effects of urban heat islands.

CLF identified common challenges and barriers, best practices, and gaps in research in order to develop a strategy for accelerating urban forestry efforts in New England. To accomplish this, we reviewed municipal urban forest master plans, interviewed urban foresters working in community organizations and municipal governments, explored funding opportunities through carbon credit markets, conducted geospatial analyses, and supported research and pilot projects to test potential solutions to common challenges and barriers. The themes and findings that emerged from our research are described below.

1 Morgenroth and Östberg 2017, Johnson et al. 2021

Access to information about the existing urban forest is critical.

If urban foresters do not have a complete and current tree inventory, they are hindered in their task of effective tree preservation, planting and maintenance. An ideal urban forest is equitably distributed and is diverse in tree species, size, and age. Without a current and complete inventory, it is difficult to ensure that an urban forest meets these criteria. For many communities, the first step towards a thriving urban forest is creating a tree inventory to assist in the development of a roadmap for future planting, preservation, and maintenance.

Local rules and standards can help grow and preserve the urban forest, which is threatened by all scales of development and the actions or inactions of private property owners.

Undeveloped land that contributes to the urban forest is challenging to protect due to high costs and competing public and private interests. As land is developed or improved, the existing trees on the site may not have adequate tree protection mechanisms in place. Developing local rules and standards that preserve undeveloped land and protect the existing trees on developed parcels can help maintain the urban forest in many urbanized areas.

Conflicting and competing land uses present unique challenges to the urban forest.

Overhead utility lines are vulnerable to tree branches, leading to tree-trimming practices that can be harmful or fatal to the trees. Underground utilities are vulnerable to tree roots, and installation and repair of these utilities can result in harm to existing trees. For these reasons, urban foresters are reluctant to plant trees in areas with existing utility lines. Additionally, urban foresters often target planting strips in the right-of-way for new tree planting sites. Occasionally, this includes creating additional planting space by enlarging the strip, encroaching on streets, sidewalks, and parking areas. Otherwise-suitable planting sites could lead to shade conflicts with solar panels once new trees grow. Urban foresters may have to compete for suitable planting sites with other necessary and conflicting uses.

The urban forest is not equitably distributed.

For a variety of reasons, existing trees are often concentrated in specific areas or neighborhoods of the community, providing most of the benefits for residents in that area. Members of the community who live in areas with lower canopy coverage do not enjoy the same benefits, resulting in inequitable experiences and outcomes. The areas with low canopy coverage are often areas with high concentrations of historically marginalized populations including people of color and low-income residents. To address this inequity, communities must create a basic inventory of their urban forest and analyze current or historic policies and practices that contributed to existing inequities. Once this is done, local urban foresters can prioritize efforts in underserved areas.

Growing the urban forest can be expensive and laborious.

Planting urban trees can be very expensive for a multitude of reasons. Tree procurement, site preparation, and labor costs are all variable and can be unpredictable, making it hard to implement urban forest plans and achieve urban forestry goals. Many cost-reduction strategies have been explored and implemented by New England urban foresters, but the most readily-available strategies often have tradeoffs. For example, purchasing lower cost trees often means purchasing younger trees, which have higher maintenance costs, at least for the first few years. Tradeoffs are not only related to costs – planting trees on less-expensive sites may mean making tradeoffs in other ways, such as growing canopy coverage in underserved areas which often have fewer readily-available planting sites.

Urban forest management requires support and coordination.

Lack of coordination between departments can result in inefficiencies, which only increase as non-governmental organizations become involved, though these partners are often needed to provide additional support for municipal departments that do not have sufficient staff to preserve and maintain their urban forest. In many communities, the effectiveness of an urban forest program is impacted by the engagement and support

Photo credit: Mabel Lemoniel, Groundwork Lawrence

of residents. An engaged civilian corps can greatly expand the impact of local urban forestry efforts, assisting with planting and maintenance. For this to be effective, however, citizen volunteers need to be organized and trained.

Climate threats to the urban forest impact preservation, planting, and maintenance.

Current threats to urban forests, including damage from extreme weather, threats from pests and diseases, and heat and precipitation pattern changes, are likely to increase, but the scale and time horizon of these challenges is not yet fully understood. As future climate models are refined, urban foresters may be able to make more informed choices about tree species selection and maintenance requirements.

Flexible funding is needed to jump start and accelerate urban forest initiatives.

To help explore new solutions to urban forest challenges, CLF created a mini-grant program for New England-based communities and community organizations to preserve and grow their urban tree canopies. The goal of this program was to infuse radically flexible dollars into communities to help overcome immediate hurdles to growing the urban forest. CLF awarded $10,000 - $13,500 to seven mini-grant recipients across six New England communities in Massachusetts, Connecticut, and Vermont. Some grantees used the funds to increase the capacity of their current work planting trees, maintaining trees, expanding their tree inventory, and similar activities. Other grantees took advantage of having unrestricted funding to solve challenges in ways that are typically unsupported by current common sources of urban forest

dollars, such as starting a non-profit nursery to source urban forest trees or to remove dead trees and grind stumps to create planting sites.

Carbon credit markets could help offset urban forest costs.

Understanding that limited funding is a near-ubiquitous challenge for urban forest programs, CLF explored the use of carbon credits as one solution, developing a potential process and model for local organizations or municipalities to follow. Given the administrative and legal hurdles associated with this process, we were unable to stand up a New England pilot over this one-year project, but there is interest from communities in further exploring the possibility. Several expressed interest in the concept more generally and might explore it in the future.

Spatial analysis has demonstrated the physical capacity of mini-grant programs to participate in the Urban Forest Carbon Program.

CLF partnered with researchers from the University of Connecticut to conduct a spatial analysis of tree planting and preservation opportunities in each of the six mini-grant communities. The analysis dovetails with the concurrent assessment of carbon credit opportunities for those communities. Based on a set of standards and protocols defined by City Forest Credits, the spatial analysis concluded that there was sufficient physical capacity and extent of eligible lands in each of the mini-grant communities to participate in the Urban Forest Carbon Program. The resulting maps and calculations can also serve as a point of reference for other similar communities to tangibly understand what urban contexts might serve as opportunities to generate carbon credits in their communities.

Additional questions remain for further research and study.

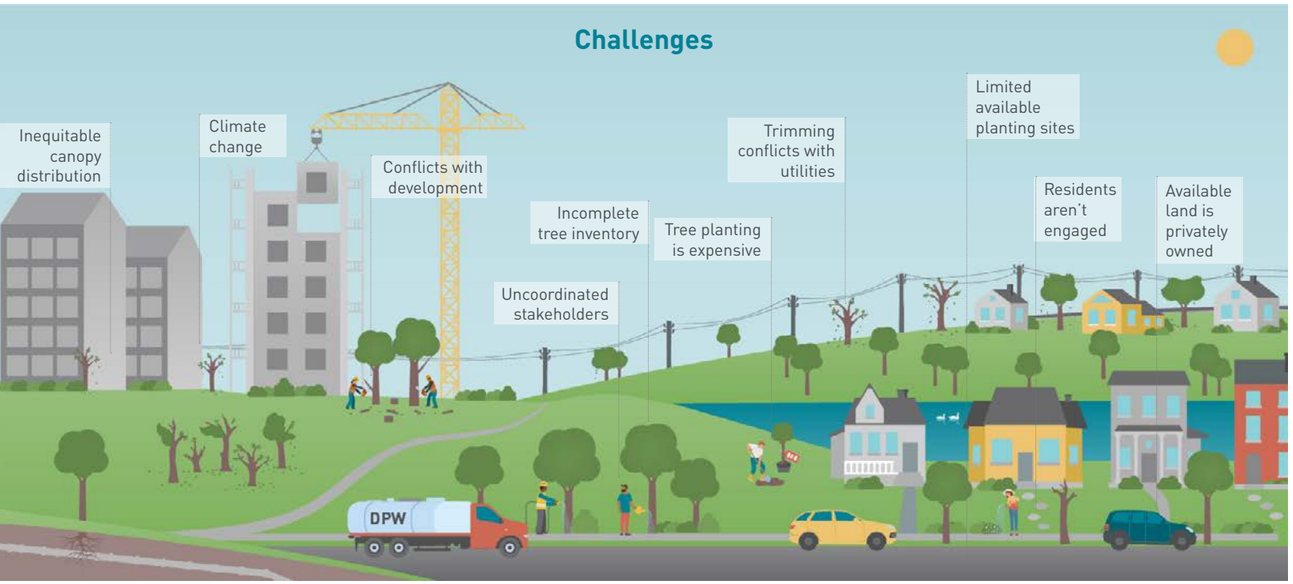
While enterprising urban foresters have found solutions to many of the commonly-occurring challenges they face in their work, there are still many gaps in knowledge and practice. Further investigation into potential solutions through a combination of academic research or pilot fieldwork projects could help identify solutions for these unsolved, commonly-occurring problems. Additionally, certain urban forestry objectives and opportunities could be better addressed at a larger scale, through regional or state entities, though fewer urban forestry programs exist in a robust manner at these geographies. Future phases of work could explore these opportunities in order to help preserve, maintain, and grow the urban forests of New England and beyond.

Photo credit: Mabel Lemoniel, Groundwork Lawrence

Photo credit: Mabel Lemoniel, Groundwork Lawrence

Urban Forest Challenges and How to Solve Them

Urban forests are made up of all trees and plant communities in cities. They provide important benefits that support the well-being of residents, contributing to improved physical and mental health and climate resiliency. Common challenges persist for communities seeking to grow and maintain an urban forest; the solutions identified below have worked for some communities and serve as a toolkit for other urban foresters.



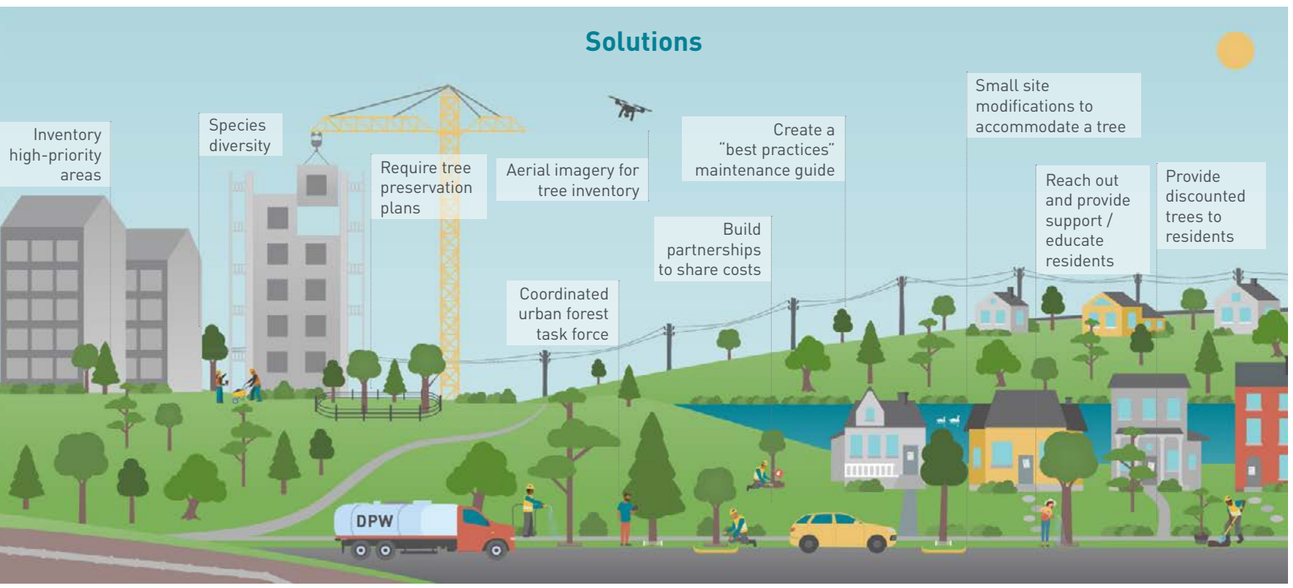


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Photo credit: CT Department of Energy and Environmental Protection

Introduction

Conservation Law Foundation (CLF) is the premier environmental advocacy organization in New England, forging lasting solutions to some of the toughest environmental challenges in the region. CLF's mission is to protect New England's environment for the benefit of all people. We use the law, science, and markets to create solutions that preserve our natural resources, build healthy communities, and sustain a vibrant economy. CLF is headquartered in Boston, Massachusetts with regional offices in Rhode Island, New Hampshire, Vermont, Maine, and Connecticut.

CLF's Healthy and Resilient Communities (HRC) program works in partnership with residents, civic leaders, universities, and impact investors to advance CLF's mission and create lasting change on the ground. We apply our expertise in planning, policy, research, and finance to the most urgent challenges facing New England's communities, from climate change to disinvestment and displacement. Together with our partners, we have built the largest participatory action research study in the country focused on health and place; launched three impact investment funds for healthy neighborhoods totaling $85 million; connected 1,000 New England farmers and food entrepreneurs with pro bono legal support; and successfully advocated for more equitable, inclusive, and climate-resilient development.

With increasing temperatures due to the climate crisis and the documented heat island effect of high temperatures in dense urban neighborhoods, there is an urgent need to increase urban tree canopy to provide more shade and help cool buildings and streets where people live, work, walk, and play. CLF is building on tree canopy-related work already done and/or underway in Boston, Cambridge and Lawrence, Massachusetts, as well as Manchester, New Hampshire, and in looking to expand this initiative, partnered with a total of seven municipalities and community-based organizations in New England, to investigate ways to accelerate tree canopy growth in low-income communities with significant disparities in health and green infrastructure.

As part of this project, CLF conducted outreach and partnership development in select New England cities, building on existing partnerships; conducted an urban forestry policy scan; identified and proposed a structure for bundling carbon credits; and supported a mini-grant program to help partner organizations overcome immediate hurdles in growing their urban forest. The participants of the mini-grant program also completed a short-form survey and a one-hour interview as part of this project.

There were three overarching goals for the project. The first goal was to establish new partnerships with community organizations and city departments engaging in urban forestry in New England and both assist them in accelerating their urban forest initiatives and learn from their experiences on the ground. The second goal was to conduct a multi-faceted research project to assess the current state of urban forestry in the New England region and elsewhere and facilitate knowledge transfer with partner

organizations and others. The third goal was to assess the viability of, and develop an implementation roadmap for, a carbon credit program to financially support and sustain a local urban forest program that could be used by partner organizations. The following report documents the findings of the research into urban forestry in practice in New England and the carbon credit market opportunities, including the results of a geospatial analysis of opportunities in six New England pilot communities. Supporting documents and work products can be found in the appendix.

Photo credit:Tom Riley

Urban Forestry Landscape Analysis

Urban forests are made up of all trees and plant communities in cities. The trees of the urban forest, as well as the shrubs, herbaceous plants, and mosses that support them, exist in places commonly used by people, such as parks and residential yards, as well as other places like conservation areas and woodlands.[1] The structure of the urban forest is described by these locations, the spatial relationships of the trees, and the physiological features of the trees, including diversity and age.[2]

Trees provide important benefits and services that support the well-being of city residents; for example, they contribute to improved physical and mental health, improved stormwater management, and increased shade.[3] These services are not only anecdotally beneficial but are also quantifiable in terms of monetary cost savings and returns on investment. For example, a sample of nearly 100,000 street trees across 50 California cities were shown to have an estimated annual value of $1.0 billion, and a benefit of $5.82 returned for every $1 spent on tree management.[4] Another study found that the human health benefits of trees in urban areas range in value from $103.70 to $286.30 per hectare across the New England states; this study only considered the health benefits from reduced air pollution, so these values are conservative.[5]

In addition to the many environmental and health benefits of the urban forest, it has also recently emerged as a key climate resilience strategy for addressing climate change-induced extreme heat. Urban areas in New England and across the United States are particularly at risk of extreme heat given that they already experience warmer temperatures than surrounding suburban and rural communities – a phenomenon known as the urban heat island effect. Trees help address the urban heat island effect in two ways: 1) the provision of shade and 2) evapotranspiration.[6] Studies have found up to a 40°C surface temperature difference between shaded surfaces under dense tree canopies and unshaded asphalt.[7] Likewise, evapotranspiration reduces the amount of heat in the air around trees; studies have found up to an 8°C difference in air temperature below the tree canopy attributable to evapotranspiration.[8]

CLF undertook a scan of local urban forestry efforts in New England and other select locations across the U.S. to identify common challenges and barriers, best practices, and gaps in the existing research in order to develop a strategy for accelerating local urban forestry efforts. We reviewed ten municipal urban forest master plans— including seven from the New England region—to identify common challenges that municipal governments and their community-based partners face

1 Morgenroth and Östberg 2017, Johnson et al. 2021
2 Miller et al. 2015, McPherson et al. 1997
3 Dobbs et al. 2017
4 McPherson et al. 2016
5 Nowak et al. 2014
6 Rahman et al. (2020)
7 Rahman et al. (2019)
8 Rahman et al. (2017)

in preserving, growing, and maintaining their urban forests. The chart on the next page shows the urban forest master plans that were reviewed as part of this project and the common challenges among those communities.

We also surveyed and conducted interviews with representatives of the seven New England municipalities and community-based organizations that participated in the urban forestry mini-grant program that was administered as part of this grant to gain further insight. Some of these municipalities overlap with the communities we reviewed as part of the urban forest master plan scan.

From the research described above, the following overarching themes emerged:

- Access to information about the existing urban forest is critical;
- Local rules and standards can help grow and preserve the urban forest;
- Conflicting and competing land uses present unique challenges;
- The urban forest is not equitably distributed;
- Growing the urban forest can be expensive and laborious;
- Urban forest management requires support and coordination; and
- Climate threats to the urban forest impact preservation, planting, and maintenance.

Below, we explore these seven thematic challenges in greater depth as well as potential solutions based on information gathered from our review of municipal urban forest master plans, other local policies and best practices, peer-reviewed literature, and stakeholder surveys and interviews. This assessment also identifies several gaps in current urban forestry efforts and the implications for future research.

Table 1: Common Urban Forestry Challenges

	Boston, MA	Brookline, MA	Cambridge, MA	Columbus, OH	Dallas, TX	Durham, NH	Hartford, CT	Holyoke, MA	Windsor, VT	Seattle, WA
Above-ground Utilities	X	-	X	X	-	-	X	X	X	X
Below-ground Utilities	X	X	X	X	-	-	X	-	-	X
Climate Change Impacts	X	X	X	X	X	-	X	X	-	X
Community Engagement	X	X	X	X	X	-	X	X	X	-
Conflicts with Other Infrastructure	X	-	X	-	X	-	-	X	-	X
Consistent Tree Watering	X	X	-	-	-	-	X	X	-	X
Coordination Between Stakeholders	X	X	X	X	X	X	X	X	-	-
Difficult Planting Conditions	X	X	X	X	X	-	-	X	-	X
Inadequate Emergency Response & Risk Management	X	-	X	X	X	-	X	X	-	-
Inadequate Soil Quantity & Quality	X	X	X	X	X	-	X	X	-	X
Insufficient Budget	X	X	X	X	X	X	X	X	X	X
Mature Tree Preservation	X	X	X	X	X	-	X	X	X	X
Nonexistent, Outdated, or Incomplete Inventory	X	-	-	X	X	X	-	X*	X	X
Private Property	X	X	X	X	X	X	X	X	X	X
Rental Properties	X	X	-	X	-	-	-	X	-	X
Staffing Limitations	X	X	X	X	X	X	X	X	-	-
Turning Plans into Action	X	-	-	-	X	-	X	-	-	-
Urban Forest Diversity	X	X	X	X	X	X	X	X	X	X

*Since Holyoke published its Urban Forest Equity Plan, the city was able to complete its public tree inventory with funding from the Wells Fargo-supported urban forest mini-grant program.

Access to Information about the Existing Urban Forest is Critical

Accurate and up-to-date information about the urban forest is necessary for effective management and planning. Simply planting trees where there is available land is not a good long-term strategy for growing the urban forest. Likewise, failure to understand vulnerabilities in the existing urban forest hinders long-term efforts to preserve and grow it. An ideal urban forest is equitably distributed and is diverse in a number of ways, including tree species, size, and age.[9] A tree inventory, which records the location and characteristics of trees, is the primary tool used to gather and evaluate this information. Different approaches to measuring the urban forest may be used depending on the desired inventory outcomes and factors such as available staff capacity, resources, and time. For example, to evaluate a broad measure such as canopy cover, a municipality only needs one-dimensional data that outlines the presence/absence of tree cover for a given area; there is no need for further detail on individual tree characteristics.[10] However, to create a more detailed management plan, one might opt to include more comprehensive variables and/or measures of condition, as well as nuanced data about the structure of individual trees, including total tree volume or leaf area.[11] For all tree inventories, regardless of their intended use, it is crucial that urban forest managers regularly update them to maintain their effectiveness.

Challenge: Lack of a Complete and Current Tree Inventory Hinders Effective Tree Preservation, Planting, and Maintenance

Although cities and towns have different urban forest needs and capabilities depending on their size, geography, staffing, and funding, tree inventories are crucial for effective management across all communities. While tree inventories appear to be more common in larger communities, many cities, including smaller ones, are increasingly using them to enhance management. However, many cities still do not have a tree inventory, or they have one that is out-of-date and/or incomplete.[12]

In our scan of urban forest master plans, the need for a complete and accurate inventory was commonly cited. In the absence of a tree inventory, urban forest managers may make management decisions about the resource with limited knowledge of its condition.[13] As a result, managers may not be able to monitor conditions, maximize ecosystem services, minimize maintenance costs, mitigate hazards, or develop informed policies and management strategies.[14] For example, an inventory may be used to understand which areas of the city are most at risk from a certain pest, such as the Emerald Ash Borer. Without knowing precisely where ash trees are located, urban forest managers will be less effective in monitoring at-risk trees or creating a treatment plan. Similarly, an inventory may reveal that a certain species of tree is heavily concentrated in one area of the city. As a result, this area of the city's urban forest may be in danger of being decimated if a species-specific pest or disease were to infect trees in that area.

Since the majority of a city's urban forest is often located on private property, tree inventories that are focused on public land and rights-of-way (ROWs) have limitations in terms of usefulness for comprehensive planning, monitoring, and maintenance. Due to capacity and access limitations, a stem-by-stem inventory of trees on private land is not feasible for most municipalities, so inventories are often incomplete, only including trees on public land and alongside streets.[15] A study of cities worldwide found that trees on private property account for more than half of all urban trees, so inventories containing only public trees are lacking key information about the urban forest.[16]

Some communities may approach inventorying by using a sample-based model that can provide a solid and statistically valid foundation for urban forest management. Complete inventories may be limited to specific areas where the city needs information about tree condition, species, etc.[17]

Furthermore, many municipalities do not have adequate time or resources to regularly maintain their inventory, whether it is complete or incomplete. Simply having a tree inventory is not sufficient for municipalities seeking to effectively manage their urban forest. To reflect ongoing changes in the urban forest and remain a useful tool, the inventory needs regular upkeep.

Best Practice: Conduct a Partial Inventory of High Priority Areas

If a complete tree inventory, measuring the characteristics of all the trees in the urban forest, is not a feasible approach because of funding, staff capacity, or other reasons, a partial inventory can be used to measure a subset of the urban forest.[18] This type of inventory can be partial in the sense that it only includes a portion of the urban forest and/or that it only includes limited details (e.g., location and species) about the trees, with the former being most common. Communities should identify high priority areas to conduct the partial inventory, such as areas that have lower than average tree canopy coverage or a high concentration of historically marginalized populations. Communities should also develop a phasing schedule so that additional partial inventories can be strategically implemented over time, eventually resulting in a complete inventory.[19]

In Holyoke, MA, the city's urban forestry program has been limited by inadequate funding. However, by using funding where available, the city completed a partial inventory of its urban forest. This inventory included trees in public spaces and the public right of way within high-priority areas of the city. The four prioritized neighborhoods were those with the

9 Sax et al. 2020
10 Morgenroth and Östberg 2017
11 Nowak et al. 2008
12 Hargrave et al. 2023, Ma et al. 2021
13 Harper et al. 2017
14 Morgenroth and Östberg 2017, Nowak 2017
15 Miller et al. 2015
16 Pataki et al. 2013, Avolio et al. 2015, Monteiro et al. 2020
17 Smiley and Baker 1988
18 Morgenroth and Östberg 2017
19 Morgenroth and Östberg 2017

lowest incomes, highest proportions of non-white residents, and lowest existing canopy cover, as determined in previous projects done by the city. With the findings of the partial inventory, Holyoke began improving the urban forest in the areas with the highest need. With the partial inventory, the city was able to have a more immediate impact than if they had waited for funding to do a complete inventory all at once.

The City of Holyoke was able to complete their public tree inventory with funding from the Wells Fargo-supported urban forest mini-grant program. The funding was used to hire a qualified arborist firm to inventory the remaining trees – approximately 2,415 trees. The completed inventory will be used to further understand the city's canopy needs and priorities, as well as to improve the overall management of the urban forest. Grant funding was also used to lead educational training sessions for community members. The goal of these sessions is to equip community members for future citizen science efforts to keep the inventory up to date.

Best Practice:
Leverage Volunteers, Nonprofit Organizations, and Other Interested Groups to Conduct a Tree Inventory.

Gathering information for a tree inventory can and should be a collective effort. While some communities rely on urban foresters and arborists to conduct inventories, this can be prohibitively expensive. Leveraging trained volunteers and students to conduct sample-based inventories can both help reduce costs and encourage citizen stewardship of the urban forest. A variety of stakeholders often engage in assessing and inventorying the urban forest, including researchers, governments, and residents.[20] Several studies have documented the promise of volunteer data collection or virtual surveys as a means to conduct a tree inventory, for example, using Google Street View or engaging students through university classes.[21] Partnering with a nonprofit organization could also help reduce costs for a municipality who would otherwise have to rely on their own staff or private contractors to do the inventorying.

Leveraging the rising interest in citizen science, the town of Bedford, MA, conducted a public tree inventory using resident volunteers. This effort was organized by the Bedford Arbor Resources Committee, the town's Department of Public Works, and the Massachusetts Department of Conservation and Recreation (DCR). The town was divided into zones, with each zone having a captain, or lead volunteer. The captain received training from DCR on iTree software, tree and pest identification, and other factors covered in the inventory. All volunteers were given basic instructions and an illustrative guide prior to conducting the inventory. Interested volunteers who could not participate in the actual inventory were recruited for later data upload tasks.

In Lawrence, MA, the city partners with Groundwork Lawrence (GWL), a local nonprofit organization, to develop and maintain the city's tree inventory. Since GWL already has a license for Esri's ArcGIS Pro, they host the tree inventory rather than the city. The tree inventory includes information on all the trees that GWL has planted in Lawrence, including those on privately owned land. With recent technology upgrades, GWL staff can update the inventory "on the fly" when they are in the field doing tree work. Through this partnership, the city enjoys a robust and well-maintained inventory, something that may not be possible without GWL's support.

There are many other examples of engaging stakeholders in tree inventory work. Casey Trees is a nonprofit organization based in Washington D.C. that trains thousands of volunteers in tree planting and care. They have trained and mobilized residents in D.C. to help inventory city trees and monitor their health. Volunteers receive brief hands-on training and then work in teams to document tree species, height, trunk diameter, crown width, and other defining features of the urban forest. They also maintain an open-source, ArcGIS-based tree inventory map online for use by residents and other stakeholders.

Best Practice:
Leverage Science and Technology to Capture a More Complete Picture of the Urban Forest.

Tools such as aerial imagery and LiDAR analysis, used together or separately, can be effective in obtaining more complete information on the urban forest. Aerial imagery is an accessible and affordable way for urban forest managers to get an estimation of tree canopy, including on private land.[22] LiDAR, which requires a drone flyover and specialized analysis, is a more expensive approach that may not be feasible for many municipalities. However, LiDAR offers much more detailed and accurate information on individual trees, such as species, height, and condition.

iTree is a peer-reviewed software from the USDA Forest Service. The online software provides analysis and assessment tools for urban and rural forestry management. Due to its ability to quantify urban forest structure and the benefits provided by trees, as well as its no cost accessibility, iTree is an important tool for strengthening urban forestry management and advocacy.[1]

In Vermont, the City of Burlington has worked with the spatial analysis lab at the University of Vermont to assess their urban forest via LiDAR. While this type of analysis has become more common, when initially completed 15 years ago, it was a first-of-its-kind report. Five years ago, the city received funding from the state's urban and community forestry program to repeat the study, finding the canopy had grown about four percent over 10 years. These analyses provided important insight into the urban forest on both public and private land, an invaluable asset to the city's urban forest program.

In Cambridge, MA, the city used LiDAR, a five percent sample tree inventory (about 4,100 trees), and satellite imagery to estimate the number, condition, and species of its trees, including those on private land. By analyzing this data

20 Morgenroth and Östberg 2017
21 Berland et al. 2019, Cowett and Bassuk 2012, Coleman et al. i.p

22 Liknes et al. 2010

between 2009 and 2018, the city identified privately owned land as the land type with the greatest tree losses. This study has been critical to the city's work towards data-driven urban forestry policies and plans and provides a key model for cities looking to use a sample-based inventory approach.

Using a similar process, urban foresters in St. Albans, VT used aerial imagery alone to estimate the state of the urban forest on private land. While this type of analysis is not very precise, it can be a critical strategy for municipalities that would otherwise not have any information about trees on private land due to funding and/or resource limitations.

Best Practice:
Increase Efficiency to Keep the Inventory Up to Date

For communities with an existing inventory, it is common practice to update the inventory as work is done. For example, after pruning a tree, an urban forest staff member will update the tree's condition in the inventory software. Likewise, after planting a tree, urban forest staff can enter it into the inventory software. Maximizing efficiency can help ensure that the inventory is routinely updated, making the tool as effective as possible.

In Burlington, VT, the urban forestry team maximizes their efficiency by systematically planting trees. At the direction of the city arborist, the team has been working their way through each ward and filling all plantable sites, starting with the wards identified as having the lowest canopy cover. This approach cuts down on transportation time and costs, increasing the efficiency of tree planting; incorporating inventory updates into such an efficient process would ensure that the inventory remains an up-to-date and useful tool.

Gaps in Practice and Research

More Knowledge is Needed About the Impact of Inventory Platforms and Tools

In recent years, technology that facilitates conducting and maintaining tree inventories has become popular among urban forest managers. These inventory platforms help urban forest managers track work orders, pruning schedules, stump locations, and more; examples include TreeKeeper by Davey Trees, TreePlotter by PlanIT Geo, ArborScope by Bartlett Tree Experts, and iTree by the USDA Forest Service. While the effectiveness of this technology is supported by anecdotal evidence, more research is needed to understand its true impact. For example, there is very little existing research on whether municipalities and CBOs are leveraging the full potential of these tools, maximizing their value, and getting a high return on investment. Further analysis on this subject may help urban forest managers understand whether it is effective to direct resources and funding towards these inventory tools and how best to leverage them.[23]

23 Sowlati 2005

Local Rules and Standards Can Help Grow and Preserve the Urban Forest

Well-protected trees are more likely to survive, maintain a healthier condition, and generate greater ecosystem services.[24] Both regulations and incentive mechanisms are common approaches to promote tree protection and address drivers of tree loss.[25]

Approaches to protecting the urban forest through policy and regulation range from land preservation and development restrictions to planting and mitigation requirements. In any case, effective tree preservation begins at the conceptual stages of planning design or development proposals.[26] However, appropriate laws, policies, and ordinances may not be in place to avoid tree damage and curb negative effects of new development or construction from the outset.[27]

Tree-related rules and standards generally fall into two categories: (1) rules incorporated into zoning and development review processes that are targeted at properties undergoing construction and redevelopment, and (2) rules targeting all private property regardless of its development status.

Strong political support is needed to adopt and enforce these rules and standards. From our surveys and interviews of New England urban forest programs, we found that municipal support for the urban forest is often more superficial than substantial. As to whether our mini-grant recipients feel that their local government sees urban forestry as a priority, the most common answer was "yes, but...". Additionally, within the local government, work affecting the urban forest can be siloed. For example, one of our interviewees spoke about the challenge of protecting the urban forest during sidewalk reconstruction. Sidewalks are not under the jurisdiction of the city forester, so they must rely on another department to keep them up to date on current projects and help them enforce tree-related guidelines. To protect urban forests, local governments must have cross-departmental support and coordination; this is particularly true for enforcement. Enforcement of these policies and standards is critical to their success and a lack of coordination across government departments can pose a barrier to effective implementation.[28]

Challenge: Urban Land Protection is Challenging Due to Limited Availability and Costs

Permanently protected land is likely the gold standard in promoting urban forest growth; however, it also limits a city's opportunities for new development. Several legal and financial mechanisms exist to permanently protect land, with the exact process varying between states. Government entities, like state agencies and local departments, as well as dedicated organizations, like land trusts,

24 Miller et al. 2015
25 Ordóñez-Barona et al. 2021
26 Matheny and Clark 1998, Ames and Dewald 2003
27 Miller et al. 2015
28 Clark et al. 2020

are common partners to hold title or other land rights for conservation purposes. Examples of urban land protection include community gardens, landscaped parks, conservation areas, and sensitive wildlife habitat, like vernal pools. Urban land protection may also involve reclaiming land, such as vacant lots or brownfields, for opportunities to expand the urban forest.

Urban land protection can look similar to land protection in suburban or rural contexts and can serve to improve the quality, quantity, and usability of neighborhood open spaces. However, since urban land protection is often more challenging than its suburban and rural counterparts, largely due to limited land availability and high land costs, it is not a common strategy for tree preservation. Out of our seven survey respondents, only two have participated in land preservation projects.

Land in urban areas is usually in short supply and high demand. This can drive up the purchase price of land beyond that which is feasible for an interested municipality or conservation group.

In fact, a recent study of land values across the United States found that the cost of conservation has been greatly underestimated in previous studies, by up to a factor of two in urban areas.[29] The short supply of land can also make it challenging to find land suitable for protection. Additionally, as property values in a city increase, green space owners may decide to sell their land to rid themselves of the increasing burden of property taxes; the highest bidder in these cases is not usually a conservation-minded group.[30]

Best Practice:
Implement Land Protection Policies at the Local Level

Local policies that promote and facilitate land protection can have significant benefits for the urban forest. Protecting land for open space creates opportunities for tree planting and increases the likelihood of tree preservation. Land protection policies should be tailored to fit the unique needs of each community. Additionally, it is important to ensure that these policies are designed and

29 Nolte, C. 2020
30 Van Fleet, T. et al. 2015

Photo credit: miamidade.gov

Photo credit: Friends of the Rail Park

Photo credit: Studio Bryan Hanes

implemented in a way that promotes equitable access to greenspace for all residents.[31]

Baltimore Green Space (BGS) is an environmental land trust operating in Baltimore, MD. With the support of residents and local leaders, they have successfully advocated for policies that promote land protection. For example, BGS advocated for a policy that allows vacant land, whether privately or publicly owned, to be transferred to a qualified land trust for use as community managed green space. Previously, community members were informally using vacant lots for community gardens and pocket parks, but had no ownership rights, leaving them and the land in a state of uncertainty. Under this new policy, community members can apply to a city-approved land trust and, if it accepts the request, the land trust will initiate the review and transfer process with the city. This policy encourages the preservation of vacant lots as community open space, creating more opportunities for tree planting.

31 Oldekop et al. 2016

Best Practice:
Take Advantage of Opportunities to Reclaim and Reuse Land

Because land in urban areas is often scarce and expensive, opportunities to reclaim and reuse land, even small parcels, should be pursued enthusiastically. Many urban areas have vacant or underutilized sites in need of remediation and reuse. Some of these sites may be unattractive to private developers because of the environmental cleanup challenges they present. In other cases, a strip of land may be awkward in size or location making it less attractive to the private market. For example, many communities have taken advantage of abandoned railroad tracks to create rail trails and parks. Whatever the case may be, these sites represent opportunities for local governments and other stakeholders to step in and acquire the land for conservation purposes.

In Philadelphia, PA, the Reading Viaduct Project, also called the Rail Park, is taking advantage of an old, elevated train track

to create a linear public green space. In 2003, the City of Philadelphia obtained a grant to fund a study of alternatives for the development of the Viaduct and found that the cost to demolish was nearly 10 times as much as the cost to redevelop the structure into a park. In 2018, the first phase of the three-mile vision opened to the public. The final vision for the park would connect more than ten neighborhoods in Philadelphia.

Gaps in Practice and Research

There is a Need for Strategies that Ensure Land Protection Opportunities are Equitably Distributed

In many cities, residents who are low-income and/or people of color tend to live in denser grayer neighborhoods than their more affluent and/or white counterparts.[32] Opportunities for land protection are more likely to exist in less dense areas, so land protection may disproportionately benefit a city's whiter and more affluent residents, exacerbating existing environmental inequities. For example, one interviewee described the low-income neighborhoods in his city as extremely dense with triple-deckers packed onto small lots – not areas likely to have green space protection opportunities. Alternatively, taking advantage of vacant land or brownfields for tree planting and parks in low-income neighborhoods could have the unintended consequence of increasing surrounding property values, thereby pricing long-term residents out of their neighborhoods. More research is needed to understand and provide guidance to local governments and other stakeholders on how to pursue land protection opportunities equitably given these constraints.

Challenge: Tree Protection Mechanisms During Construction and Development May be Inadequate

Tree protection should be prioritized during building construction and development since they may otherwise be intentionally removed or unintentionally damaged. The consequences of removing large mature trees are serious and often irreversible in the near-term. These trees contribute significantly to the overall canopy and provide more ecosystem services than newly planted trees – it can take decades for new trees to provide the same benefits as those they are intended to replace.

Tree protection during building construction and development should account for the whole tree: prohibiting the use and storage of heavy equipment within the drip line to prevent soil compaction, limiting construction activity within a certain distance of trees, etc. Tree protection interventions should also aim to understand the tolerance of specific tree species to a given construction situation when making retention or removal decisions.[33] Studies have shown that this type of intervention works; for example, a long-term 40-year research study in Milwaukee, WI, found success in a program that protected trees during new construction.[34]

32 Watkins and Gerrish 2018

Photo credit:canopy.org

Best Practice:
Require Municipal Review and Approval Prior to Tree Removal During Development

Development review processes create opportunities for a municipality to influence decisions on private property during construction and redevelopment. Some municipalities have extended development review to include restrictions on tree removal. In many communities, tree loss is primarily happening on private property so this type of intervention may be significant in slowing tree removal. However, private property can be categorized in two ways: properties that are undergoing development, thereby requiring development review, and properties that are not undergoing development. The development review and permitting processes will only have influence on the former.

An ordinance in Knoxville, TN, prohibits the removal of more than 25 percent of a parcel's trees during construction or redevelopment without the prior approval of the city forester. Even once the removal is approved, at least six trees per acre must be retained on site. If this retainment rate is not met, replacement trees must be planted to achieve a density of at least eight trees per acre.

In Atlanta, GA, a tree removal permit is required prior to removing any tree with a six inch or greater diameter at breast height (DBH) during construction or renovation on private property. The permit application must include the project's location, who will be removing the tree, and information on the tree to be removed, such as the location on the property, the species, the diameter, and any other identifying characteristics. At the discretion of the city arborist, the applicant may need to submit and implement a tree replacement plan so that the project does not result in a net loss of trees on the property. All replacement trees must be at least two and a half inches in caliper at the time of planting. There are also certain tree types that cannot be used as replacements, for example, columnar or fastigiate species or cultivars. All other construction permits for a project must already be approved for the city arborist to approve the tree removal permit. Once a permit is approved, but prior to the removal, there is a required preconstruction conference, where the

33 Koeser et al., 2013
34 Hauer et al. 2020

city arborist and applicant meet on site to review the accuracy of the permit application.

Best Practice:
Require Tree Planting and/or Preservation for New Development

Development review processes can also require applicants to submit plans for tree planting and/or preservation. Tree planting requirements support municipal efforts to expand the urban forest, taking advantage of space on private property. Tree preservation requirements are important because large mature trees are crucial to the structure and function of the urban forest. Some municipalities may find more community support by creating a tree preservation requirement rather than a tree removal restriction; although both do the same thing, the phrasing may impact how residents perceive the new requirement. Furthermore, targeting the largest trees through preservation requirements may resonate with residents who understand the substantial benefits that such trees provide the community.

In Fairfax County, VA, any development requiring the submission of a site plan, subdivision plat, subdivision plan, conservation plan, and/or a grading plan, must also submit a tree conservation plan. The plan must show how the development will retain trees on site so that, after ten years, the canopy is projected to meet the minimum canopy requirement for the given zoning district. All reasonable efforts to preserve existing trees must be taken before replacement plantings can be used to fulfill this requirement. This condition makes clear that tree preservation is a priority.

Both Knoxville, TN, and Charlotte, NC, have regulations in place to incentivize tree preservation over replacement plantings. In both cases, developers that are not able to meet tree retainment requirements must replace trees at a higher rate, ultimately dedicating more land to trees. In Charlotte, development plans must identify a minimum "tree save area" where all removals are prohibited. If any part of the tree save area is not preserved, the replacement area must be provided at 150% of the area removed and have trees planted at a rate of 36 per acre. In Knoxville, any development work that requires a building permit must retain trees on site at a rate of six per acre. If this requirement is not met, trees must be planted at a higher rate of eight per acre.

New or reconstructed parking areas represent another opportunity for increasing tree planting opportunities. In Lawrence, MA, the city set landscape requirements for all new or expanded parking lots so that trees must be planted at a rate of two shade trees or three ornamental trees per ten spaces. This requirement takes advantage of space in a land use type that is often devoid of trees.

Challenge: Trees on Private Properties that Are Not Undergoing Development May Not be Adequately Protected

While zoning and development review processes are ideal mechanisms for addressing concerns about tree removal during construction, a significant portion of the urban forest is on private properties that are not undergoing development. Decisions by individual private property owners to remove trees can add up to significant losses over time. Historically, most municipalities have not attempted to regulate trees on these properties, but communities are increasingly interested in adopting rules and standards to help curb the loss of healthy trees on these properties.

Best Practice:
Adopt a Tree Protection Ordinance

Local ordinances are a common and important tool for increasing tree protection. A tree protection ordinance is a signal that the community values trees and the critical services they provide. Tree protection ordinances are often standalone from development and zoning requirements, although the two may overlap in some cases. Tree protection ordinances are most effective for extending requirements to trees outside of the construction/redevelopment context, since unlike zoning and development codes, properties that do not require permitting are unable to evade these protections.

Tree protection ordinances across the country vary in terms of scope and restrictiveness and often include a range of provisions such as standards for planting and/or maintenance, permit requirements, restrictions on tree removals, and enforcement mechanisms and fines. Each municipality should decide what to include in their ordinance to best suit the needs of their community and urban forest. Most ordinances approach tree protection by restricting the removal or destruction of trees and/or requiring mitigation (e.g., replacement planting, fees) in exchange for such actions. Some combination of these approaches is likely the most effective way to preserve and grow the urban forest.

While tree protection ordinances can extend to private property, many municipalities limit their scope to trees in the ROW and other public property. In some cases, this limitation may be due to a lack of political will – local leaders find it is controversial to exert control over trees on private property. This is particularly true for protections that extend to private property outside of the redevelopment process. For example, one interviewee noted that while residents in her community are generally supportive of the urban forest, she does not think there would be support for a tree protection ordinance extending to private land. In other cases, municipalities may limit the scope of their ordinance so that its provisions can be reasonably monitored and enforced with the existing staff capacity. An ordinance that does not extend to private property may be less effective than one that includes private trees. This is especially true for municipalities where most of the annual tree loss occurs on privately owned land outside of the construction/redevelopment process. However, for municipalities where a far-reaching ordinance is not feasible, a public tree ordinance is still an important step towards increasing tree protection.

In Providence, RI, the scope of the tree ordinance is limited to public property. The ordinance gives the city forester authority and jurisdiction over the regulation, protection, maintenance, removal, and planting of trees on streets, parks, and other public places. A permit, issued by the city forester, is required before anyone can plant, spray, prune, cut, remove, or otherwise disturb a tree on any street, park, or other public place. For any

tree removal permit, the city forester can require replacement plantings as a condition of approval. The ordinance also outlines protective measures that must be implemented during construction and development projects on public land. Any person performing tree work in Providence, RI must be a licensed arborist and certified by the State of Rhode Island.

Somerville, MA, is an example of a municipality with a tree ordinance that extends to private land. The tree warden is responsible for enforcing the ordinance and issuing relevant permits, as well as managing all trees in the ROW and on other public property. The senior urban forestry and landscape planner is responsible for developing additional policies, regulations, and manuals necessary to carry out the intent of the tree ordinance. The ordinance states that no "significant tree," defined as any living tree with eight inches or greater DBH, may be removed from private property without a permit from the tree warden. If significant trees are permitted to be removed, replacement trees, totaling the caliper removed, must be planted onsite within 18 months. If the site does not allow for this, the tree warden can permit payments in lieu, according to a fee schedule established by the senior urban forestry and landscape planner.

35 City of Cambridge (2019)

Tree protection ordinances are most useful when they are data-driven and are informed by the unique existing characteristics and conditions of a community's urban forest. It is tempting for cities, especially those with limited funding and staff, to simply adopt the language of nearby communities' ordinances without acknowledging the difference in circumstances. This can sometimes be counterproductive to the cities' tree protection goals. For example, in Cambridge, MA, residents anecdotally believed that tree loss in the city between 2008 and 2018 was primarily a result of new construction and redevelopment projects. However, a data-driven urban forest planning process revealed that there was no single factor responsible for tree loss on private property. New building construction, paving, landscape renewal projects, inadequate maintenance and protection, and natural decline all contributed to the loss of trees on private land.[35] Further, there was a large proportion of tree loss happening on private properties outside of the redevelopment process. This finding was instrumental in charting a path forward on tree protection – namely expanding the jurisdiction of the ordinance to include private properties outside of the redevelopment process through a tree removal permit program.

Table 2: Tree Protection Ordinance Requirements and Regulations (removal or destruction)

City/town	Trees with a minimum DBH on private property are protected (outside of develop. process)*	Exemptions other than dead/ hazardous condition	Special/heightened requirements for Heritage/Exceptional trees or the equivalent	City/town has policies on planting or canopy loss	Zoning-esque landscape and design standards are included in tree protection ordinance	Dedicated commission/board/ council involved in enforcement or implementation	Requires compliance prior to inspection or C.O.
Atlanta, GA	X	X	-	X	X	X	X
Dallas, TX	X	X	-		X	X	X
Seattle, WA	X	X	X	-	-	X	-
Portland, OR	X	X	X	X	X	X	-
Austin, TX	X	X	X	X	-	-	-
Providence, RI	X	X	-	-	X	X	-
Arlington, MA	-	X	-	-	-	X	-
New York, NY	-	X	-	-	-	-	-
Washington, DC	X	X	X	-	-	X	X
Nashville, TN	X	X	X	-	-	-	X
Tampa, FL	X	X	X	-	X	-	X

*These trees are often referred to as "significant trees" in tree ordinances and are defined based on a minimum DBH (usually between 6 and 8 inches DBH). This is distinguishable from Heritage/Exceptional tree protections which are usually reserved for mature trees or trees with special characteristics.

Table 3: Tree Protection, Mitigation, Fees, Maintenance

City/town	Tree fund or account maintained separate from general account	Mitigation or replanting requirements for trees removed during development	Mitigation or replanting requirements for property owners outside of development process	Requires performance guarantees/bonds/ covenants for maintenance	Permit or notice required for pruning (private property)	Standards or guidance for pruning (private property)	Prohibits excessive pruning
Atlanta, GA*	X	X	X	-	-	X	X
Dallas, TX*	X	X	X	-	-		X
Seattle, WA*	-	X	-	-	X	X	X
Portland, OR	X	X	X	X	X[L]	X	X
Austin, TX*	-	X	X	X	-	-	X
Providence, RI	-	X	-	-	-	-	-
Arlington, MA	X	X	-	-	-	-	-
New York, NY	X	X	-	-	-	-	-
Washington, DC	X	X	X	-	-	-	-
Nashville, TN*	X	X	X	-	X[L]	-	-
Tampa, FL*	X	X	X	-	X	X	X

*Tree protection requirements were either recently revised, currently undergoing revision, or being considered for revision
[L] Only required in certain circumstances

Best Practice:
Afford Additional Protection to Trees with Notable Characteristics

Not all trees contribute equally to canopy cover or provide the same benefits. From its growth each year, a tree that is 100 centimeters (about 40 inches) in diameter adds the equivalent biomass of an entirely new 10-to-20-centimeter (about four to eight inches) diameter tree; this comparison underscores the role of mature trees in carbon sequestration.[36] Likewise, mature trees provide more ecosystem services, including shade and habitat, than newer trees.[37] Some communities make a special effort to protect large/mature trees due to these benefits.

Marin County, CA, has two tree designations: protected and heritage. The criteria for these designations vary by tree species. For example, if the DBH of a Box Elder is between 10 and 30 inches, it is a protected tree, but if the DBH is greater than 30 inches, it is a heritage tree. Property owners must apply for a tree removal permit to remove more than two protected trees within a twelve-month period or to remove a single heritage tree at any time. The county can also require an applicant to provide replacement trees or mitigation payments as a condition of permit approval.

In Brookline, MA, an application must be submitted prior to tree removals that will remove 32 inches or more DBH of protected trees. A protected tree is any tree with a DBH of at least 8 inches. The tree removal application must include an Erosion and Sediment Control Plan, a written description of the work, and any additional information that may be helpful for the Department of Public Works in reaching a decision. This requirement is codified in the town's stormwater management bylaw.

In Indianapolis-Marion County, IN, heritage trees are defined as trees of a species enumerated in the tree protection ordinance with a DBH greater than 18 inches. The ordinance prohibits the removal of any heritage tree unless one of several exceptions applies, including that the tree is dead or diseased, interferes with public services or is a traffic hazard, or is preventing development or redevelopment.

In San Jose, CA, polices take a similar but distinct approach to protecting heritage trees by allowing residents and property owners to nominate trees for protection. The city describes heritage trees as those on either public or private property that have special significance to the community due to their history, girth, height, species, or unique quality. Nominations for heritage tree designation go to the city arborist for review. Nominations must originate from the property owner or have their written permission. Once accepted, removal is prohibited and subject to a $10,000 fine and any pruning must be done in consultation with the city arborist.

Challenge: Tree-related Rules and Requirements are Underenforced

Rules and standards are only as good as their enforcement. For many local governments with limited staff capacity, ensuring that rules related to tree removal and protection are enforced can be a challenge. This is especially true when roles and responsibilities within government departments are siloed. For example, the building inspector in a city might be responsible for inspecting a newly constructed building before presenting a certificate of occupancy (C.O.) but may be unaware of tree-related requirements that were a condition of the development receiving a C.O.

In some cases, individual property owners may not be aware of tree-related requirements including restrictions on removal. In these cases, especially where only a tree or two is being removed, it is almost impossible for the city to identify and enforce violations. Some cities may rely on tips from neighborhoods that

36 Stephenson et al. 2014

37 Moomaw et al. 2019

unauthorized tree work is going on – something that local governments worry can put a strain on relationships within the community.

Best Practice:
Insert Tree Inspections into the Process for Approving New Development

Though many cities include tree-related requirements, including replacement plantings, into the development review process, few have a process to confirm those requirements have been met before issuing a building permit or certificate of occupancy. In some communities this may be because the planning and development staff and the city arborist are in different departments. In other cases, it may be that tree-related requirements live in a regulatory framework that is separate from zoning and development requirements with no clear enforcement path.

In Dallas, TX, the city's tree protection ordinance states that single family and multifamily development projects requiring replacement trees must plant the trees before 65 percent of the development has received a final building inspection or a certificate of occupancy and all trees must be planted prior to the completion of the development. In all other cases, replacement trees must be planted prior to the issuance of a certificate of occupancy.

Similarly, in Boerne, TX, the removal of protected trees may require a Tree Preservation Plan (TPP), which is a map or site plan illustrating the general layout of proposed buildings, structures, driveway, and on-site areas along with the design of landscaped areas, including detail of the location, species, and trunk circumference of trees that are to be retained or removed, and trees that are to be planted as replacement. The city's code enforcement department inspects each site for conformance with the approved TPP prior to issuing a Certificate of Occupancy.

Due to instances of tree damage and unauthorized tree removal on construction sites, the Planning and Building Department for the County of San Mateo, CA, instituted an "Erosion Control and/or Tree Protection Pre-Site Inspection" requirement prior to the issuance of a building permit for construction or demolition. The new rule applies to projects implemented at any time of the year that require tree protection of any significant or heritage tree.

Best Practice:
Use Penalties/Fees to Disincentivize Violations

Penalties for failing to comply with tree-related requirements may also be an effective enforcement measure. Instituting significant penalties and/or fees may help disincentivize violations by property owners. While this approach still requires staff capacity for enforcement, a significant enough penalty can deter a property owner from violating the rules even if the chances of being caught are low.

In Charlotte, NC, the city's tree ordinance establishes civil penalties for violations including a $50 fee for each tree not planted under a replacement plan; up to a $20,000 fee for injuring or destroying a tree; and a $1,000 fee for failing to install or maintain required tree protection measures during construction.

In Dallas, TX, the city's tree ordinance establishes a civil fine of $2,000 per protected tree removed or seriously injured without authorization or per day for any other violation. It also establishes criminal liability for removing or seriously injuring protected trees subject to certain exceptions.

Best Practice:
Create a Registry of Tree Service Providers

While it is common for cities to require tree removals to be conducted by a licensed contractor, some communities are taking this a step further by requiring tree removal companies to register with the city. This can be an effective strategy for enforcing tree-related requirements on private property because it requires the removal company, rather than the individual property owner, to be aware of and comply with the law. While an individual property owner may be unaware of requirements or willing to risk a fine for noncompliance, tree removal companies are more likely to be cautious about violating the rules.

In 2022, Seattle, WA, passed a bill requiring: (1) tree service providers to register with the city before conducting commercial tree work and consultations on private property, and (2) property owners to post a public notice on-site before any tree work beyond routine maintenance. The tree service provider registry is accessible to the public. The Director of the Seattle Department of Construction and Inspection will remove a registered tree service provider from the public registry for one year after the provider has been issued two notices of violation. Following the one-year removal period, the provider must apply to be added back onto the registry.

Gaps in Practice and Research

Need to Develop Strategies for Dealing with a Lack of Political Will or Resident Support for Development Requirements

For municipalities that do not already consider tree removal and mitigation in their development review process, there may be obstacles to adding these requirements. New development often presents an opportunity for municipalities to increase their tax base, create jobs, etc. As a result, any restrictions on development may be viewed unfavorably by local leaders. Likewise, residents, developers, and other stakeholders in the real estate community may resist amendments to the local code that restrict the ability to develop private land. More research is needed to understand how municipalities can successfully incorporate trees into local regulations and overcome these challenges. In some cases, it may require finding a middle ground between rules and incentives.

Need to Develop Strategies for Enforcement of Tree-Related Policies to Ensure Effectiveness

Effective tree protection ordinances and design review processes require consistent enforcement. One of our interviewees spoke about their city's policy that requires developers to replace trees that are removed or make a payment in lieu of planting ($250 per inch of DBH removed). While a great policy in theory, following up on these replacement trees

and payments is solely the responsibility of the city forester. With all the other responsibilities assigned to the city forester, their capacity to enforce this policy is limited. More research is needed to understand how municipalities can craft tree-related policies that are both effective and feasible given varying staff capacity. Possible approaches include expanding enforcement authority to city staff in other departments or strategically inserting urban forest staff into relevant permit approval processes.

Conflicting or Competing Land Uses Present Unique Challenges for Urban Forest Programs

There are several categories of conflicting or competing land uses that emerged in our research including those between trees and:

- Shared street space (sidewalks, bike lanes, on-street parking etc.),
- Above and underground utilities, and
- Solar panels.

We found that in some cases the uses themselves create conflict or competition, while in other cases, it is simply the lack of coordination internally between government departments or with other stakeholders that lead to conflict. Because each of these three categories is unique in terms of both challenges and solutions, they are separated out into subsections below.

In addition to specific land use conflicts, we found there is a general challenge around how residents, governments, and other stakeholders view the urban forest. Generally, urban forests and the individual trees that populate them are not viewed as valuable public infrastructure in the same way as other forms of shared infrastructure, including streets, utilities, and sidewalks. This leads to the prioritization of other uses over trees where conflict or competition exists. In other words, trees are deprioritized in our urban landscapes as something that is a "nice to have" rather than a "need to have."

Challenge: Conflicts with Aboveground and Underground Utilities

Utility companies interact with the urban forest through regular maintenance and installation of utility infrastructure. While above- and underground wires are the types of utility infrastructure most commonly thought of in the urban forest context, other underground utilities like water, sewer, gas and oil pipes are equally, if not more, challenging to work around. Since utilities are essential to everyday life, it may be complicated and unpopular for municipalities to restrict tree work when it is being undertaken to preserve utility function. These constraints and conflicts can affect the extent of urban forest cover, species composition, and species diversity.[38] Extensive utility networks and their potential to conflict with trees may also contribute to the view held by residents that trees are a nuisance and a liability, deterring them from planting trees. For these reasons, utility companies are often given broad discretion over their tree work, which can result in management strategies that prioritize utility infrastructure over tree health.

In both the surveys and interviews of our mini-grantees, utilities were one of the most cited barriers to effective urban forest management. Five of our mini-grant recipients noted aboveground/ overhead utilities as a key barrier to urban

38 Roman et al. 2018

forest management. For aboveground electric utilities, tree management often consists of trimming trees within a narrow "protection zone" to reduce the likelihood of tree or branch failures and power outages. For example, a utility company may top a tree to ensure a wide clearance from overhead utility wires, but tree topping is not an ideal strategy for the long-term health and growth of a tree. For the sake of efficiency, utility contractors may also use equipment that is detrimental to tree health, such as climbing spurs, which injure a tree's vascular tissue. In many cases, tree management for aboveground utilities also includes the removal of trees under the powerlines, which, although it may be a more efficient process than meticulous pruning, does not prioritize the health of the tree.

While it is well known that overhead utilities pose a barrier to urban forest management, it was surprising to learn from many of our mini-grant recipients that management of underground utility infrastructure also poses a significant risk to trees. In fact, this challenge was cited in the survey by six of our seven mini-grant recipients. For example, utility workers digging to access a gas pipe may haphazardly cut into a tree's roots or, if using heavy equipment, compact the soil around a tree, limiting its ability to access water and nutrients. While moving utilities underground is sometimes presented as a solution to aboveground conflicts – particularly in the case of electric wires - this approach could introduce a new set of conflicts in which the trees, again, are not the priority.

Best Practice:
Regularly Meet with Utility Companies to Review and Standardize their Practices

Rather than give utility companies broad discretion over their tree work, municipalities can periodically review the standards and guidelines of the work and encourage closer coordination between utility companies and city staff on activities like pruning. This approach can prevent unnecessary tree pruning and removals without placing excess administrative burden on the municipality or overly restricting the utility companies.

In Charlotte, NC, the city requires utility companies to annually submit written pruning and trenching specifications for municipal review. All specifications must meet the ANSI 3000 standards for tree care operations. Additionally, all tree work must be completed by workers who, through related training and on-the-job experience, are familiar with the techniques and hazards of such work. Topping and the use of climbing spurs are both prohibited. Once approved, the utility company can perform tree work without a permit, if it conforms to the specifications.

In Massachusetts, state law authorizes municipalities to require utility companies to submit annual Vegetation Management Plans. Within 60 days of receiving the plan, the city must approve or reject it. If approved, the utility company is exempt from certain requirements, such as requiring a permit to prune a public shade tree, so long as the work is covered in the approved plan. The City of Cambridge is one city that requires utility companies to submit annual Vegetation Management plans. Cambridge's city arborist maintains a good relationship with Eversource, the primary electric utility company serving the city. The city arborist reviews the plans submitted by Eversource to minimize the tree clearance around overhead utility wires to the maximum extent possible.

Best Practice:
Require Municipal Review and Approval Prior to Utility Tree Work

Many municipalities require people to obtain approval prior to pruning or removing trees on public land, including the ROW. However, utility companies are often given more freedom, whether through a formal exemption or informal practice. By requiring utility companies to follow a process like others working on public trees, municipalities may be able to better influence tree outcomes in utility ROWs.

In New Haven, CT, utility companies are responsible for pruning trees in their ROW. For overhead electrical wires, the utility companies identify which circuits they need to work on and then meet with the city forester. The city forester goes into the field with a utility representative and discusses each tree that they have requested to prune or remove. The utility company usually requests to remove trees near utility wires, but the city forester diverts them to pruning whenever possible. However, if the condition of the tree is poor, the city forester will permit the removal, since it is done with the utility company's resources, rather than city resources.

Gaps in Practice and Research

Strategies Are Needed for Overcoming Resistance to New Policies for Tree Work in Utility ROWs

The status quo for many communities is that utility companies have broad discretion over tree maintenance in ROWs. Municipalities seeking to adopt new policies or standards for utility tree work may be met with resistance. The priority of utility companies is keeping their infrastructure in working order, so any policies or standards that limit their control are unlikely to be enthusiastically embraced. Residents, many of whom do not recognize trees as critical infrastructure, may also be against new policies and standards because they fear disruption in utility services or the creation of hazardous situations. Gathering political will and resident support for new policies is likely critical for their adoption and success, but more research is needed to identify the most effective approaches.

Standards are Needed to Guide the Quality of Utility Tree Work

Maintaining proper function of utility infrastructure is critical. Due to the prevalence of utility infrastructure, it is inevitable that there will be conflicts with trees that need to be addressed through pruning or removal. One of our interviewees noted that, while tree maintenance for the sake of utilities is necessary, the quality of their work is often poor. Utility companies do not have an incentive to balance their interests with those of the urban forest. Some may approach vegetation management by excessively pruning and removing trees in an effort to avoid any future conflict or

disruption in service. However, since the municipal staff does not have the capacity to do it themselves, there is no easy alternative. A clearer set of best practices for setting and enforcing standards for utility tree work could be a starting point for communities that are resource constrained.

Strategies are Needed to Balance Trees and Utilities that Do Not Undermine the Functionality of the Urban Forest

Unsurprisingly, the limited amount of ROW available in cities for competing uses puts overhead and underground utility lines at conflict with trees. Municipalities and community planting partners often base their tree species choices, as well as their planting locations, on the presence of overhead and underground wires. For example, to avoid aerial conflicts, many municipalities choose to plant small-maturing trees. This may result in oversaturation of the same species which can be detrimental to urban forest diversity. Interviewees agreed that because utility services are culturally viewed as critical infrastructure and the urban canopy is not, trees, especially street trees, are deprioritized when there are land use conflicts. This may lead municipalities to, for example, plant less desirable tree species that provide less shade, carbon sequestration, or other co-benefits because other species may be more likely to disrupt power lines. This may also contribute to inequitable distribution of canopy in some communities. More research is needed to identify strategies to balance these competing interests in the ROW without compromising the long-term health of the urban forest. Existing best practices do not appear to go far enough.

Challenge: Conflicts with Shared Street Space

The ability to plant trees today is limited by the built environment constructed years, decades, or even centuries ago. During interviews, several participants spoke about the limitations of the built environment. One participant spoke about the limited plantable space along streets built in the nineteenth century before cars were dominant. Another mentioned how limited street parking encouraged property owners to pave over what should have been lawns to create parking lots. Six of our seven survey respondents cited parking areas as a major barrier to tree planting. While it is becoming more common for the transportation sector to include trees in project designs, the standard guideline is to provide a 1.5-foot offset between the travel way and roadside objects, such as street trees; in areas with narrow streets and sidewalks, this guideline may reduce the opportunities for street tree planting.[39]

In terms of space in the ROW, interviewees identified rooting space and adequate soil volume as two of the biggest challenges. These challenges are commonly encountered where streets are narrow. Inadequate soil volume can lead to other issues for street trees like access to water and nutrients. Adequate moisture is critical for trees, especially during drought conditions which are becoming more common with climate change. While there are some solutions, like suspended pavement and using structural soil under sidewalks to improve tree survivability and growth, these techniques can be prohibitively expensive.

Planting trees along narrow sidewalks can also increase conflict with elements of the built environment such as buildings or street signs. One of our interviewees noted the benefits of planting trees that grow a narrow canopy, for example certain honey locust cultivars, in the ROW. However, this is not a comprehensive solution since there will be negative implications for urban forest diversity if there is too great of a focus on narrow-canopy trees.

Best Practice: Expand Municipal Planting Efforts Beyond Public Land and Rights-of-Way

Among our mini-grant recipients, six of the seven primarily work in the ROW and other public spaces. However, urban forest programs should consider plantable space beyond the ROW. In some places, state statute allows for public funds to be used for planting trees on private property within a certain distance of the public ROW, an approach called "setback planting." Where allowed, many communities are taking advantage of this approach. The proximity to the ROW ensures that the trees confer benefits to the greater community, not just the property owner, while their setback location results in more adequate space and soil depth for the trees to thrive. A recent literature review found that street trees have the highest annual mortality values of urban planting locations, so taking advantage of space on private land may be one way to increase urban trees' survivability.[40]

ReGreen Springfield works closely with the US Forest Service since its director is a member of the USFS and Springfield is part of the USFS Amherst-Springfield Urban Field Station. One of their current projects is focused on linear urban forests. Accounting for the idea that, by 2080, it will likely be possible to have much narrower roads due to the growth of autonomous vehicles, the project looks at transforming half of all of Springfield's roads into a linear urban forest. Through a partnership with MIT's visualization lab, the project will be able to simulate driving in Springfield in 2080 and seeing the linear urban forest that has replaced much of today's road area. The simulation will be shown to residents to gather feedback on the concept. While Springfield is the model city, the study is meant to create a national model for this type of work. In support of this project, ReGreen Springfield applied for American Rescue Plan Act (ARPA) funding to pilot the concept on one thousand feet of roadway in the city.

In Northampton, MA, the city created its setback tree program to increase opportunities for municipal tree planting. Through this program, property owners can request a free tree from the city to be planted within 20 feet of the ROW. Although the tree is on private property, it remains the city's property and responsibility; the setback trees are classified as protected public shade trees as well. In Arlington, MA, a similar

39 Dumbaugh and King 2018

40 Hilbert et al. 2019

program requires the requestor (the abutting property owner) be responsible for ongoing maintenance instead of the city.

In Concord, NH the city operates a setback planting program that may be a more feasible model for municipalities with limited resources. Upon resident request, city staff will plant a tree on the resident's front yard within ten feet of the ROW. While the labor is free, residents are responsible for 50 percent of the cost of the tree and ongoing maintenance. This cost-share approach will increase program accessibility for some residents, but the 50 percent obligation could be a barrier for low-income residents of Concord.

Best Practice:
Seek Opportunities for Compatibility Between Trees and Other Land Uses

It is easy to identify all the ways in which trees conflict with other competing land uses, but there are also several opportunities for urban forest managers and local governments to highlight *compatibility* between trees and other uses. Identifying and promoting these areas of compatibility can increase support for the urban forest and reduce pressures to deprioritize trees in favor of other uses.

Residents of Seattle, WA, have advocated for the city's planning department to take a "trees and" approach during projects. This approach recognizes that trees and other uses do not need to conflict. In our interview with Burlington, VT's city arborist, this same sentiment was echoed. For example, new sidewalks can be constructed with suspended pavement systems, so trees have adequate rooting space without taking up additional width, leaving room for a bike lane or street parking.

One of our mini-grant recipients spoke about a potential project designed to emphasize the compatibility between large parking areas and trees. Through a stormwater-focused grant, the local government, in partnership with the state agency that owns the land, hopes to redevelop a parking lot to reduce impervious surface and increase green infrastructure, including many new trees. Similar projects will also potentially be implemented for parking lots at two public schools and a local hospital. If successful, these projects can serve as a model for future projects in the city.

Portland, OR, launched a pilot program to add bump-outs to trees in East Portland, a part of the city that currently has low canopy cover and experiences more extreme heat. The city notes that the pilot not only supports street tree health, but has natural stormwater management features as well. The city has developed a Pedestrian Design Guide, which includes considerations such as street types, whether on-street parking or other curb zone use is present, and whether existing sidewalk space can accommodate the needed quantity of soil or stormwater facilities.

In its recently completed Urban Forest Master Plan, urban forest supporters in Boston, MA, acknowledge the constraints of limited space in the city and recommend planting trees in the street as a possible workaround. The city notes that on-street parking represents a significant amount of surface area that could be used for the creation of bump outs or other means of providing new high-quality planting space. Other cities, like Providence, RI, acknowledge that an added benefit of this approach is making streets safer for people by visually narrowing the street and slowing down cars. These types of multi-functional features support numerous co-benefits like stormwater management, shading and cooling, traffic calming, and more.

Best Practice:
Use Zoning, Development, and Design Guidelines to Promote Space for Trees

While tree planting can be limited by the existing built environment, carefully crafted local policies can create new space suitable for trees or alternative green infrastructure where tree planting would be infeasible or ineffective.

Zoning is one useful tool for promoting urban forest growth. Zoning requirements can be wide ranging from overlay districts and minimum planting requirements to mitigation requirements for removal of trees and flexible scoring to reach site-based or area-wide canopy coverage or shade goals. Zoning standards can allow for flexibility in meeting canopy coverage goals where sites may be constrained by conflicting uses. For example, in Cambridge, MA, the city council recently adopted new zoning requirements that address the long-term impacts of increased flooding and heat from climate change. The Green Factor Standard, which was partially an outgrowth of the city's Urban Forest Master Plan, is a performance-based standard that encourages heat mitigation through site and landscape design with cooling benefits. Qualifying sites will need to achieve a "Cool Score" based on design factors such as planting new trees, preserving existing trees, and creating planting areas. However, the "Cool Score" also allows for alternatives to tree planting such as green roofs and non-tree planting areas. In their efforts to achieve the necessary "Cool Score" project proponents are likely to create suitable space for trees where none existed before or take alternative approaches to cooling where site constraints preclude planting trees.

Cambridge's Urban Forest Master Plan also provides a model for cities dealing with low-canopy neighborhoods due to narrow streets. The city identified the neighborhood of East Cambridge as a priority for planting due to its disproportionately low canopy cover. They determined that most residents of the neighborhood lacked a front yard setback and that large gaps in the canopy were associated with large or closely spaced buildings and surface parking lots. Because the neighborhood has very narrow sidewalks and limited front yard space for tree planting, the study identified four streets in the residential part of East Cambridge where roadway space could be recaptured for another row of street trees. This asymmetrical approach to street design would allow an additional row of planting that would increase the soil volume for both existing and new trees.

Cities should also consider developing design standards for tree pits and planting strips that can be consistently used whenever streets are undergoing construction, reconstruction, or maintenance. One of our interviewees

spoke about the absolute bare minimum design guidelines they would like their local government to follow. For example, to properly plant trees, the interviewee wants all planting strips to be at least three to four feet long with three to six inches of soil volume. The interviewee noted that when planting strips are not properly designed, it makes it difficult for the urban forest program to utilize them for tree planting. While the exact needs will vary from tree to tree, adhering to these guidelines would avoid the creation of planting strips that are useless to urban forestry efforts.

In Miami Beach, FL, an Urban Forest Master Plan provides a "design toolbox" that has a specific tree planting strategy for each of the different corridors within the city, including commercial, urban residential, suburban residential, cultural, and more. The toolbox also acknowledges the different challenges and opportunities in each corridor. For example, for commercial street frontage with a width of six feet and curb-side parking, the city recommends certain specifications soil volume, species selection, planting suitability, and canopy growth patterns. It also recommends design alternatives like constructing parking areas out of pervious concrete instead of asphalt; installing parking areas directly over a soil cell system to eliminate the need for a roadway sub-base; constructing portions of the curb and gutter using pervious concrete to allow for runoff to be directed to the tree pit and the tree's root ball; and installing utilities beneath the parking strip to avoid conflicts with tree roots.

Best Practice:

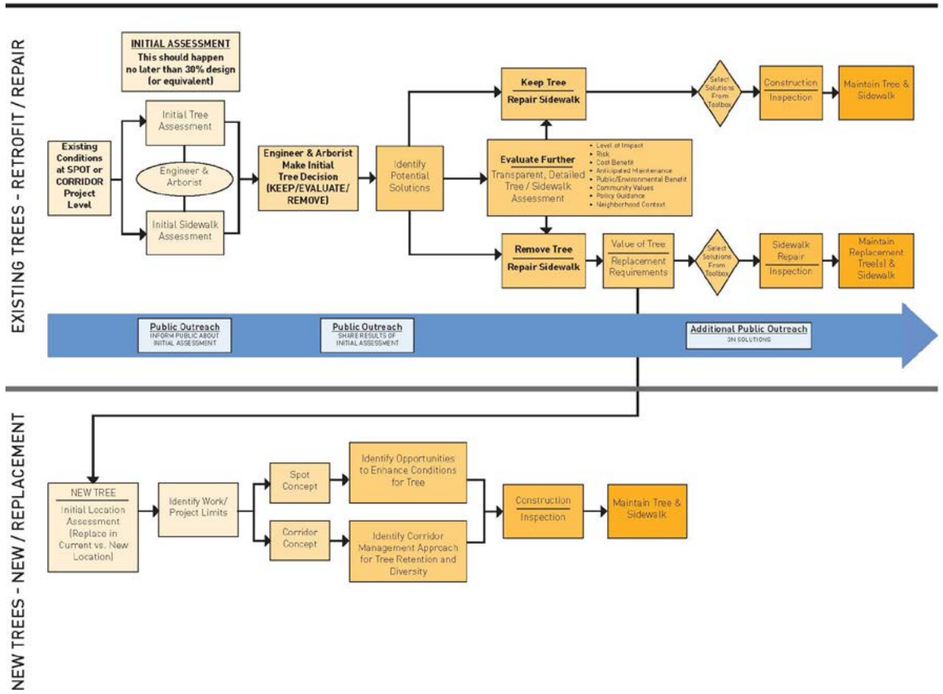
Facilitate Close Inter-Departmental Coordination on Capital Projects

Local governments typically have the most influence over what happens in the ROW. This is particularly true for road and sidewalk reconstruction projects. These projects present a critical opportunity to coordinate across departments in order to minimize conflicts, maximize compatibility, and promote the multi-functionality of the ROW. Many cities group divisions and staff that manage sidewalks, streets, and public trees in the same department – typically either transportation or public works departments. However, other cities may distribute these staff across different departments like planning and development, sustainability offices, or a dedicated urban forestry department.

One of our interviewees spoke about how their local government is investing in street reconstruction that promotes tree canopy growth. About seven years ago, the city adopted new standards, part of the "Great Streets Initiative," for the reconstruction of streets in the downtown core. The goal of these standards was to transform downtown into a walkable, sustainable, vibrant, and functional space. The city's downtown was, at the time, an area characterized by large buildings and minimal green space and canopy cover. One part of the plan is to invest in suspended pavement systems along the streets to promote healthy tree growth; this has already been implemented over two blocks. Incorporating this into the street reconstruction process can help promote early coordination, making the plantings more successful and saving on capital costs.

In 2015, the Seattle, WA, Department of Transportation published a "Trees and Sidewalks Operations Plan." The plan acknowledges that both street trees and sidewalks play vital roles in the city's public realm and being proactive about their management can reduce conflicts that compromise pedestrian access and/or tree health. The plan clarifies responsibilities and work processes and provides guidance on the installation, repair, and maintenance of sidewalks and street trees. It also includes a "solutions toolkit" that provides a broad range of strategies to address sidewalk and tree conflicts including guidance on paving and surface materials, root zone-based materials, infrastructure-based design solutions, and tree-based solutions. For example, the "paving and other surface materials" section of the toolkit addresses the use of pavers. Unit pavers (including new rubber or composite varieties) provide a more flexible surface, resisting the cracking commonly seen with concrete sidewalks, and may be reset more easily if upheaval becomes a problem. Root zone-based materials include basics such as mulch or root barriers, as well as more involved tools such as providing root paths to help direct roots and focus their growth in desired locations.

Tree/Sidewalk Assessment & Work Process



Source: Seattle Transportation Department, Trees and Sidewalks Operations Plan

Gaps in Practice and Research

There Are Not Adequate Solutions for All Land Use Conflicts

There are some land use conflicts that are particularly challenging to overcome. As mentioned above, utility infrastructure is probably the most common conflict. Parking was another commonly cited example of a land use conflict. Interviewees shared that strategies to reduce or eliminate parking to create more space for street trees tend to result in contentious debate among passionate stakeholders. Similarly, sidewalk infrastructure is often impacted by tree roots causing issues for pedestrians and leading to expensive reconstruction projects. Interviewees noted that this can also contribute to residents' dislike of street trees and make it less likely that residents will be supportive of new plantings. Surprisingly, bike lanes were not identified as a common land use conflict. One interviewee noted that conflicts with existing bike lanes can typically be managed by proper maintenance. For example, when it comes to bike lanes, trees need to be pruned a bit higher to account for the additional height, compared to that of a pedestrian, from being on a bike. It is less clear whether competition for space for new bike lanes presents a bigger challenge. While several best practices exist for how to manage conflicts in new development and construction, there is less guidance on how to address existing conflicts and more research is needed.

Urban Forest Managers and/or Residents May Be Wary of Public Trees on Private Land

While increasing plantings on private property through setback planting can help reduce ROW conflicts, planting trees on private land requires support and cooperation from the local government and residents. For one of our interviewees, the city forester in the community in which they are working is not yet interested in expanding efforts onto private land. The sites in the ROW are easier from an administrative standpoint – no permission is needed, the trees remain under the city's control, etc. Another interviewee noted the skepticism that residents feel when the city offers to plant trees on their property. There is a sense of mistrust towards the city, as well as a misconception about trees in general (e.g., trees are a liability, a nuisance, etc.), that needs to be overcome. In anticipation of the challenges likely to arise from planting on private land, one interviewee noted that their city forester obtained funding for a community engagement staff member who can help facilitate the process, although it remains to be seen how effective this will be. More research is needed to identify other approaches for engaging community members and property owners to increase opportunities for planting on private land.

Photo credit:www.peakpx.com

Challenge: Conflicts with Solar Panels

Land used for solar panels and arrays presents another challenging conflict for the urban forest. The primary concern is that trees create shade and leaf litter, both of which can reduce the efficiency of solar panels and decrease their functionality. However, in some cases, proper tree placement and pruning can allow solar panels to function in proximity to shade trees. For example, solar panels rather than trees should be prioritized for the west and southwest facing sides of a home because these directions receive the strongest sunlight and are the best option for solar panel placement. In other cases, a more targeted approach may be needed. In general, we found that outside of proper placement and pruning, there are two approaches to managing conflicts between trees and solar: (1) concentrating solar in a specific area so as not to interfere with street trees and trees on private property and (2) taking advantage of new technology to allow for co-location of trees and solar.

Best Practice: Concentrate Solar Panels and Arrays to Avoid Conflicts with Trees

One approach to minimizing conflicts is to concentrate the uses in separate areas. In Boulder, CO, the city promotes the use of solar gardens to reduce conflicts between trees and solar panels. By concentrating a neighborhood's solar panels in one area, residents can benefit from both solar production and the presence of trees. Colorado's Solar Gardens allow customers to buy shares in solar array and achieve annual savings. Over 20 solar gardens were built in Colorado through Xcel Energy's pilot program, including two in Boulder. The gardens generally require up to 16 acres. The maintenance and operation of the solar garden is provided by the operator, and credits are distributed as reductions in monthly Xcel Energy bills. This approach has the added benefit of reducing barriers to entry with relatively low-cost share options. In Colorado, at least five percent of solar garden subscribers must be low-income.

Best Practice:
Utilize New Technology to Reduce the Shading Effect of Trees on Solar

New technology is available to help reduce the shade effects of trees on solar panels. A Renewable Energy Laboratory study found that shadows over photovoltaic (PV) panels reduce power production by one third but that productivity under shade can be increased by 12 percent using microinverters instead of string inverters within PV panels.[41] String inverters are suspectable to power reduction by partial shading because even if one cell of a 36-cell solar panel is shaded, its overall power output is reduced due to the cells being connected in a series string. In other words, the weakest cell brings down the others. There are two different technologies – SolarEdge and Microinverter systems – that allow each panel in an array to maximize power output independently. SolarEdge provides power optimization for each solar panel, while microinverters provide power optimization at the module level.

41 Deline et al. 2012

The Urban Forest is Not Equitably Distributed

Increasing awareness of the benefits of urban trees has motivated massive tree planting efforts in cities across the world.[42] In the United States, many municipalities have set lofty goals to increase tree canopy cover, often creating momentum for specific urban tree planting initiatives distinct from routine tree operations.[43] For example, strategic tree planting has been encouraged as a climate change mitigation or adaptation strategy; trees are intentionally planted near buildings to reduce energy used for cooling or tree planting is intensified to increase stormwater infiltration.[44] Our survey also found that a lot of tree planting is driven by the goal of replacing removed trees. Considering the existing uneven distribution of tree canopy in many communities, urban forest managers should be mindful that their approach to planting does not perpetuate inequities.

The quantity and quality of space for urban trees varies between cities, neighborhoods, and streets. One reason for this variation may be factors that affect a tree's survivability, such as the space available in the ROW or the quality of a site's soil.[45] Issues such as vandalism, limited maintenance, and car damage may also reduce the lifespan of a tree.

Another reason for this variation may be the history of investment and development, or lack thereof, in each neighborhood. In recent efforts, environmental justice neighborhoods and low-income areas, where previous research has found low distribution of canopy cover on public and private land, are often targeted for new tree plantings.[46] However, due to a history of disinvestment, these areas are often dominated by impervious surfaces, leaving little room for tree planting. Additionally, these neighborhoods often have large renter populations, so many residents have little control over whether trees can be planted on or in front of their homes.

In four of our interviews, rental properties were identified as a barrier for urban forestry efforts, particularly tree planting. Interviewees were hesitant to plant trees in the ROW in front of rental properties without buy-in from the property owner, even when there was interest from the tenant in having a new tree.

Challenge: Communities Need to Analyze Where and Why Canopy Cover is Low in Order to Strategize and Prioritize Future Efforts

Numerous studies have found that low-income and communities of color are less likely to have trees in their neighborhoods than their white and affluent neighbors. Cities across the country have increasingly identified equitable canopy coverage as a goal but encounter challenges in identifying where to prioritize their efforts or how to overcome barriers to planting in places that need trees the most.

42 Young 2011, Yao et al. 2019, Eisenman et al. 2021
43 Eisenman et al. 2021
44 Stafford et al. 2013, Bell et al. 2006
45 Gerhold et al. 1993, 14, Kronenberg 2014, Roman et al. 2015
46 Brooks et al. 2016, Schwarz et al. 2015

With a grant from the Wells Fargo-supported urban forest mini-grant program, **ReGreen Springfield** is leading a project focused on empowering community members. The first phase of the project will be using iTree and EPA's EJScreen to identify the Springfield census blocks with the least canopy cover and the residents facing the greatest environmental health burdens. This project will be the first analysis of environmental justice in the city at scale as granular as census blocks. In the second phase of the project, equipped with detailed environmental justice information, ReGreen Springfield will work with community members to empower them to become changemakers whether they are planting new trees, working as citizen scientists, or advocating for local policy changes. The information will also be used to strategically plan for new tree plantings that begin to address the city's inequitable canopy distribution.

The disproportionate distribution of existing and potential canopy throughout a city has profound implications for environmental equity. Legacies of social and political segregation have shaped the composition and accessibility of tree-lined streets.[47] Former policies, such as redlining, systematically barred financial and social services to select racial and ethnic communities, limiting not only where populations were able to live, but also restricting the flow of public and private financial investment in residential vegetation. While the modern impacts of redlining on urban environments and ecosystems remain unclear, a recent study showed that, at present, formerly redlined neighborhoods (mostly racial and ethnic minority populations) have nearly half as much tree canopy cover as higher-ranked, non-redlined neighborhoods (mostly U.S.-born white populations living in newer housing stock).[48]

47 Nesbitt et al. 2018
48 Locke et al. 2021

Best Practice:
Create a Plan to Identify and Prioritize Low Canopy Areas and Promote Tree Equity

Trees play a critical role in the comfort and health of residents in all communities. Improved air quality, carbon sequestration, shade and cooling, and stormwater management are all well-known benefits of the urban forest. However, not all communities benefit equally. Tree equity is increasingly a consideration for local urban forest programs as data becomes available demonstrating the canopy coverage disparity and its correlation to low-income and marginalized populations. These concerns dovetail with efforts to address climate impacts and natural disasters as well as racial injustice.

In 2021, American Forests launched its "Tree Equity" tool which can assist communities in examining their gaps in tree canopy coverage and how it relates to the race and socioeconomic status of residents. The open-source tool gives each census tract within a community a tree equity score based on census data and factors like population density, demographics, health trends, and urban heat indexes. This information is a good starting point for communities looking to identify and prioritize certain areas for canopy growth, especially if they do not have access to local data.

The City of Holyoke, MA, released a first-of-its-kind Urban Forest Equity Plan in 2021 that uses an equity lens to plan for the growth, preservation, and care of the urban forest. The ultimate goal of the plan is to provide equitable access to a healthy and abundant urban forest and the benefits it provides. The plan identifies and focuses on four neighborhoods in the city that are disproportionately impacted by community challenges, including disproportionate canopy cover. Community engagement played a critical role in the development of the plan, including outreach to Holyoke residents most impacted by existing community challenges and inequities. Some of the community engagement strategies the city employed included bi-lingual outreach, a dedicated page to the project on the city's website, media outreach, postcards, a "call for selfies" from residents, virtual community forums on Zoom and Facebook Live, and both online and printed surveys in English and Spanish.

Efforts to promote tree equity need not be formalized in one document. Other cities have taken various approaches to identifying and prioritizing certain areas for tree planting based on their assessments of disparate canopy coverage. For example, Groundwork Rhode Island recently announced a partnership with American Forests and various other stakeholders to fund an urban forestry grant program that focuses on increasing tree cover in a "Health Equity Zone." Health Equity Zones are a State of Rhode Island designation to prioritize investment in participating communities to improve people's health. Building off of its Tree Equity tool, American Forests also created a companion tool for the Rhode Island project, Tree Equity Score Analyzer, to provide more specific information on the neighborhoods and individual parcels of land where trees can be planted in order to achieve equitable canopy cover.

Equity may also be incorporated into a larger urban forest management or planting strategy. For example, the Parks and Recreation Department in Portland, OR, includes equity as a focal point in its planting strategy. The city identified priority planting areas in neighborhoods where there was a high percentage of low-income residents and low existing canopy coverage. The City of Cambridge, MA, took a similar approach in its urban forest master plan identifying priority areas by overlaying areas of existing canopy deficit with other key data indicators like at-risk populations, heat island hot spots, and the location of community infrastructure. At risk populations were defined using demographic indicators like race, income, and language spoken at home.

Challenge: A Lot of Suitable Land for Tree Planting is Privately Owned

Many urban forests are predominately located on private land. In fact, private property is often the single greatest opportunity for new tree planting, having high growth potential due to greater land availability.[49] However, despite the fact that planting, preservation, and maintenance of trees on private property has significant impacts on the urban forest, these decisions are not typically within a

49 McPherson et al. 2007, Pelletier and O'Neil-Dunne 2009

municipality's control. Cities may also find it difficult to identify opportunities for canopy growth on private property in less affluent communities where there is typically a higher percentage of renters and absentee property owners. Furthermore, in many municipalities, properties with abundant green space and room for trees are likely to be in more affluent communities that are already benefiting from the presence of street trees.[50]

Best Practice:
Incentivize Tree Planting Through Giveaways, Free Assistance, etc.

Urban forest stakeholders seeking to promote tree planting should create incentives for residents and property owners. Whether it is a program facilitating the planting process or education on potential cost-savings, incentives can be an effective way to encourage resident tree planting and make tree planting available and/or affordable for those who would not otherwise have access.

The City of San Jose, CA, partners with the local nonprofit Our City Forest (OCF) to facilitate a low-cost planting process for property owners. The program targets areas of the city with low canopy cover. At no cost to participants, OCF will process all necessary permits, plant the tree, and provide maintenance resources and tools for the first three years. Residents that do not live in eligible areas can instead apply to the city for a rebate of up to $100 when they purchase and plant a tree.

Rhode Island's Department of Environmental Management (DEM), in partnership with the Arbor Day Foundation and the Regional Greenhouse Gas Initiative, hosts the Energy-Saving Trees Program. This program creates two incentives for tree planting: (1) residents receive a free tree and (2) residents are given technical assistance so they can plant their tree in a location that maximizes energy savings. The program has been running for seven years and is very popular among residents.

In Eugene, OR, residents are encouraged to plant trees through the potential for stormwater credits. New large trees planted within 25 feet of impervious area and new small trees planted within 10 feet of impervious area are eligible for these credits. Stormwater fees are calculated based on a property's impervious area; a 100 square foot or 200 square foot deduction is given for each qualifying deciduous or evergreen tree, respectively. Existing trees are also eligible for the credits, subject to the same 25 feet and 10 feet requirements as the new trees; the deduction for each existing tree is equal to one-half of the canopy size. Trees contributing to stormwater credits must remain in good health; if a tree dies, it must be replaced within six months.

Gaps in Practice and Research

Not All Residents Like or Want Trees

In some cases, despite carefully crafted incentive frameworks, there will be residents who do not want to plant trees on their property. Five of the seven interviewees noted that residents hold an indifferent or negative view towards trees. One interviewee noted that residents see trees as an afterthought rather than critical community infrastructure. Another interviewee put it plainly, "people just don't want trees." In their experience, people are quicker to think of leaf litter or sidewalk damage than the numerous benefits trees provide. Resident concerns around sidewalk damage were also consistently mentioned in our interviews. In all of the mini-grant recipients' communities, private landowners are legally responsible for trees on their property so there is a need to identify best practices for shifting residents' mindset around trees and the urban forest. A positive framing that many interviewees agreed with was educating residents to view trees as critical shared infrastructure like they do streets, sidewalks, utilities, etc. This requires not just education but a cultural shift in people's views of the urban forest. More research on resident perception of trees and ways to effectively engage them will be useful in crafting education, outreach, and planting strategies.

Renters Have Less Power and Control Over Their Homes

Throughout our research, especially in our interviews with municipalities and nonprofits engaged in urban forestry, the challenges posed by rental properties were a recurrent theme. Renters typically do not have the authority to plant trees or give permission for others to do so. The City of New Haven, CT, operates a tree planting program in partnership with the Urban Resources Institute (URI). URI requires renters to get permission from their landlord to request a tree be planted in the public ROW in front of their rental property. One reason for this requirement may be that renters are transient and, without buy-in from the property owner, the tree is less likely to be cared for in the long term.

Only three of our seven survey respondents reported that they have an approach for including rental properties in their urban forest efforts. In Lawrence, MA, Groundwork Lawrence (GWL) uses an annual mail campaign to try to engage out-of-town landlords; however, they typically only receive 20 or less responses, and even fewer translate into actual planting opportunities. More research is needed to understand the best practices for engaging with renters and landlords to encourage more tree planting.

Institutions Are Often Large Landholders with Significant Influence on the Urban Forest

In certain municipalities, institutions, such as colleges and hospitals, may own a significant amount of land. In most cases, urban forest managers do not have an efficient way to identify tree planting opportunities on this land or conduct outreach to institutional landowners. Additionally, since institutional land is privately-owned, decisions about trees are typically out of a municipality's direct control. While there are many institutions that are excellent stewards of their trees (e.g., colleges with arboretums), there are some that may not prioritize trees in their land use decisions. More research is needed to identify best practices for effectively engaging institutional property owners in tree preservation, planting, and maintenance.

50 Nesbitt et al. 2018

Growing the Urban Forest Can Be Expensive and Laborious

Most municipalities need consistent and substantial planting efforts to meet their tree canopy goals. This requires considerable time, money, and other resources, which may not always be feasible. A recent survey of nearly 100 major urban tree planting initiatives across the United States, excluding routine municipal tree planting programs, found that nearly 75 percent of programs rely on funding that is outside the scope of the municipality's typical urban forestry budget.[51]

Further, funding available through state and federal grants, philanthropy, and other sources may limit a community's flexibility in how they spend funds. In our interviews with grantees, one gap identified was lack of grant funding for tree removal and stump grinding. Funding for these activities is not as readily available as funds for tree planting, tree maintenance, and urban forest planning. This funding gap can significantly impact a community's ability to grow the urban forest because new trees cannot be planted until dead and diseased trees are removed.

Challenge: Numerous Factors Affect the Cost of Tree Planting

There are many factors that contribute to the cost and effort of planting trees. Cost may be impacted by things like where the tree is sourced and how it is prepared. Some communities plant primarily bare root trees while others plant larger caliper balled and burlapped trees; there can be a significant cost difference between the two approaches. Similarly, some communities rely on commercial nurseries for sourcing their trees and if those nurseries are not nearby, they may face significant shipping costs. Other communities have access to a local nursery or municipal- or nonprofit-run nursery which may provide trees at a lower cost than commercial alternatives.

There are varying views on the benefits of bare root trees versus balled and burlapped trees. While bare root trees can be less expensive to acquire and plant, they require more watering and care during the establishment period. There may also be logistical challenges. For example, one interviewee noted that their municipality does not have storage space for bareroot trees and once removed from the ground, it is important to replant them within one to two days. Nurseries also have a more limited selection of species available as bare root trees. In contrast, balled and burlapped trees are more expensive and often very heavy which makes them more cumbersome to plant.

The method of labor for planting can also have a significant impact on the overall planting cost per tree. Some communities may leverage volunteers to do planting or have significant nonprofit or city staff who can do the plantings themselves. Others may rely on contractors, which can be expensive, or have a commitment to a workforce development program that involves overhead costs. Other factors like tree species and site characteristics may impact cost per tree as well, albeit less than others.

51 Eisenman et al. 2021

Graph 1: Total Estimated Planting Cost Per Tree in New England Pilot Communities

Source: The chart above summarizes survey results of the seven mini-grantees of the urban forest mini-grant program, 2023

The above graph represents the estimated total cost to plant a single tree reported by each of our grantees in our 2023 survey. Municipality 1 primarily plants bare root trees purchased from a nursery run by a local non-profit and all the labor is provided by an in-house urban forestry crew. CBO 3 plants larger caliper balled and burlapped trees sourced from a commercial nursery; the major driver of the planting cost for this organization is contracted labor. The cost reported by CBO 4 is what they charge their municipality for each tree including labor, materials, and a 3-year guarantee; this cost is approximately three times what it costs the CBO to plant a tree (materials, labor, transport, etc.).

Several of our interviewees also noted the funding and cost impacts of peer competition. For example, the survey results showed that state and federal grants are the primary funding source for our mini-grant recipients. The other most common funding sources included municipal general funds, philanthropic grants, and individual donations. The reliance on external grants suggests that there may be overlap, and therefore competition, in urban forest funding opportunities. Another interviewee highlighted this challenge in regard to the influx of federal funding for urban forestry through the Inflation Reduction Act (IRA). This interviewee is concerned that the influx of IRA funding for trees could rapidly increase the demand for trees and other key resources, driving up prices. This is especially true for tree species, such as honey locusts, that are already in high demand since they have proved to be well-suited to the ROW. This type of competition can make existing urban forest budgets and funding opportunities less impactful.

Further impacting the total cost of tree planting is the immediate care required by newly planted trees. Young, newly planted trees require dedicated water, attention, and time. In studies that have tracked the same tree planting programs over time, annual mortality tended to be highest during the first five years after planting.[52] Young trees must also be pruned early and often to encourage development of strong branching structures that are less vulnerable to storm and wind damage. Hazardous or diseased trees must also be removed.[53]

52 Hilbert et al. 2019
53 Bell and Wheeler 2006

Best Practice:
Leverage the Support of Volunteers to Promote Tree Planting and Maintenance

Volunteers are key contributors to many successful urban forestry programs. Their work can range from tree planting and watering to resident outreach and engagement. In some cases, volunteers may dedicate time monthly, weekly, or even daily. In other cases, volunteers may join on special occasions, for example, planting trees on Arbor Day.

As part of the Wells Fargo-funded urban forest mini-grant program, the **City of Burlington** will use its grant to support efforts to focus tree planting in areas with low existing canopy cover. These areas of Burlington also tend to have more low-income residents, larger communities of color, larger renter populations, and more severe impacts from the urban heat island effect. The funding will be used to purchase bare root trees and other supplies for the upcoming planting season. All work will be performed by the city arborist and their crew of ISA-certified arborists.

Watering trees is one common volunteer activity. Newly planted trees, and all trees during periods of drought, require supplemental watering. In Cambridge, MA, resident volunteers add support through the Urban Forest Friends program. On the city's website, residents can access an interactive map that displays the location of every public tree in the city. Residents can click on a tree near their home and sign up to be its caretaker, which primarily consists of regularly watering the tree during the establishment period and periods of drought.

In Kirkland, WA, there is a different model for volunteer watering. Each summer, when drought is most common, the city operates the Green Kirkland Summer Watering program. Interested residents must sign up and attend an orientation to join the program. Participants commit to two hours a week, on their own schedule, from June to September; each participant is responsible for watering the trees in their assigned locations.

Despite the benefits of a robust volunteer program, for many municipalities and nonprofits, there may not be sufficient capacity to administer one. In Columbia, MO, urban foresters overcame the challenge of limited staff capacity by creating a special class of volunteers. This small group of "TreeKeepers" are intensively trained by city staff so that, going forward, they can administer the larger volunteer program. The TreeKeeper program effectively expands the city's staff capacity, making it more feasible to have an impactful volunteer program.

Best Practice:
Utilize Partnerships to Lower the Cost of Tree Planting

Some urban forest stakeholders have been successful in lowering the cost of tree planting through partnerships. The total cost of tree planting includes several components such as the tree, staff time, and transportation. An effective partnership may be able to lower the cost of one or several of these components.

In Burlington, VT, the city works with Branch Out Burlington (BOB) to save money on tree procurement. The city saves an estimated $20,000 per year due to this partnership. With its community nursery, BOB can grow saplings for $100 per tree, compared to the $200-300 charged by commercial nurseries. In our interview with the city arborist, we learned that planting balled and burlapped trees is cumbersome; the root ball of a two-inch caliper tree will weigh about 250 pounds so transporting and planting these trees is difficult and inefficient. The urban forestry team in Burlington has been able to plant as many as 45 bare root trees in a single day, something that would be unimaginable with balled and burlapped trees. The city gets 90-100 bare root trees from the nursery each year for planting along the city's streets and in parks. Bare root trees have been successful in the city with an estimated survival rate of 98 percent. BOB volunteers are also active in supporting the city's urban forest through donations, planting, and basic maintenance activities.

Photo credit: Branch Out Burlington

In Baltimore, MD, the city works with the Neighborhood Forestry Initiative (NFI), a green jobs program to address the cost of labor for tree planting. The program creates employment opportunities for adult residents of the city that are long-term, well-paid, and environmentally friendly. Participants' wages are paid through the Baltimore Tree Trust, a nonprofit supported by grants and donations, rather than through the city's own resources. NFI supports the city's urban forest program through tree planting, allowing the city to reallocate some resources to other program areas, such as tree maintenance and community engagement.

As part of the Wells Fargo-supported urban forest mini-grant program, **Keney Park Sustainability Project (KPSP)** will use their grant to help establish a tree nursery in Keney Park. The nursery will serve as a shelter and staging area for trees in various stages of development to support afforestation efforts in Hartford, CT. The nursery is expected to begin operating in Fall 2023. The funding will also be used to lead free tree care workshops and for recruiting and training Hartford youth to assist with tree care and planting throughout the city. Through this project, KPSP will help its partner, the City of Hartford, access trees at a lower cost and leverage additional labor. The project will also create meaningful opportunities for workforce development within the Hartford community.

Best Practice:
Integrate Urban Forest Efforts with Other Initiatives to Garner Support

In some cases, urban forest managers may be able to attract support for their work by connecting it to other local priorities. For example, urban forest managers may decide to use this strategy to garner support in cases where urban forestry alone is not seen as a high priority or when integration opens new opportunities for funding and other resources.

One of our mini-grant recipients has promoted urban forestry by connecting tree planting to the city's stormwater management goals. As a result of climate change, the city is expecting more frequent and intense precipitation which will exacerbate stormwater runoff challenges. The city arborist has advocated for tree planting as one strategy for addressing these impacts.

Another city forester we interviewed spoke about their emerging partnership with the city's new Department of Climate Sustainability. There are countless ways in which trees help to mitigate impacts of climate change – carbon sequestration, stormwater management, air quality improvement, increased shade, etc. By working with the director of climate sustainability, the city forester can ensure the urban forest is considered, and whenever appropriate, prioritized, in future grant applications and project plans.

In 2014, the D.C. Department of Transportation published green infrastructure standards with the goal of capturing more stormwater and avoiding runoff to sewers and rivers. The plan, which has a stormwater management focus, highlights the role of trees and other green infrastructure as low-impact design features that can help restore ecological function. For example, the standards push for green areas to retain stormwater in heavily paved areas like sidewalks and streets. The standards also require minimum soil volume for street trees and have additional specifications for the use of structural soil.

Minnesota's Stormwater Management Manual notes that urban forestry can help satisfy Municipal Separate Storm Sewer System (MS4) stormwater management requirements in a cost-effective manner. Trees manage water through interception, evapotranspiration, and filtration ultimately reducing peak stormwater rates and volumes, filtering runoff, and stabilizing base flows in streams and rivers. MS4 permits authorize public entities, like local governments, to discharge pollutants from public stormwater systems into bodies of water. The permits are subject to a set of requirements under the Federal Clean Water Act.

In New Jersey, the Department of Environmental Protection uses money raised through its participation in the Regional Greenhouse Gas Initiative, a multi-state market-based program that establishes a regional cap on carbon dioxide emissions from fossil fuel power plants, to fund a Natural Climate Solutions grant program. The grant program has funded a number of tree planting projects across the state given the nexus between trees and carbon sequestration and other environmental benefits of trees. In 2023, the grant program funded over $6 million in tree-related projects including a $1 million project to plant 800 trees across three public spaces and 215 trees in public housing complexes in Camden City, NJ.

National Pollution Discharge Elimination System (NPDES) permits are required to discharge pollutants (any industrial, municipal, or agricultural waste) from a point source into a water of the United States. NPDES permits specify an acceptable level of a pollutant or a pollutant parameter in a discharge that permittees must obtain. Stormwater is one of several NPDES program areas. Decreasing impervious surfaces is one common best management practice (BMP) permittees use to maintain an acceptable level of pollutants. Extending these requirements to private land, such as institutions, could spur additional tree planting and preservation in an effort to stay compliant with the permit. This is currently being explored in the New England region following a lawsuit by CLF.

Best Practice:
Identify Opportunities to Create Additional Resources for Urban Forestry

While urban forestry programs require resource inputs to function, they can also create new resources. In reviewing routine urban forestry operations, urban forest managers may be able to identify opportunities to create resources that ultimately benefit their program.

For example, one of our CBO mini-grant recipients runs a lumber milling operation at their headquarters, a site leased from and shared with the local government. Trees that were in good condition when removed (e.g., removed for a utility conflict) are processed into wood used for parks benches or boards for community gardens. In partnership with a local business, some of these trees are even processed into specialty items, like charcuterie boards, that are sold at events to raise money for the CBO's urban forestry operations. Trees that were removed in poor condition are processed into mulch that is used to maintain vacant lots and nature trails throughout the city. Tree removal is a necessary part of urban forestry, so finding a way for it to benefit the community is noteworthy.

Another example is Boulder, CO, where the city partnered with a nonprofit that serves people experiencing homelessness to develop the TreeOpp program. The program trains and employs local artisans that tutor apprentices in conjunction with the nonprofit's workforce development program. They use wood from ash tree removals to create marketable products for the community including furniture and crafts. This has proved to be a successful strategy for reducing urban forest residuals that would have otherwise ended up in landfills.

Best Practice:
Provide New Tree Plantings with Adequate Attention During the Establishment Period

Leveraging partnerships and volunteers is one way to ensure that new trees require the care they need during the establishment period to ensure survivability. As noted in the Boulder, CO Urban Forest Master Plan, municipal funding for trees is generally dedicated to resolve issues in the largest, most mature trees, while younger trees become

neglected. The deferred maintenance on younger trees eventually leads to higher, long-term costs that negatively affect the urban forest.

Even if a newly planted street tree is the property and responsibility of the municipality, some residents may take it upon themselves to care for it. However, it is important to provide simple and accessible instructions to ensure residents are not inadvertently harming trees. Door hangers and mailbox flyers are some good ways of distributing this information.

The Chicago Region Trees Initiative (CRTI) distributes door hangers that offer guidelines on watering and mulching trees. The door hangers provide basic information but also a link to the CRTI website where instructional videos and more detailed information can be found. Not only do these door hangers educate residents on proper tree care, but they may also encourage more residents to care for their nearby street trees. Although this strategy has been effective for CRTI, one of our interview participants noted the importance of making sure this type of outreach makes residents feel like they are partners in the work, rather than that the work is being done to/for them.

TreePennsylvania, a state-wide, nonprofit organization dedicated to nurturing forests in Pennsylvania, created a "Young Urban Tree Monitoring Training Toolkit" to enable volunteers and citizen scientists to monitor newly planted trees across the state and ensure their long-term survival. It offers short, ready-to-use training materials including a citizen-oriented training guide, an example curriculum and agenda, and customizable presentation and handouts. The toolkit also leverages the PA Community Tree Map, which is a free tree mapping tool that offers a means of conducting tree inventories, storing data, and tracking tree maintenance.

As part of the Wells Fargo-supported urban forest mini-grant program, **KNOX** will use its grant to improve Hartford, CT's urban forest by adding new trees and maintaining existing trees. KNOX horticultural staff will evaluate the condition of existing trees and perform necessary watering, mulching, weeding, pruning, and staking. KNOX will also purchase new tools to bolster their maintenance activities.

Gaps in Practice and Research

Practices that are Effective in One Community May Not Be Successful in Others

Given the unique nature of each community's urban forest and program, it is unlikely that all approaches can be replicated successfully across all communities.

For example, while urban foresters in Burlington, VT, have found success with bare root trees, some potential challenges to their use were brought up in interviews with other communities. For example, nurseries may have a limited selection of species for bare root trees, they must be planted soon after they are removed from the nursery, and they require significant input after planting, including protection from root predation (e.g., rabbits, groundhogs). Additionally, while the nursery partnership has been very effective for Burlington, another interviewee noted that there are key benefits to using a commercial nursery. For example, commercial nurseries often offer insurance so that if a tree dies within the first two years it would be replaced at no cost, whereas with the municipal nursery, they must bear the cost of replacement.

Communities Lack of an Economies-of-Scale Approach

More research is needed to determine if there is a more effective economies-of-scale model to address issues of costs per tree. For example, whether there is a model whereby a state or regional entity could source trees in bulk at a discount and subsidize the per tree costs in distributing them to community urban forest programs. State and regional entities may also be better positioned to leverage state and federal grant dollars to help subsidize the cost of trees as well. As noted above, one of our interviewees was concerned that the infusion of money from the IRA could have the unintended consequence of exacerbating supply chain issues and increasing the demand for popular tree species, thereby increasing the cost of trees for communities. A centralized approach to sourcing trees could help reduce this effect but more research is needed.

Residents May Not Be Interested In or Have the Resources for Basic Tree Care

Even with guidance on proper tree care, residents may be unable to water and mulch trees due to a lack of resources. For example, if a resident's garden hose does not reach the ROW, they may be discouraged from watering nearby street trees, not wanting to walk back and forth with a container. Likewise, if the necessary material is not easily accessible, it is unlikely that residents will take it upon themselves to mulch a nearby street tree. These challenges around consistent resident tree care may be more prominent in communities with large renter populations as residents move in and out more frequently, creating variation in levels of engagement. Municipalities and nonprofits should explore what resources are most effective in engaging residents and what tools can facilitate consistent maintenance (e.g., installing gator bags so residents have to water trees less frequently).

Maintenance is Not a Priority for Many Urban Forest Stakeholders

Maintenance needs and protocols vary widely between urban forest programs. Our mini-grant recipients reported annual maintenance costs ranging from $0 to $250 per tree, where $0 indicates that the mini-grant recipient has no maintenance responsibility (e.g., residents responsible for tree watering). While a couple of recipients have robust cyclical maintenance protocols, reactive and piecemeal maintenance is a more common approach. While in some cases, urban forest stakeholders may not prioritize maintenance by choice, in many cases it is deprioritized due to capacity and resource limitations. One interviewee spoke about how it is generally easier to get funding for projects focused on planting than on maintenance; as a result, tree planting is the default project. An interviewee also noted that, for many CBOs, tree planting is how they attract donations and volunteers, so there is pressure to plant as much as possible. More research is needed to understand how the urban forestry field can better support maintenance efforts.

Urban Forest Management Requires Support and Coordination

Urban forest stakeholders are a wide and varied group. All property owners have the potential to impact the urban forest, especially since most of the urban forest's trees are located on private land. State and federal land are also home to much of the urban forest. Due to limited staff and budget resources, many cities rely on partnerships with private landowners, organized citizen groups, and nonprofit agencies to effectively manage urban ecosystems.[54] A successful urban forest program should seek to foster support and coordination across these diverse stakeholders.

Collaboration across traditional boundaries engages constituents, increases environmental and political awareness across generations, and enables communities to better address complex issues such as climate change.[55] Whether within a municipality, across different levels of government, or between different organizations, communication and coordination are necessary to efficiently manage the urban forest.

In addition to stakeholders external to the local government, support and coordination among municipal departments is also important for urban forest management. Without adequate coordination and communication, local priorities may conflict with one another. For example, one of our interviewees spoke about conflicts between their city's goals of canopy expansion and reaching net zero. There is a proposed project in line with the net zero ambitions that would send steam, produced at the city's biomass plant as a waste product, to the local medical center. However, to build the underground pipe system, hundreds of trees would need to be removed, with no guarantee of same-site replanting. Without adequate interdepartmental coordination, more projects that do not consider the urban forest are likely to move forward.

Challenge: Lack of Coordination Between Departments and/or Organizations May Result in Inefficiencies

Insufficient coordination between departments or organizations that coordinate urban forestry work can result in informational silos, misguided actions, and uninformed planning. This concept was highlighted in a conversation with one of our mini-grant recipients. Through a grant in 2015, this city was able to stock its municipal tree nursery with 400 trees in liners intended to be planted throughout the city in the following years. However, the city never dedicated resources or staff to the nursery project, so our interviewee's predecessor, a team of one, was unable to systematically plant the trees. Today, there are close to 100 trees remaining in the nursery and, due to stability concerns, they are unlikely to be planted elsewhere. While 300 trees were planted, this situation highlights the inefficiency and wasted resources that can result from insufficient coordination.

As mentioned previously in the context of capital projects, lack of coordination between government departments and staff can make the implementation and enforcement of urban forest management plans inefficient and difficult. However, coordination must extend far beyond just capital projects for urban forest programs to be successful.

Best Practice:
Include All Relevant Departments in Urban Forest-Related Plans and Work

In many municipalities, the urban forest falls under the jurisdiction of the Department of Public Works (DPW). While some cities have a dedicated urban forestry staff within DPW, others may assign primary responsibility of the urban forest elsewhere, for example the streets and sidewalks staff. Other relevant parties within the local government may include a Conservation Commission, Parks Department, Planning Division, Mayor's Office, etc. The exact group will vary from place to place, but each city should aim to include all relevant departments in their urban forest work.

Cambridge, MA's Department of Public Works (DPW) manages the city's urban forest. DPW took the lead on developing the city's Urban Forest Master Plan, but they took steps to engage other departments too. DPW asked for feedback on the plan's key principles, learned about other departments' urban forest-related opportunities and challenges, and developed an interdepartmental working group for continued communication. This resulted in a more cohesive vision for the urban forest across city government, as well as ongoing opportunities for collaboration. Further, the responsibility for implementing the plan is shared among different city departments and staff helping to ensure that managing and protecting the urban forest continues to be a cross-departmental effort.

In Seattle, WA, there are nine city departments engaged in urban forestry work. Each department brings its own important expertise, perspective, and resources to the work. For example, while the parks department is responsible for planting and maintaining trees in parks, the Department of Construction is responsible for reviewing permits for tree removal. To facilitate communication and coordination, the city's Mayor created the "Core Team" which consists of a representative from each relevant city department. This team meets regularly with the city's Urban Forestry Commission to help ensure all urban forest work is cohesive and well-coordinated. The city also put in place the "Trees for Seattle Team" that serves as the communications umbrella for all urban forest efforts. Finally, the city established an Urban Forestry Commission to advise the Mayor and City Council on the establishment of policy and regulations to protect, manage, and conserve trees.

Local governments may also take a centralized approach to urban forest management by empowering a stand-alone board or commission to make decisions about the urban forest or creating a council with cross-department representation. In Vancouver, WA, the city created an Urban Forest Commission to manage the urban forest and assist both property owners and public agencies in improving and maintaining the urban forest in a manner consistent with adopted city policies. The Commission is made up of seven appointed members, reports to the City Council, and is staffed by the city's Urban Forester.

54 Stafford et al 2013
55 Bloniarz and Ryan 1998, Svendsen and Campbell 2008, Campbell and Weisen 2009

In Hartford, CT, the Department of Public Works leads a monthly tree maintenance working group. Group members include representatives from the Tree Commission, Office of Sustainability, Corporation Council, and the Planning Division. These interdepartmental meetings help to align departments on urban forestry goals and practices. Also at the local level, the neighboring Maine cities of Lewiston and Auburn have a Joint Community Forestry (CF) Board. The board is responsible for implementing the CF program, advocating for the CF, consulting on relevant projects across departments, and recommending policy changes to the city councils. Having a single entity responsible for interdepartmental coordination helps to align urban forest-related work in the municipalities.

Best Practice:

Coordinate Efforts and Leverage Partnerships Across All Levels of Government

Urban forest stakeholders are scattered across different levels of government. While local, state, and federal stakeholders have different roles in the urban forest, it is important that they recognize the interdependent nature of their work and identify opportunities for communication and collaboration.

At the state level, the Vermont Urban and Community Forestry program, funded through the USDA Forest Service, hosts the state's Urban and Community Forestry Council. Council members include representatives of professional associations, learning institutions, nonprofits, local tree boards, and state agencies. Regular meetings and communication encourage coordination. The program and council help ensure everyone in Vermont, regardless of their professional affiliation, is working towards a unified urban forestry vision. New York ReLeaf is a similar program that brings together tree care professionals, municipal staff, utility arborists, educators, and state and local government officials to support urban forestry across the state. The program promotes the value of trees, proper care, and sound management practices through technical expertise, resources, and training opportunities. ReLeaf holds regional workshops, webinars, Arbor Day events, the annual ReLeaf Conference, and other events to connect urban forest stakeholders throughout New York.

The Massachusetts **Greening the Gateway Cities Program (GGCP)** is a collaboration between the several state departments, participating cities, and local organizations. GGCP is an environmental and energy efficiency program that increases tree canopy cover to reduce household heating and cooling energy use; however, the trees planted have a multitude of benefits beyond energy efficiency including the provision of shade, better air quality, and improved stormwater management. Trees are planted by state crews and crews hired from local communities. All three of our mini-grant recipients from Massachusetts operate in cities that participate in GGCP (City of Holyoke, Groundwork Lawrence, ReGreen Springfield); each of these mini-grant recipients mentioned the importance of GGCP to their local urban forest efforts.

Gaps in Practice and Research

Common Municipal Landscaping and Maintenance Practices Can Harm Trees

Common maintenance tools, such as road salt, weed whackers, and lawn mowers, can cause severe injury to trees when not used in accordance with tree protection best practices. In our interviews, when asked to identify the biggest threat to the urban forest in their community, one participant quickly identified the city's landscapers; their partner called this phenomenon, "death by DPW." In their experience, DPW do not pay enough attention to trees and routinely bump into them, which is particularly dangerous for newly planted trees. Another participant noted that there is misconception that the nylon string of a weed whacker cannot harm a tree; however, successive hits with the weed whacker strip away vascular tissue, eventually killing the tree. More research is needed to understand how to align routine municipal practices with stated goals of a healthy and growing urban forest.

Other Municipal Departments Do Not Include the City Forester/Arborist in the Planning or Review of Municipal or Private Projects

In several of our interviews, the participants noted that the city forester (or city arborist) is usually not brought into conversations until it is too late, or they are not included in conversations at all. For example, in Burlington, VT, a major road construction project was designed to include a multipurpose path and tree belt. However, when the city forester was finally given the chance to walk the site with the contractor, he discovered that the tree belt was above four feet of solid stone, making it unsuitable for any tree planting. If the city forester had been brought into more discussions earlier, the problem may have been avoided. Major capital projects such as this have lasting impacts on the urban forest, so it is important to identify best practices for promoting these conversations.

Municipal Staff are Already Working at Full Capacity and Have Competing Priorities

Local government staff are often working at full capacity and are stretched between various municipal priorities. For example, in the community of one mini-grant recipient, the city forester is also the parks superintendent, the playground inspector, and, as needed, a city snow plower. With their attention stretched across several roles, the city forester's work in this community is limited to reactive tree maintenance. The city arborist from a different community expressed in their interview that, while there are many interesting projects they would love to pursue, something more urgent always comes up. For example, within six months of their start as the city arborist, the Emerald Ash Borer (EAB) was detected in the state, a matter that required their full attention. Between urgent issues and their everyday responsibilities, it is not feasible for the city arborist to undertake new initiatives that bolster the city's urban forest. Especially as cities and towns work towards increasing their tree canopy, it will be important to identify ways to expand the capacity of municipal urban forest programs.

Challenge: Non-Governmental Organizations Are Often Needed for Additional Support of the Urban Forest

Growing, maintaining, and preserving the urban forest requires substantial time and resources. Our survey results showed that, except on private property, the local government tends to have legal responsibility for the urban forest. Some of our mini-grant recipients expressed that, despite having legal responsibility, their municipality does not reliably or adequately support the urban forest. For example, one interviewee noted that their municipality does not allocate money from the general fund for tree planting, just tree removals. This same interviewee joked that the municipality's only approach to tree replacement is paving over old tree pits. In these situations, whether the municipality is uninterested in the urban forest or unable to take the lead, there is typically a gap in urban forest management.

Best Practice:
Develop Partnerships Between Municipalities and NGOs that Capitalize on Their Respective Strengths

An effective partnership will make the most of each partner's unique skills, experience, and resources. Partners can support one another by filling any gaps in urban forest management that may exist otherwise.

The Texas Trees Foundation is a nonprofit organization that promotes the local urban forest through research-based plans and projects that educate and mobilize the public. For decades, this foundation has provided technical assistance, support, expertise, volunteers, and fiscal sponsors to support urban forests throughout North Texas. In Dallas, TX, the Texas Trees Foundation regularly partners with the the city on urban forest projects. In 2021, the partnership created the Dallas Urban Forest Master Plan. The foundation was able to provide planning expertise, while the city will be responsible for implementing the plan. This is one example of how a public-private partnership can take advantage of each partner's capabilities.

Another example is the partnerships forged by Trees Atlanta through the One Million Trees Initiative. This initiative is a collaboration of ten nonprofits and twelve cities in metro Atlanta, GA, to plant and conserve one million trees by 2030. The nonprofit organizations bring community-engagement expertise, volunteers, and additional funding opportunities to the initiative. This is crucial for success since the initiative's goal cannot be reached without planting and preserving trees on private property. The cities contribute to the initiative by planting on city-owned land, providing city staff, and acquiring land for preservation. Before joining, cities must formally approve participation with a City Council vote or by signature of the Mayor or City Manager; this signals that the city is committed to furthering the initiative. Although only in its second year, this initiative has so far been successful in increasing tree planting and preservation throughout Metro Atlanta.

In the New England region, Groundwork Lawrence (GWL) and KNOX are examples of nonprofits that closely partner with their municipalities on urban forestry. GWL is the primary organization responsible for planting trees in Lawrence, MA. While they primarily fund their work through grants, they also operate through formal contracts with the city. For example, following the Merrimack Valley gas explosions in 2018, GWL received a $100,000 contract to plant trees in impacted areas. In Hartford, CT, KNOX is the city's official tree planting partner. They operate on a contract basis, planting in public spaces throughout the city. In each of these cases, the city's partnership with the nonprofit is memorialized through a legal agreement which allows them to act on behalf of the city in planting and maintaining trees on public property.

Gaps in Practice and Research

Partnerships May Require Administrative Support Not Readily Available to the Municipality

An effective partnership such as those outlined above requires significant administrative capacity. For many municipalities, urban forestry staff are already stretched thin with their day-to-day operations, so this administrative commitment is out of reach. Likewise, while partnering with a nonprofit can be a great solution, not all municipalities have a high-capacity nonprofit organization with which to partner. One of our interview participants with a successful partnership noted that it takes a lot of effort and input to start and maintain such a relationship.

A Municipal Partnership Does Not Guarantee Political Buy-In or Support

In some cases, a partnership between a municipality and a CBO may be superficial rather than symbolizing true buy-in or support from the local government. In one of our interviews, the CBO staff spoke about how, although the city is not a hinderance to their efforts, they are not a source of dedicated support. For example, while local leaders are happy to show up for pictures on Arbor Day, they are unlikely to dedicate staff or resources to routine urban forestry efforts. Another interviewee spoke about the scale of their work relative to the support provided by their local government. Despite limited staff, funding, and other resources, this CBO is able to plant 700 to 800 trees per year for the city. However, due to its own capacity limitations, the city is unable to provide much additional support beyond fulfilling their contractual obligations (i.e., fee-for-service work). More research is needed to understand what it takes to create and sustain meaningful partnerships between municipalities and CBOs.

Challenge: The Effectiveness of an Urban Forestry Program is Impacted by the Engagement and Support of Residents

A strong urban forestry program needs buy-in from the community. Residents can help advocate for the urban forest, strengthen the municipality's maintenance capacity, and promote urban forest health on private land. For example, in one of our mini-grant recipient communities, Burlington, VT, a large portion of funding for the municipal urban forestry program comes from a dedicated tax. The community's urban forest was devastated by an ice storm in 1998. The city arborist and administration at the time had an idea to bolster the urban forest's funding through a dedicated tax; the tax, an additional property tax, was approved overwhelmingly by voters and continues to have strong support today. It is likely not

a coincidence that this community has a very robust and well-funded urban forestry program._

It is also important to note that outreach efforts to residents should be designed carefully to avoid exacerbating any existing environmental inequities. In many cases, volunteers in urban forestry are not representative of the communities that they are serving; most commonly, urban forestry volunteers are middle aged, well-educated white women.[56] Without equitable resident engagement, there will likely be significant gaps in urban forest management.

Best Practice:
Design Equitable Engagement and Outreach Efforts to Increase Representation from Across the Community

All engagement efforts to garner resident support for the urban forest should be designed and implemented equitably. Urban forest managers should be mindful of their program's context and ensure that historically underrepresented groups are meaningfully engaged in all aspects of the urban forest. Ultimately, urban forest programs may want to work toward sharing power and decision-making with community leaders and stewards.

In Boston, MA, a history of exclusion and discrimination against communities of color has led to distrust of the local government. In developing its Urban Forest Master Plan, the city established an Equity Council composed of 24 representatives from grassroots community-based organizations working from/in historically excluded and marginalized communities. The Equity Council was regularly consulted during the planning process and had the final say on the plan's overall goals. The planning team hopes that this council will build trust in the city's urban forestry work and attract resident support.

In Portland, OR, the Parks and Recreation Department created a Community Advisory Committee to review project outcomes and recommendations for its tree planting strategy. They selected thirteen community members to participate on the committee including people of color, immigrants, refuges, and residents from low-income and low-canopy neighborhoods. This broad representation was important as their work included identifying barriers to tree planting for communities of color, low-income, refugee, and immigrant communities; providing recommendations on how to best work with communities to plant trees and gain community support; reviewing city priorities around tree planting; and reviewing the planting tool for selecting tree planting sites. The city also conducted five culturally specific focus groups to ensure that perspectives from marginalized populations were included in the project.

Several of our interview participants also spoke about the value of workforce development within urban forestry programs. For example, one interviewee spoke about his work with inmates from a local detention facility; he brings groups to the city's nursery to teach them green skills and helps them get relevant certifications. This program supports the city's urban forestry efforts with labor in the nursery, while also putting the inmates in a better position to get a good job upon their release. Another interviewee, although proud of the workforce development program run by his organization, mentioned the need to expand representation among participants, citing the queer community as one underrepresented group.

56 Elton et al. 2022

The Greening of Detroit (TGD) was a program established in 1989 to reforest Detroit, MI. With authority from the local government, TGD began a tree planting program focused on the city-owned ROW in residential neighborhoods. TGD staff decided in which areas of the city to plant trees, which tree species to plant, and how the trees would be maintained. TGD staff and volunteers were overwhelmingly white and not from Detroit. Between 2011 and 2014, almost 25% of residents approached by TGD about tree planting in front of their home submitted "no-tree requests" (NTR). An evaluation of TGD found that the NTRs were primarily driven by resident dissatisfaction with the decision-making process and a sense of distrust towards the city. Residents expressed that they would have been more likely to accept a tree if they were given more control over the species, the location, etc. Additionally, given the lack of resident control and representation within TGD, some residents were hesitant to participate in any city initiative, often citing past negative experiences with the city.[1] This analysis of TGD highlights the need for meaningful community involvement in urban forestry programs.

Carmichael and McDonough (2018)

Best Practice:
Use an Adopter Model to Engage Residents and Maximize Tree Care

Adopter models allow residents to request trees to be planted in their front yard and/or in the ROW in front of their home. The principle behind this model is that people who want trees enough to request them are more likely to take care of the tree consistently over time.

In Florida, Miami-Dade County offers an Adopt-a-Tree program for single-family and duplex homeowners with up to two free trees per year. Over 200,000 trees have been adopted since the program's inception in 2001. In Connecticut, the City of New Haven partners with the Urban Resources Institute (URI) to do much of the tree planting in the city. Residents that want a tree planted in the ROW in front of their home can request a tree from URI. Once URI plants the tree, the tree becomes the responsibility of the homeowner (e.g., for watering). Although there are not exact numbers to support this, anecdotally, the mortality rate of trees planted through this program is quite low.

Another one of our interview participants echoed a similar sentiment. When working with a resident to decide what type of tree to plant on their property, he puts a lot of effort into choosing a tree that fits their values and/or needs. For example, some residents might want a tree for shade, while others might want a tree that produces beautiful flowers. By accommodating these specifications, residents are generally happier with their trees and more likely to maintain them.

Gaps in Practice and Research

Adopter Models and Other Resident Request Frameworks May Be Inequitable

While resident tree request frameworks are an important strategy for increasing engagement, unless carefully designed, they may exacerbate existing inequities in canopy cover. Higher-income residents are more likely to request services from the local government and, therefore, receive more services from the local government.[57] Possible reasons for this are that higher-income residents are more likely to have knowledge of local government, time to make requests, and confidence in doing so. From our interviews, this pattern is true for tree request programs run by both municipalities and nonprofit organizations. Several of our participants noted that resident requests tend to come from whiter and/or more affluent communities, rather than the environmental justice neighborhoods they are hoping to target. Additionally, as mentioned in our interviews, renters may be excluded from these programs if they are unable to get permission from their landlord. Best practices to ensure equity in these request frameworks should be explored further.

57 Feigenbaum and Hall (2015)

Threats to the Urban Forest Impact Tree Preservation, Planting, and Maintenance

Urban forests help control the causes and consequences of climate change and related threats; however, they may also be negatively impacted by climate change.[58] A recent study has found that nearly three-quarters of global urban tree species will be at risk from projected changes in mean annual temperature and annual precipitation.[59] In New England, trees are most at risk from increased frequency of extreme temperatures and more intense storm events. In other regions, issues like drought may be more prevalent. Changing climate conditions also bring about new pests and diseases to regions that are not accustomed to dealing with them. Changing climate conditions may also exacerbate existing pest and disease issues. Urban forest programs need to thoroughly consider these threats when making any decisions about tree preservation, planting, and maintenance efforts.

Challenge: An Understanding of Tree Risk is Needed for Effective Preservation, Planting, and Maintenance

Climate risks should be a key factor in tree preservation, planting, and maintenance decisions. Climate-related risks for urban forests tend to have three main elements: (1) an adverse event or consequence, (2) some likelihood that the adverse event could occur, and (3) a specified time period.[60] One important tool for evaluating climate risk is a tree risk assessment. Tree risk assessments can provide tree owners and managers with information to make well-informed decisions that enhance tree benefits, health, and longevity. However, while a tree risk assessment is a valuable tool for effective urban forest management, many communities do not utilize them consistently or at all. Possible reasons for this may include lack of expertise, inadequate staff capacity, and lack of interest. As a result, many communities may misunderstand or underestimate the risks facing their urban forest.

58 Safford et al. 2013
59 Esperon-Rodriguez et al. 2022
60 Klein et al. 2019
61 Safford et al. 2013

Best Practice:
Proactively Monitor and Understand Tree Risk

Proactive risk assessment is necessary to protect urban forests against climate-related threats and to sustain urban forests for future generations.[61] Most of the urban forest master plans we reviewed indicated that the city recognized the importance of and was interested in proactive management of risks. However, staffing and funding were commonly cited barriers to effective management programs.

The driving principle of NYC's urban forest risk management protocol is to identify concerns before they become major problems through regular tree inspections and preventive tree care. Tree work is then prioritized through a combination of public service requests, the schedule

of routine maintenance cycles, and level of assessed risk. Risk inspection criteria include likelihood of tree failure, likelihood of impact, and consequences of impact.

In Seattle, WA, private property owners are responsible for the care and maintenance of trees on abutting public property including ROWs. The Transportation Department developed a "Risk Assessment Form" that is available through their Street Tree Manual to help property owners conduct risk assessments of trees on or abutting their property. The form provides guidance on factors like site conditions, including soil and topography, as well as tree health, tree species, and common tree defects.

As part of the Wells Fargo-supported urban forest mini-grant program, **Groundwork Lawrence (GWL)** will use its grant to further develop a geospatial information system (GIS) to track the City of Lawrence's tree assets, guide, and document maintenance activities, and develop an interactive storyboard about their Green Streets program. Through the Green Streets program, GWL provides and plants free trees for residents, in parks, and along streets. The work funded through the mini-grant is expected to help GWL achieve a 90% survival rate for all trees planted, increase resident engagement with the Green Streets program by 30%, and help current and future funders verify the trees they have donated have been planted. Additionally, upgrades to the GIS will allow GWL staff to update their tree inventory while in the field, ensuring that it remains an up-to-date and useful tool.

Best Practice:
Assess the Current Diversity of the Urban Forest and Make Plans for Improvement

Planting a diverse mix of trees that are pest-tolerant, well-adapted, low-maintenance, long-lived, and drought-resistant can ensure greater resilience and minimize risk.[62] For decades, the 10-20-30 rule has been the standard guideline for urban forest diversity. It recommends that no species, genus, or family should make up more than 10, 20, or 30 percent of the urban forest, respectively. However, as climate change inserts new uncertainties and vulnerabilities into urban forest management, some stakeholders are reconsidering this rule of thumb. The Wisconsin Department of Natural Resources now recommends the 5-10-20 rule. St. Charles, IL, and Portland, OR, have both adopted this more stringent rule as a guideline for their community to create a more resilient urban forest.

In Philadelphia, PA similar effort used knowledge from the city's tree inventory to develop an approved tree species list. The list groups trees by size, to minimize infrastructure conflicts, provides a suggested frequency of planting (e.g., high, moderate, low), and indicates at what time of year each species should be planted. According to the Philly Tree Plan, a revised list that also incorporates climate change projections will be released in 2023. Although private landholders are not bound by this list, it is a publicly available resource that may influence decisions on private land. The city plans to regularly update the list as new information is available, so it remains a useful tool for promoting diversity.

62 Nowak et al 2002, Bell and Wheeler 2006

Challenge: The Risk of Extreme Weather is Likely to Increase with Climate Change

In New England, trees will be at increased risk from more frequent extremes in temperature and precipitation. Increased winter precipitation puts urban forests at greater risk from physical damage due to increased snow and ice loading.[63] On the other hand, increased summer drought conditions are often exacerbated by urban soil compaction and impermeable surfaces. More frequent and intense extreme weather events increase the likelihood of severe flooding, which may uproot trees and cause injury or death to tree root systems if waterlogged soils persist for prolonged periods.[64] The occurrence of storms and other weather events are out of a municipality's control, but the opportunity to assess risk, plan for climate change, and increase resiliency is within reach.

While there are several planting lists being developed that consider the changing climate, some assume that trees from warmer climates can be climate-adapted in the northeast. One of our interviewees noted that they have seen urban forest programs run into challenges making this assumption. To be climate-adapted, trees in the northeast will need to be tolerant of extremes of heat and cold, as well as drought and occasional saturation. The interviewee learned this lesson themselves with Japanese tree lilac, a species that does well in the sun and is very drought-tolerant but does not do well with saturation. After a wet spring and summer, many of these trees were lost.

63 Johnston 2004
64 Johnston 2004
65 Plant and Kendal 2019

Best Practice:
Incorporate Climate Change Projections into Tree Planting Decisions

An urban forest resilient to climate change will be diverse in species, age, and size, as a lack of diversity can put the forest at greater risk from the impacts of climate change.[65]

In Cambridge, MA, the city determined that climate change was likely to increase tree mortality potentially causing the city's canopy cover to drop to as low as 10 percent by 2050. As part of its Urban Forest Master Plan, the city simulated future canopy scenarios based on climate projections and determined that they should plant more flood tolerant species in flood-prone areas and drought tolerant species near impervious surfaces.

In Columbus, OH, the city integrated climate change projections into its Urban Forest Master Plan. Specifically, the city used data from the USDA Forest Service Climate Change Atlas to begin planning for future tree planting efforts. Based on several different climate change projections, the plan predicts whether suitable habitat will increase, decrease, or stay the same for each tree species in the existing urban forest. This knowledge will help guide the city towards planting decisions that will result in a climate-resilient urban forest.

Similarly, the State of Pennsylvania's Department of Conservation and Natural Resources issued tree planting guidance that considers climate change. One recommendation is that municipalities

plant native trees that are common to the state's southernmost region and tolerate wetter soil; these species will have a better chance of thriving in the projected future climate conditions.

The Vermont Urban and Community Forestry program has also begun to integrate climate change into its annual tree selection guide for municipalities. One indicator included in the guide is a species' tolerance; municipalities can select more tolerant species that will thrive in a wider range of scenarios to account for the uncertainty of future climate conditions.

ReGreen Springfield works closely with the U.S. Forest Service (USFS) in its Climate Change Resource Center. Through its resource center, the USFS continually updates its list of trees that are expected to be the most dominant species in each region based on expected climate in 2060. For example, while sugar maples are currently growing in Springfield, by 2060 they will be better suited for a more northern climate with lower average temperatures. By 2060, Springfield will be planting trees that are currently growing as far south as South Carolina. Because Springfield is part of the USFS Amherst-Springfield Urban Field Station, ReGreen Springfield and the city are able to benefit from the USFS work going on locally. For example, 3,000 oak trees are about to be planted in Springfield as part of a research project. The trees were germinated in Kentucky from acorns that ReGreen Springfield collected.

Best Practice:
Prioritize Planting Sites That Will Increase the Resilience of Trees During Storms

Growing an urban forest that is resilient to storms starts at the time of planting. By planting trees in places that maximize rooting space and promote overall health, urban forest managers can decrease the likelihood of tree or limb failure during storm events that are expected to increase with climate change.

In addition to street tree planting, the City of East Providence, RI, also operates a setback tree planting program. The goal of this program is to plant shade trees on private property where they have more space, above and belowground, to grow, giving them a higher chance of survival. With greater soil volume compared to sites in the right-of-way, these setback sites allow trees to develop strong stabilizing root systems, a characteristic important for tree resilience. Since the trees are planted within 20 feet of the right-of-way, they still confer important public benefits and contribute to the city's tree canopy._

Several of our interview participants also spoke about techniques, such as suspended pavement systems (aka by their brand name, Silva Cells) and structural soil, that can increase trees' rooting space and contribute to their stabilization. While these approaches will increase a project's cost, they are a worthwhile investment since the trees will be more likely to be well-established and survive common threats, such as storms. Another participant noted that the impact of drought is usually worse for trees in the ROW because they have less soil available to retain moisture; suspended pavement systems and structural soil can also help to mitigate this challenge.

Gaps in Practice and Research

Technology to Increase Trees' Resilience Exists but May Be Cost Prohibitive

Despite being a worthwhile investment, the upfront costs of technology like structural soil and suspended pavement systems may render them inaccessible to urban forestry programs.

Structural soil can support construction elements like sidewalks and roadways while also creating rooting space and providing high quality soil for trees. However, since it increases a project's cost, developers rarely opt to use it. One interviewee commented that because structural soil is not mandated for new developments and construction projects, it is almost never used; there was one recent development where the city forester got involved and successfully advocated for its use, but this is not often the case.

Suspended pavement systems are stackable plastic cells filled with high quality soil; the cells give trees up to two thousand cubic feet of soil, even though they are planted in a small space. However, the cost of the cells may prohibit many communities from extensively using the technology. One interviewee estimated that, for a recent project using a suspended pavement system, it cost about $20,000-$25,000 per tree. At this cost, it is easy to see how few project proponents would voluntarily incorporate suspended pavement systems into their design.

66 Cullington and Gye 2010, Tubby and Webber 2010
67 Tubby and Webber 2010
68 US EPA (2022)

Challenge : Threats from Pests and Diseases Are Likely to Increase with Climate Change

Pests and disease can spread quickly throughout the urban forest and have a devastating impact. Although climate change may reduce the risk of certain pests and diseases in New England, many others are able to adapt and some will even see a shift in their range, entering the region for the first time.[66] Milder winters may also favor pests and diseases that have been kept at low levels by cold winter temperatures.[67] Managing this risk is especially important for municipalities since they will bear the long-term costs of infestations.

Best Practice:
Adopt an Integrated Pest Management Program

Integrated pest management (IPM) is an effective and environmentally sensitive approach to pest management that leverages a combination of different practices. In urban forestry, IPM considers the lifecycle of the trees and the pests to create a management strategy that is effective and efficient. IPM also strives to minimize hazards to people, property, and the environment.[68]

The strong integrated pest management program in Brookline, MA can serve as a model for other municipalities. The tree warden determines an action threshold for each pest that serves as a guideline on when treatment is warranted. When the presence of a pest exceeds its threshold, town tree crews initiate control measures on public land and in the public right-

of-way. If these measures include the application of pesticides or chemicals, a closed-system approach is used to limit exposure. Brookline's pest management program also emphasizes proper planting techniques and proactive pruning regimes.

The Arizona Community Tree Council developed an Urban Tree Threat Response Guide for insects, disease, and environmental threats to urban trees in Arizona and New Mexico. The guide comprehensively describes 24 different insects and diseases that weaken or kill urban trees, including signs and symptoms to look for and different control measures. Some insects and diseases identified in the guide are currently present in the states and others that are not yet detected but could make their way to the state in coming years. The guide also discusses environmental and cultural factors that could put urban trees at risk for insects and disease including tree injuries, water supply issues, and more.

Best Practice:
Adapt Pest and Disease Management Protocols to Account for New and Emerging Threats

In the face of climate change, even urban forest programs with strong pest and disease management strategies will need to adapt. Climate change is likely to expand and shift the range of pests and diseases, introducing unfamiliar threats that may not yet be accounted for.

The Hemlock Wooly Adelgid (HWA) has been present in Hartford, CT, for years. Until recently, HWA was not a major concern because most of the population died off in the cold winter months each year. However, as winters become milder due to climate change, HWA may pose a greater risk to Hartford's urban forest. The city plans to commit to a more rigorous monitoring program to detect and control the HWA and any other pests before they become a significant problem.

One of our interviewees spoke about how climate change may impact their tree pruning restrictions. Under existing policy, trees can only be pruned in the dormant season, from November through March. By limiting pruning to the dormant season, fresh wounds are not exposed to pests and disease, such as Oak Wilt and Elm Disease, which are of particular concern for this community since oaks and elms make up almost one-third of the canopy. The interviewee is concerned that, as climate change progresses and winters become milder, the dormant season will shorten and/or cease to exist. Even this year, they are concerned that there was not a true dormant season during the winter.

Best Practice:
Engage with Peers and Other Resources to Stay Up to Date on New and Emerging Threats from Pests and Diseases

Learning about potential threats early on and taking prompt action can significantly decrease the risk to the urban forest. Communication with regional peers is a key tool for facilitating this. Opportunities for peer gatherings should be taken advantage of for this reason. One interviewee said they found peer-learning opportunities invaluable for their work.

Urban foresters in Dallas, TX, are taking proactive steps to avoid any potential threats to the urban forest. The municipal urban forestry staff are encouraged to attend state and regional events to build connections with other practitioners and remain up to date on new and emerging pests and diseases. More generally, one of our interview participants noted that such peer learning opportunities have been an invaluable resource for her work. Sharing information and experiences can help with early pest/disease detection and other common urban forestry challenges.

Best Practice:
Promote Urban Forest Diversity as a Pest and Disease Risk Management Tool

A diverse urban forest will be more resilient to pests and diseases. One of our interviewees spoke about their city's focus on increasing diversity throughout the tree canopy. In their view, the more diversity the better since there is no doubt that more insect and disease problems are on the horizon. In a diverse urban forest, outbreaks of species-specific pests or disease will likely be easier to contain and have less of an impact on the urban forest.

For the Chicago Region Trees Initiative (CRTI), increasing tree diversity is a primary pest management tool. CRTI recommends that the urban forest should not consist of more than five, ten, or fifteen percent of any one species, genus, or family, respectively. CRTI works directly with nurseries to help communities meet this diversity goal. Nurseries can be hesitant to expand their production or grow species not commonly planted, but CRTI has overcome this hurdle with contract growing. Contract growing is a process where the buyer preorders trees and pays a deposit for their production, with anticipated collection in five to seven years. This allows the buyer to lock in a price and get trees needed to increase diversity, while also decreasing the financial risk for the nursery.

Best Practice:
Explore Both Conventional and Innovative Treatments to Manage Pests

There are a wide range of approaches for managing pests, such as insects and invasive species. In Holyoke, MA, four of the neighborhoods with the lowest canopy cover are also dominated by green ash trees. With this near-monoculture and the threat of the Emerald Ash Borer, the neighborhoods are at risk of losing their already limited tree canopy. In 2021, the city used conventional pesticide treatments to lower the risk of infestation. However, the treatment needs to be applied every two years, so the city will soon have to decide whether to reapply treatment or remove the trees altogether.

In Springfield, MA, through a Community Preservation Grant, a local nonprofit organization, ReGreen Springfield, is experimenting with using steam to control Japanese knotweed, an invasive species, in public green spaces. They hope that applying steam to young Japanese knotweed plants will be effective in stopping their growth and reduce the need to use herbicide.

Key Takeaways

Urban forests are a critical resource that provide communities with numerous health, economic, environmental, and social benefits. Through a review of municipal urban forest plans, local and state policies and programs, a survey, and a series of interviews, CLF assembled this landscape scan to identify the common themes, challenges, potential solutions, and gaps in knowledge for the urban forestry field.

In general, communities both in and outside of the New England region are facing similar challenges in preserving and growing their urban forests. Even though many of the challenges are common, the solutions identified and implemented in one community may not adequately address the same challenge faced by a different community due to different state laws, different attitudes and culture about trees, differences in the built environment or natural climate, etc. For these reasons, CLF focused on describing a suite of potential solutions that include physical solutions, policy solutions, and process solutions for each of the common challenges that can most effectively help all communities working to grow their urban forests. By using this approach, instead of identifying one "best practice" for each challenge, urban foresters using this report will be able to identify options that best align with their unique community characteristics.

Some of the key takeaways from this research include:

- Effective urban forest management starts with data collection and analysis including a tree inventory to understand the current state of the forest.
- Land use competition and conflicts can often be addressed through comprehensive design standards and leveraging co-benefits.
- Local rules and standards are an important tool for preserving and growing the urban forest but require enforcement to be effective.
- Early and broad-ranging coordination within government and with external stakeholders is critical to the success of urban forest programs and is a primary tool in addressing financial resource deficiencies and enforcement challenges.
- The urban forest is not equitably distributed and achieving urban forest equity requires analysis of existing disparities and multi-faceted strategies for prioritizing low canopy communities.
- Leveraging all types of private property – development, private residences, institutional – is important for meeting urban forest canopy goals.
- Local governments must engage with residents, including private property owners, to secure buy-in for urban forest goals.
- Urban forests are both threatened by climate change and are an important tool for addressing climate impacts.

While this report highlights known opportunities to streamline and accelerate urban forest efforts by providing communities with resources guides, best practice solutions, and other tools, it also highlights gaps in literature and practice that require additional research. This is true for both long-standing challenges like conflicting and competing land uses as well as emerging challenges like adapting urban forests for climate change. CLF looks forward to continued engagement and advocacy, guided by the identified gaps and continued conversations with stakeholders, for the acceleration of urban forestry programs across New England.

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Photo credit:Keney Park Sustainability Project

Mini-Grant Program

As part of its *Advancing Climate Resilience and Health through Urban Forestry* project, CLF created a mini-grant program for New England-based communities and community organizations to preserve and grow their urban tree canopies. CLF dedicated $80,500 of Wells Fargo Foundation funds to provide awards of $10,000-$13,500 to seven recipients. By infusing radically flexible dollars into local urban forestry programs, grant recipients were able to overcome challenges and/or take advantage of previously unavailable opportunities to advance local urban forest projects and initiatives. Each grantee used their award for community-specific projects during the spring of 2023. CLF leveraged the mini-grant program to better understand how to encourage and facilitate new pathways for urban forestry growth and preservation in a replicable and scalable way. Further, as part of their participation in the mini-grant program, each of the grantees participated in a survey and interview that helped inform our regional landscape scan and reviewed and provided feedback on our final documentation. The seven mini-grant projects are summarized below.

City of Burlington, Vermont

Burlington is the most populous city in the state of Vermont with approximately 45,000 residents. The city's overall canopy is estimated at 42%; however, the tree canopy varies greatly from ward to ward. For example, canopy coverage in Burlington's Ward 8 it estimated to be as low as 18%. Ward 8 also has a median household income that is significantly lower than the city and state average and a rental population that makes up about 86% of housing units in the ward compared to 60% citywide. With its mini-grant, the City of Burlington will purchase bare root trees and other supplies for planting trees this spring. All work will be performed by the city arborist and his crew of ISA-certified arborists. This work will support the city's efforts to focus its planting in areas with low existing tree canopy, a characteristic that, as described above, typically correlates with neighborhood demographics, such as income and the presence of renters.

Groundwork Lawrence (GWL)

Groundwork Lawrence (GWL) is a non-profit community group operating in Lawrence, Massachusetts, a city in northeastern Massachusetts with a population of approximately 88,0000 people. Approximately 81% of Lawrence residents identify as Hispanic or Latino. The city's poverty rate is 21%, which is significantly greater than MA's overall rate of 9.4%. Likewise, Lawrence's median household income is $45,045, compared to $84,385 for the state's median. Approximately 31% of Lawrence youth live in poverty and many children and their families struggle with economic, environmental, and public health disparities. With this grant, GWL will develop a geospatial information system (GIS) to track their tree assets, guide and document maintenance activities, and develop an interactive storyboard about the Green Streets program. Through this program, GWL provides and plants free

trees for residents, in parks, and along streets throughout the city. GWL hopes to increase resident engagement with its Green Streets program and improve the long-term sustainability of Lawrence's urban forest through monitoring and stewardship programs to achieve a 90% survival rate for trees planted.

City of Holyoke, MA

Holyoke is one of two cities in the Springfield Metropolitan Area in western Massachusetts, with a population of approximately 38,000 people. More than 75% of Holyoke residents live in an Environmental Justice block group as defined by the State of Massachusetts. The City of Holyoke is using its grant to complete the city's tree inventory, giving the first complete picture of the public tree canopy. The city will hire a qualified arborist firm for this work which consists of inventorying approximately 2,415 trees. The completed inventory will be used to understand canopy needs and priorities, as well as improving the overall management of the urban forest. Expanding and maintaining the urban forest will also advance the city's goal of mitigating climate change impacts. Funding will also be used to lead educational training sessions for students and community members interested in the urban forest. The goal of these sessions is to equip residents for future citizen science data collection so they can assist in maintaining the inventory.

> *"The funding came at the perfect time to fill a gap in our ongoing planning efforts, with useful data now available to apply for further grant funding to implement the recommendations – notably, the present Notice of Funding Opportunity now available through the USDA Urban Forestry IRA grant."*
>
> **– Yoni Glogower**
> City of Holyoke

ReGreen Springfield

ReGreen Springfield is a nonprofit operating in Springfield, Massachusetts. ReGreen Springfield is using its grant to conduct a detailed analysis of environmental equity in Springfield, MA, at the block level. While the project will have citywide impacts, its focus will be on some of the city's lowest-income neighborhoods: Upper Hill, Old Hill, South End, Six Corners, and McKnight. These neighborhoods are also home to large communities of color. More than 75% of residents in these neighborhoods are people of color, compared to the citywide average of 70%. The median household income across these neighborhoods is $29,058, compared to $43,308 citywide. The analysis will examine key environmental and demographic indicators that consider the quality of air, water, and toxins found across the city. This work will result in the first environmental justice analysis of Springfield's urban landscape. The information learned will be shared with relevant city staff and any interested community-based organizations.

Additionally, in combination with i-Tree and EPA EJSCREEN, the information gathered will be used to strategically plan for new tree plantings that address environmental inequity in Springfield.

KNOX, INC.

KNOX, INC. is a non-profit operating in Hartford, Connecticut, a city in central Connecticut with a population of approximately 120,0000 people. Approximately 45% of residents in Hartford identify as Hispanic or Latino and 37% identify as Black. Hartford is a distinct outlier in Connecticut regarding its racial makeup – over 80% of residents are non-white, compared to only 20% statewide. Hartford's poverty rate is 28%, while the state's is 10%. Clay Arsenal, where planting efforts will be focused, is primarily a Latino/Hispanic neighborhood. KNOX will use its grant funding to improve Hartford, CT's urban forest by adding new trees and maintaining existing trees. New trees will be planted in Hartford's Clay Arsenal neighborhood, an area designated as high priority in Hartford's 2020 Neighborhood Tree Planting Priority Map. With the grant funding, KNOX horticultural staff will evaluate the conditions of the trees and perform watering, mulching, weeding, pruning, and staking activities. Additionally, the grant will facilitate the purchase of tree maintenance supplies necessary to create a strong canopy. Overall, this grant will be impactful for furthering the goals of Hartford's 2020 Tree Canopy Action Plan.

Keney Park Sustainability Project (KPSP)

Keney Park Sustainability Project (KPSP) is a non-profit community group operating in the federally-designated North Hartford Promise Zone, one of the poorest neighborhoods in the country with a population of approximately 24,000 people. Approximately 50% of North Hartford residents live in poverty, a stark contrast to Connecticut's overall poverty rate of 10%. The neighborhood's residents are predominately Black and Latino. KPSP will use the grant funding to establish a tree nursery in Keney Park. The nursery will serve as a shelter and staging area for trees in various stages of development to support Hartford, CT's afforestation efforts. The nursery is expected to begin operations in Fall 2023. Funding will be used to install fencing, for irrigation, and to transfer trees to the nursery. Additionally, KPSP will use the funding to lead free tree care workshops and recruit and train Hartford youth to assist with tree care and planting. KPSP is also creating informational materials for the public on tree care, invasive species, and the importance of the urban forest.

> *"Creating a tree nursey lowers our tree planting costs, restores the tree canopy with native trees as well as provides workforce development activities for Hartford young adults."*
>
> **– Herb Virgo**
> Keney Park Sustainability Project

City of New Haven, CT

New Haven is a coastal city on the Long Island Sound with approximately 135,000 residents. Over 70% of New Haven's residents are non-white with 34% of residents identifying as Black and 30% identifying as Hispanic or Latino. The city's median income is $48,973, compared to the statewide median of $83,572. Approximately 24.6% of New Haven residents are in poverty, while the statewide poverty rate is 10%. The City of New Haven is using its grant to remove standing dead trees and grind stumps that are preventing the installation of new healthy trees. There are over 100 residents that want the city to plant a tree in their front yard, but do not have adequate space due to a standing dead tree or tree stump. With the current maintenance backlog, the wait time for tree removal and stump grinding is anywhere from six months to a year. The grant funding will help lower this barrier to the city's tree planting efforts. The city's tree division estimates that they will be able to remove 15 trees and grind 20 stumps with the funding.

> *Although the City has a dedicated Tree Division, there is still a significant backlog of work that needs to be addressed. This funding reduced risk, expedited tree planting efforts, and made possible the future planting in 23 new locations in our communities that will most benefit from the new trees"*
>
> **– Annie Mixsell**
> City of New Haven

Photo credit: Simtropolitan

Carbon Credits

At the outset of this project, CLF understood that cost is a significant barrier to communities and community-based organizations working to achieve a healthy and robust urban forest. One emerging potential solution to this challenge is through the bundling and selling of carbon credits, specifically through the City Forest Credits (CFC) carbon registry. During this project, CLF identified and proposed a structure for bundling CDC carbon credits that could be used in New England cities and beyond. While we were unable to identify and stand up a pilot project with one of our partnering communities during the term of this grant, the possibility of implementing a carbon credit program with a partner organization remains. CLF conducted initial interviews with state coordinators funded through the USFS Urban and Community Forestry program to document a baseline understanding of current sources of funding for urban forestry programs and other pertinent details. The summary of these interviews can be found in the appendix. We also include observations and takeaways from our conversations with New England municipalities and community-based organizations about the barriers to implementing a carbon credit planting project.

Carbon Credits and Urban Forestry

This research is premised on the belief that the voluntary carbon credit market may be a viable financing strategy for preserving and growing urban tree canopy in New England. Trees are a nature-based way to capture carbon emissions in the atmosphere. By planting and maintaining trees, urban foresters can generate carbon credits based on the species and size of the new tree canopy, and sell the credits bundled with other credits to attract high volume buyers. The proceeds from the sale can be used to reinvest in community trees, particularly maintenance of urban forests. Carbon credits offer a monetary benefit for urban forests beyond the ecosystem benefits that the trees also provide. CLF's research into the carbon credit market, its potential applications for urban forestry, and potential implementation path is outlined below.

How urban tree planting and preservation fits in the overall voluntary carbon credit market

Tree planting and tree preservation are considered nature-based climate solutions. Nature-based carbon credits are seen as a short to mid-term climate solution because they are easier to deliver at scale than technology-based removal solutions like Direct Air Capture. They also provide a number of co-benefits such as improving biodiversity, mitigating flooding, and improving health.

Tree preservation credits are considered carbon avoidance credits, and tree planting or afforestation credits are removal credits. Removal credits are considered higher quality, and command a

higher price, as they remove carbon from the atmosphere, as opposed to avoiding future emissions. There is some risk to the permanence of tree planting credits due to storms, pests, and fire.

Assessment of the City Forest Credit protocols

The City Forest Credits (CFC) protocol is not currently accredited by a third party, but CFC has applied for certification through the International Carbon Reduction and Offset Alliance (ICROA). City Forest Credits publishes its protocols on its website, with the most recent version (version 11) released in February 2022. The protocol drafting group includes municipalities, arborists, and NGOs.

Based on our review, City Forest Credits (CFC) protocols generally meet the requirements for voluntary market carbon credits, with concerns noted below.

Additionality

Carbon projects are considered to have additionality if the projects would not have happened without the financing provided by the carbon credits. CFC Tree Preservation Credits are considered ex-post credits, issued either immediately or over four to five years following project validation and verification, supporting some or all of the initial cost of protecting a forested land parcel, and therefore offer a high level of additionality.
CFC Tree Planting Credits are considered ex-ante credits, issued after tree planting occurs, and they are generally issued in anticipation of tree growth over a 25-year period, subject to periodic verification.
Up to three years of tree planting can be included in a single project. As a result, a tree planting project is not dependent on carbon credit financing, even if revenue from credit sales helps to cover future maintenance costs or future projects. As a result, the tree planting protocol offers a relatively weak claim of additionality. (CFC claims any credit revenue that supports tree planting is additional to the overall baseline of the urban tree canopy, which has declined in recent years.)

Permanence

The CFC protocols require a 26-year commitment to maintaining trees for tree planting projects, and a 40 or 100 year commitment for tree preservation. The tree planting protocol deducts 20% of possible credits to account for expected tree mortality and deducts 5% of potential credits to be put into a reversal pool should additional trees die from causes other than negligence. These project lengths offer a reasonable amount of permanence for fulfilling short term progress toward net zero for 2050. However, tree planting credits are valued less than truly permanent carbon capture and storage technologies that mineralize carbon or pump carbon underground.
It is also unclear how Permanence and Reversal are structured to account for higher probability large-scale tree loss or decline under disturbance regimes (e.g. frequency, severity, size, or timing of altered air temperatures, precipitation, aridity, sea level rise, wildfires, and flooding, as well as threats from hurricanes, tornadoes, ice storms, and insects and diseases). For example, the DC-Boston corridor is among regions that are likely to face the greatest overall threat to their urban forests (Nowak et al. 2022) and the New England urban forests, specifically, have the some of the highest cumulative threats (per unit area of urban land) from pests, hurricanes, and changes to temperature, precipitation, and aridity. Any event in isolation or in combination has the potential to devastate tree/forest health and survival, rendering an overall loss of benefits.

- Additionally, land protection and zoning mechanisms are important eligibility criteria in Tree Preservation and Tree Planting protocol, however, the presence of tree protection mechanisms are not. Tree preservation ordinances may hold greater value in areas of rapid redevelopment or construction and could incentivize participation in the Tree Preservation protocol.

Leakage

Quality carbon credit projects do not cause emissions reductions in one geographic area to simply be displaced to another area. In the case of urban tree planting, it is highly unlikely that planting urban trees could cause trees to be cut down elsewhere. It is also unlikely that tree preservation in one area would cause development to occur elsewhere, although it is theoretically possible.

Double counting

CFC's project documentation is clear that credits can only be issued to one party. If tree planting occurs on city-owned property, a city can assign those credits to the NGO doing the tree planting and maintenance. CFC credits are placed in a public registry and the retirement of credits for use of offsets is documented, although the party using the offset is not revealed.

Measurability and verification

Calculation of carbon sequestration is well documented in the protocols for both tree planting and tree preservation. However, the precision is limited by the chosen methodologies and research.

- First, CFC's calculations are based on allometric equations, which is used to estimate or predict tree growth over time, but assumes that all trees grow similarly regardless of context-specific impacts that affect the growth of urban trees (like human- and biophysical-drivers or legacies of land use and infrastructure development).
- Second, metrics are based samples of trees from climate zones and reference cities that may not be representative across New England; for example, CFC Quantitative Methodology uses data from Queens, New York City (collected in 2005) to represent southern New England and the coastal and southern portions of Northern New England, while data from Fort Collins, Colorado (collected in 2002) represents the remaining portions of Northern New England. Not only may these cities have separate human- and biophysical-drivers and legacies of land use that differ from New England (and impact the composition and growth of trees over time), but these reference cities may not be most accurately modeling the present and future climate zones, growing seasons, and other conditions of New England communities.
- Third, noteworthy groups of trees (by genus and species) are missing entirely from CFC's Quantitative Methodology and cannot be accurately accounted for in carbon capture estimates. For example,

based on a recent summary of collated tree inventories across the US Northeast (Doroski et al. 2020) several of the most frequently planted street and park tree species (e.g. S*yringa reticulata, Piunus strobus*) are not included in CFC's Quantitative Methodology. Additionally, from the surveys conducted with our mini-grant communities, of the 23 genera and 22 species most recently planted, only 32% are accounted for by the CFC protocol, 42% are missing entirely, and 26% are unknown (due to missing data from the grantees).

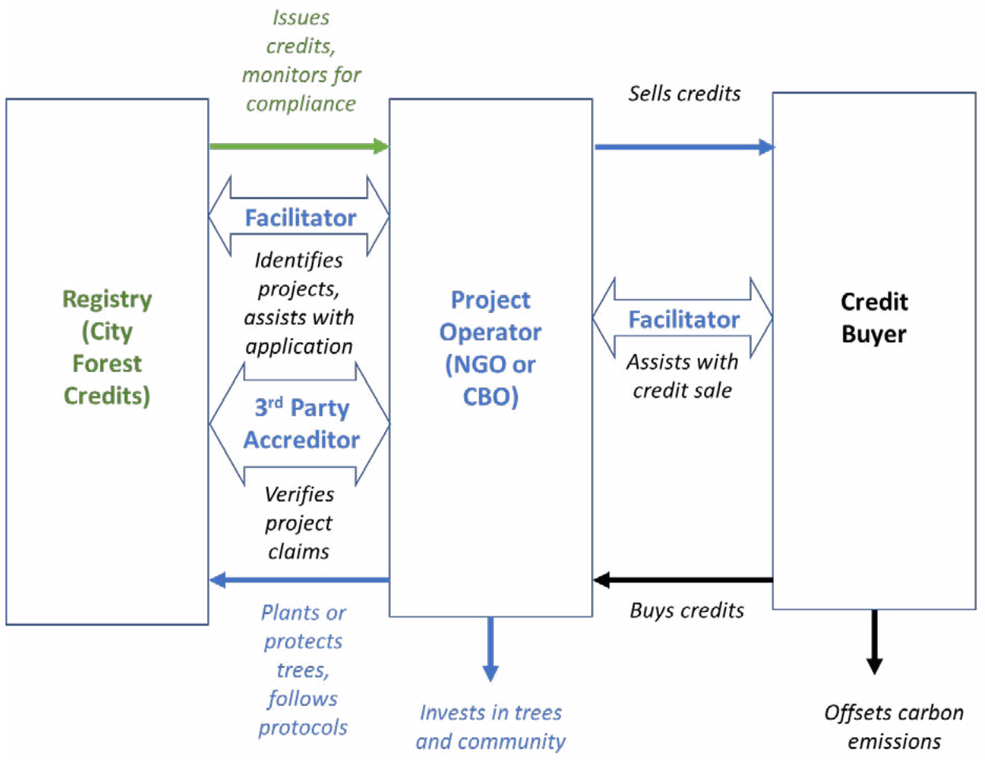
However, there is no guarantee that the effort required to undertake a comparable sampling strategy and generate a New England-specific Quantitative Methodology will result in metrics that are more accurate or more reliable than the CFC Quantitative Methodology.

Role of different parties in a CFC tree planting program

As in other carbon credit projects, there are multiple players responsible for different aspects of the project. CFC, as the registry, is responsible for developing the carbon credit protocol, validating the initial project, providing 3rd party verification of project claims, and issuing and registering the credits. The project operator is responsible for the on-the-ground tree planting or tree preservation project, including application, documentation of initial planting, maintenance of trees, and documenting ongoing viability and growth of trees. The project operator receives credits based trees planted or protected in compliance with the CFC protocol, which it can offer for sale on the carbon credit market or through a private sale. Depending on its goals, the buyer can purchase credits and retire them to use as carbon offsets or treat them as an investment that may appreciate in value.

Given the low level of awareness of carbon markets and the CFC opportunity among municipalities and state urban forestry coordinators, and limited staff capacity at the municipal and NGO level, we believe there is a role for a facilitator who educates partners about the opportunity, guides them through the initial application process, and assists in identifying a buyer for the credits. An example of this facilitator is the Chicago Region Tree Initiative's *Chicago Region Carbon Program (CRCP).*

The interaction between various parties is shown in the diagram on the next page:



Key steps and responsibilities for a 26 year CFC tree planting project

Step / Requirement	CLF as Facilitator	NGO as Project Operator
(1) Learn basics of urban forest carbon protocol requirements, assemble project partners (10 hours total)	Initial presentation to project operator on CFC benefits, process, documentation Rough P&L estimate of revenues and costs Suggest sources of upfront project financing Facilitate meeting with CFC to confirm eligibility (10 hours)	NGO to assess fit of a CFC project NGO confirms availability of documentation NGO expresses interest in proceeding (5 hours)
(2) Complete Application, Project Design Document, Ownership, and Attestations (5 hours total)	Provide initial technical assistance in completing paperwork Point NGO to documentation from other projects Facilitate pro bono legal support if needed (2 hours)	NGO completes application, attestations, social impact form NGO completes transfer of credits agreement from municipality (5 hours)
(3) Quantify CO2 storage at outset of project and document planting of trees (10 hours total)	Provide initial technical assistance in completing paperwork Facilitator can recommend tree species appropriate for project (2 hours)	NGO plants trees NGO enters tree data into quantification tool NGO attests to completing planting, arranges for 3rd party confirmation (10 hours)
(4) Engage with potential carbon buyers (20 hours total)	Work with NGO on project story Identify qualified buyers Respond to RFPs Coordinate above with broker if needed (20 hours)	Respond to questions that come up during sales process Approve first round buyer, and whether to continue with buyer in subsequent rounds (8 hours)
(5) Process receipt of credits in Registry Ledger Account and transfer to buyer (10 hours total)	Facilitate transfer of funds to NGO Facilitate pro bono legal support if needed (8 hours)	Acknowledge receipt of credits (2 hours)
(6) Visit and document sample of trees in years 4, 6, 14, and 26 (80 hours over course of project total)	CFC will send reminders Provide technical assistance as needed (8 – 40 hours)	NGO conducts field sampling for mortality and growth or provides supporting imagery showing canopy growth (80 hours – 20 hours for each assessment year)
(7) Submit annual monitoring reports (2 hours per year, 50 hours total)	CFC will send reminders	Submit report (50 hours- 2 hours per year)

Total Estimated Hours

Upfront (Year 1 – application through issuance of year 1 credits)

Facilitator: 42 hours
Project Operator: 30 hours

Ongoing – remainder of project

Facilitator: 8-40 hours – depending on need for additional price negotiations and/or need to find additional buyers in future years
Project Operator: 130 hours

Economics of CFC Tree Preservation and Planting Projects in New England

CLF completed a pro forma analysis of a sample tree planting project in Lawrence, MA. Assumptions of this analysis include:

- 2000 Trees Planted – Large Broadleaf Deciduous > 50 ft at maturity
- 20% Tree Mortality Rate* (% of credits)
- 5% Registry Reversal Account Pool* (% of credits)
- $36/hour labor + fringe – GWL Urban Forestry Project Manager
- 10% Registry Fee* (% of revenue)
- 12% Brokerage Fee (% of revenue)
- Carbon Credit Plus Price rises from $34/t in Year 1 to $75/t in Year 26* (value of carbon sequestration + co-benefits (stormwater, air quality, energy savings)

*Assumptions provided by CFC

Based on these assumptions, and CFC estimates of hours of labor required for application validation, a tree planting project would generate gross revenues just over $100K over 26 years, and net income slightly over $64K. Net income is $32 per tree planted. We estimate that this net income is equivalent to approximately 10% of the initial fully loaded project cost (cost of tree plus planting labor and overhead). Given that the structure of payments occurs at years 1, 4, 6, 14, and 26 of the 26-year period, the income is best seen as support for ongoing tree maintenance. Therefore, CFC's Carbon Plus Credits are not compelling in dollar terms and would benefit from a more layered funding strategy.

Use of CFC Impact Scorecard – economics and benefits

The impact scorecard is described as a project design tool that could be used with funders to discuss how the different Sustainable Development Goals (SDGs) across health, equity and environment will be factored into a project. Anecdotally through CFC, we have heard nonprofits have successfully used the CFC Scorecard to raise small amounts of grant funding (most under $100,000). A few other organizations who have undertaken scoring a project, have shared that the certified impact scorecard reports are completed post-project, so are not really helpful for raising grant funding pre project. A few organizations were funded by American Forests to score projects using the CFC Scorecard, but did not really see a fundraising use. These organizations also mostly raise large federal grants so did not see great value in raising smaller private grants.

Additionally, they largely see the reports as something to share with project/ organization donors post project completion and that donors really like having the impact report to share internally.

CLF believes it is still worth testing to see if a sample CFC Scorecard report could be used pre-project to raise additional grant funding to support new tree projects. CFC is already building some of the Scorecard metrics into their CFC Carbon Plus Credit application so data on a larger range of impact metrics for projects seeking carbon credit approval can be shared when going to market to sell the credits. CFC believes this information will provide further evidence supporting premium carbon plus credit pricing. CLF sees the Scorecard, when layered with urban forest carbon credits as a strategy to get closer to the true social cost of carbon.

Assessment of fit and interest from New England state urban and community forestry coordinators in City Forest Credits projects, and expected use of $1.5 billion in additional Inflation Reduction Act (IRA) funds for urban forestry.

CLF contacted state Urban and Community Forestry coordinators in New England to understand current levels of support for urban forestry and potentially identify carbon credit projects. Current USDA Urban and Community Forestry program funding to New England states is fairly modest ($250-350K per year) and has a matching requirement. As a result, grants available to communities for tree planting are also modest (up to $30-40K). The largest cities in the region tend to have their own tree trusts or apply directly for grants (e.g. TD Bank/Arbor Day Foundation). The coordinators were not aware of cities planting at a scale, especially planting on public land, that would make a City Forest Credit project viable, although individual cities like Hartford have ambitious tree planting plans and could be a site for a viable CFC project.

The Inflation Reduction Act includes an additional $1.5 billion in funding over 10 years for the Urban and Community Forestry program, with incentives (such as waiving the traditional 50% match) for federally-designated disadvantaged communities. The IRA funding opportunity is promising but state UCF coordinators (and cities like Hartford) are reluctant to apply for much higher levels of funding due to their own limited staff capacity and need to find additional matching dollars (in some cases). Individual NGOs we spoke with (such as Groundwork Rhode Island and Groundwork Lawrence) are likely to apply individually. There does not appear to be any attempt to scale urban forestry using these funds at a municipal, state or regional level. There also does not appear to be any regional strategy for deploying urban forest dollars in New England.

A detailed summary of findings by state is included in the appendix.

Assessment of fit and interest in City Forest Credits from municipalities and NGOs

Our original intent was to identify partners and launch a pilot Carbon Credit Plus project as part of this research. We heard about several obstacles to proceeding in discussions with municipalities and NGOs, including the City of Burlington, Vermont, and Groundwork Lawrence). These include:

- Challenges of assuming liability for delivering promised levels of tree survival and growth over a 26 year period, especially for NGO planting partners who do not have legal control of trees planted on public property.
- The lack of plantable space in public right of ways, which limits the number of trees that can be planted each year.
- CFC requires trees to be planted on public land to be eligible for credits. Many of the NGO planting partners we talked to plant some portion of trees on private property. At least one NGO plants predominately on private property.
- The relatively low amount of carbon credit revenue delivered over the 26 year period.
- A lack of political will to pass new urban forestry efforts, particularly during periods of leadership transition and/or just after other environmental initiatives (such as building code changes related to energy efficiency) have recently been adopted.

However, a few city arborists did express interest in exploring the opportunity but only towards the end of the grant term and working with them to stand up projects would require follow on funding. Another city arborist expressed interest but found there was not the political will at the moment given recent energy efficiency building codes that had been adopted, however, he indicated future potential to pursue a carbon credit plus initiative.

It is possible that framing urban forestry projects around the co-benefits (reduced energy use, stormwater retention, improved public health) rather than around carbon credits could generate more political and financial support. In general, partners we talked to were more interested in the climate resilience benefits of the urban forest than they were in the carbon sequestration benefits.

Development of carbon credit buyer screening criteria and best practices in using offsets in support of net zero claims

One critique of carbon credit sales is over claims of greenwashing. As a conservation organization and project facilitator, CLF would seek a private sale to a known buyer committed to using best practices in applying offsets to achieve a net zero objective. We would also seek a buyer who values both the carbon sequestration and the ecosystem service co-benefits quantified in the CFC protocol (value of improved air quality, storm water retention, and energy efficiency). CLF has developed a set of screening questions, summarized below:

Below are screening criteria for buyer of carbon credits generated through a CLF-supported project to ensure mission alignment with CLF, municipal and community partners

Determine how buyer intends to use the credits. It is important for CLF to know the ultimate buyer and user of the offsets and their intent.

- Will buyer use the credits itself to offset its own emissions (purchase and retire credits), resell the credits, or hold as an investment and resell later?

Does the buyer, or buyer's use of offsets, pose any reputational risks to CLF?

- Would credits be used to offset particularly harmful GHG pollutants such as methane, N2O?
- Is the buyer in an industry CLF is likely to challenge in court: e.g. oil, gas, coal, steel, cement, transportation?

Determine where the emissions being offset are located, to avoid unintended consequences.

- Will the use of offsets for one part of buyer's emissions result in harm to some other community, particularly an EJ community?

Is the buyer committed to following best practices in transparency and in using offsets to achieve science-based, net-zero results (reaching net zero by 2050 or before?)

Will the majority of the buyer's emissions reductions be achieved through direct reductions, with offsets only used for residual, hard to decarbonize emissions? For example, does the buyer support either of the following?

- Science Based Targets Initiative (SBTi): verified net zero claims.
- Targets are considered 'science-based' if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement – limiting global warming to 1.5°C above pre-industrial levels. Near term science-based targets or net zero targets are validated by SBTi against published criteria. Companies commit to annual reporting of their emissions. Science-based net-zero targets will require long-term deep decarbonization targets of 90-95% across all scopes before 2050. When a company reaches its net-zero target, only a very limited amount of residual emissions can be neutralized with high quality carbon removals, this will be no more than 5-10%.
- Voluntary Carbon Market Initiative (VCMI): voluntary practices in making net zero claims.

To reach the VCMI Gold Standard, company must be on track to achieve its next interim target for Scopes 1, 2, and 3 through emissions reductions within its value chain and have covered all (100 percent) remaining unabated emissions through the purchase and retirement of high-quality carbon credits. VCMI does not specify or rely on any particular pathway to reach global net zero consistent with 1.5 degrees Celsius global warming. Offers code of conduct but no independent validation of corporate claims.

Alternatively, is the buyer willing to make a climate contribution, as an alternative to using carbon offsets?

In making a *climate contribution*, a company funds a third party carbon emissions reduction project to reduce global carbon emissions, but does not claim the reductions as a credit against its own corporate emissions. A similar notion of a "mitigation contribution unit" was introduced into Article 6.4 at COP27.

Is the buyer likely to place a premium on the type of offsets generated through an urban forestry project registered with City Forest Credits?

- Is the buyer committed to the health and sustainability of the community where the urban forestry project is taking place? Do they have a stake in the eventual project outcome?
- Is the buyer committed to repeat purchases as credits are issued over the 25-year life of a CFC tree planting project, or 40-100 year life of a tree preservation project?
- Does the buyer recognize the value of the measurable co-benefits (air quality, stormwater mitigation, energy efficiency) and sustainable development goals (SDGs) associated with urban tree planting?
- Does the buyer see the additional value of the carbon removal benefits of tree planting over carbon avoidance?
- Does the buyer have an internal cost of carbon to guide its budget decisions? Does the internal cost of carbon approach the social cost of carbon?


Photo credit Mabel Lemaniel, Groundwork Lawrence

Spatial Opportunities for Tree Planting and Tree Preservation

As part of this project, researchers from the University of Connecticut conducted a spatial analysis of tree planting and preservation opportunities in each of the six mini-grant communities. This analysis dovetails with assessment of carbon credits in the section above.

The Urban Forest Carbon Program developed by City Forest Credits ("CFC") defines a set of Standards and Protocols that tree planting or preservation projects must follow in order to earn third-party verified carbon credits. These Standards and Protocols list a series of eligibility criteria that can be applied to any geographic context in the United States (see the protocol for full list of eligibility criteria).

A spatial analysis of the lands eligible for CFC tree planting or preservation projects was applied to the six New England communities for tree planting and tree preservation projects based on the most recently available protocols (CFC 2023). These communities included Burlington, VT; Lawrence, MA; Holyoke, MA; Springfield, MA; New Haven, CT; and Hartford, CT.

The purpose of this analysis was to estimate the physical capacity and extent of eligible lands within a New England community to participate in the CFC Urban Forest Carbon Program. The mini-grant communities were chosen as pilot case study locations because of the criteria used to allocate the mini-grant funding (e.g. cities with high rates of environmental justice concerns and proactive municipal urban forest management) (see Chapter 3), and they may serve as regional models where CFC protocol could have substantial impact and be implemented with the greatest expected success.

This analysis is intended to serve as a baseline that can be expanded upon to refine granular, place-based detail that cannot be applied without known priorities of the Project Operator.

Assumptions of this analysis include:

Tree planting

- Identified lands that are dig-ready and "easily" planted with broadleaf deciduous trees
- Identified alternative lands that are estimated to be plantable with greater logistical difficulty (via depaving, legal permissions in wetlands and riverfront zones, or areas immediately adjacent to buildings and roads)
- Excluded areas where trees must be planted by local ordinance or law*
- In areas < 5 acres, estimated 1 new tree planting per 10 ft*
- In areas > 5 acres, estimated 3 new tree plantings per 10 ft*

Tree preservation

- Identified lands that are estimated to contain contiguous extents of tree canopy cover (aka "urban forest patches")
- Excluded parcels protected in perpetuity or contains wetlands protection area*
- Included areas where local zoning allows for one or more non-forest use*
- Excluded local zoning overlay districts that prohibit new development*

Project operator

- Only considered lands owned by municipal government*

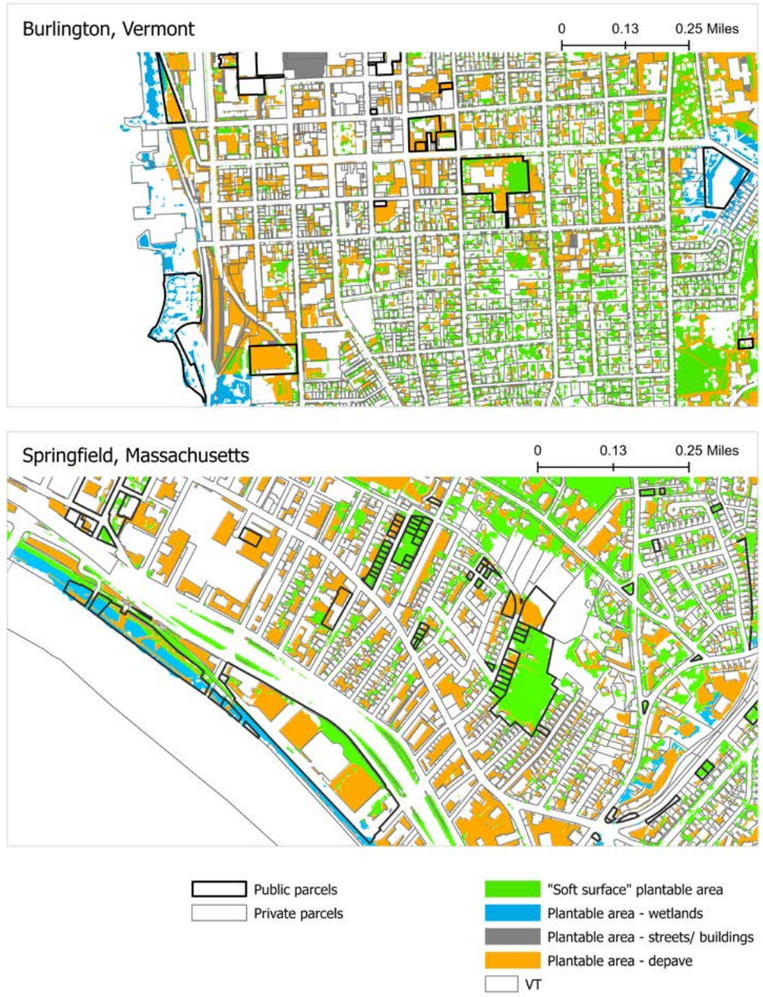
*Assumptions provided by CFC (2023)

Findings

Tree planting

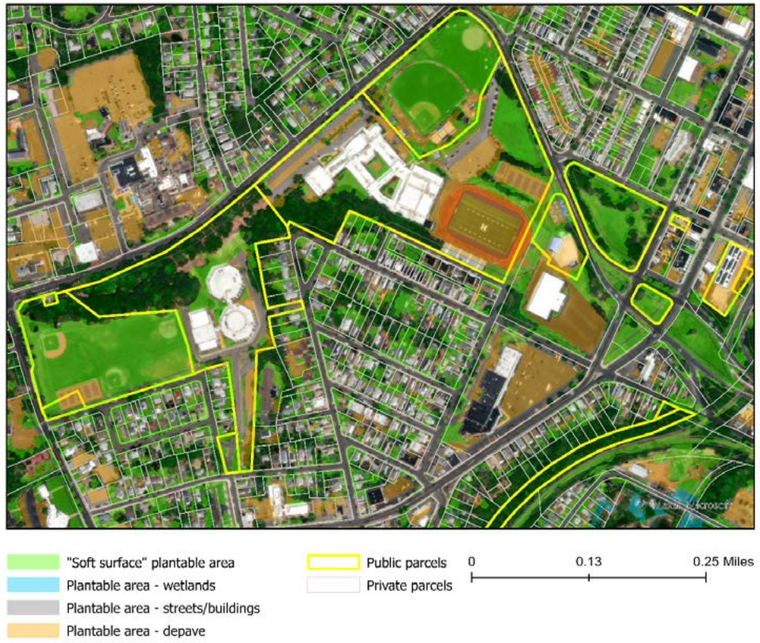
Municipal lands across all mini-grant communities have substantial opportunities to participate in a CFC tree planting project, based on the data inputs of this analysis. The greatest amounts of plantable space are "soft surface" (and "dig ready") but there is significant variation in the amount of eligible "soft surface" plantable space between mini-grant communities (Table 1) (e.g. 42 total acres of smaller plantable areas (< 5 acres) in Burlington compared to 581 acres in Springfield, Figure 1)

Figure 1. Example of plantable spaces across Burlington, Vermont and Springfield, Massachusetts. Springfield has a greater number of small public parcels compared to Burlington.



Alternate plantable space also abundantly exists in areas adjacent to streets and buildings, however there is a greater supply of plantable space within protected wetlands buffers and via depaving (Figure 2). While each alternative strategy may not only expand the options of plantable space and offer a unique set of co-benefits (e.g., reduced air temperatures from replacing pavements with trees, traffic calming from street trees), strategic tree planting within protected wetlands areas may offer the greatest variety of co-benefits and also cost the least.

Figure 2. Examples of alternate planting spaces near Holyoke High School. Areas outlined in yellow and filled in orange are public impervious surfaces (e.g. parking lots, vacant pavement) that could remove pavement to install new trees (known as "de-paving").



The abundance of plantable space across mini-grant communities may not be surprising, given the limited restrictions applied to the analysis. For example, the protocol specifications liberally permit that trees can be planted 10 feet apart (minimum) in areas less than 5 acres (or 1 tree/ 10ft), or less than 10 feet apart in areas greater than 5 acres (or 3 trees/ 10 ft)

While it is unrealistic to assume that all varieties of large broadleaf deciduous trees can be planted 10 feet apart or that all available space will be planted with trees, nonetheless, if only 30% of these eligible municipally-owned lands were to be planted with trees, each mini-grant community could likely actualize planting projects with 1000+ trees.

Table 1. Total extent of estimated lands eligible for tree planting, with municipal government project operators (as acres and # trees)

		Areas < 5 acres				Areas > 5 acres			
			Restricted Plantable Space				Restricted Plantable Space		
		"Soft Surface" Plantable	Wetlands and wetlands buffer	Streets and buildings	Depaving required	"Soft Surface" Plantable	Wetlands and wetlands buffer	Streets and buildings	Depaving required
CT	Hartford	85 ac 37,057 trees	11 ac 4,673 trees	34 ac 14,796 trees	72 ac 31,501 trees	12 ac 16,233 trees	-	-	50 ac 65,919 trees
CT	New Haven	247 ac 107,508	93 ac 40,633	38 ac 16,053	194 ac 84,211	176 ac 230,046	153 ac 200,292	-	74 ac 97,872
MA	Lawrence	92 ac 17,551	20ac 8,661	123 ac 197	123 ac 470	90 67,716	-	-	-
MA	Holyoke	154 ac 67,038	67 ac 22,013	56 ac 19,536	66 ac 25,581	118 ac 154,135	16 ac 21,182	6 ac 12,711	7ac 9,719
MA	Springfield	581 ac 97,832	105 ac 27,804	93 ac 31,342	154 ac 15,895	577 ac 465,508	69 ac 53,727	21 ac 27,473	90 ac 477
VT	Burlington	48 ac 15,701	26 ac 11,327	6 ac 2,682	39 ac 14,248	12 ac 16,141	-	-	6ac 2,720

Tree preservation

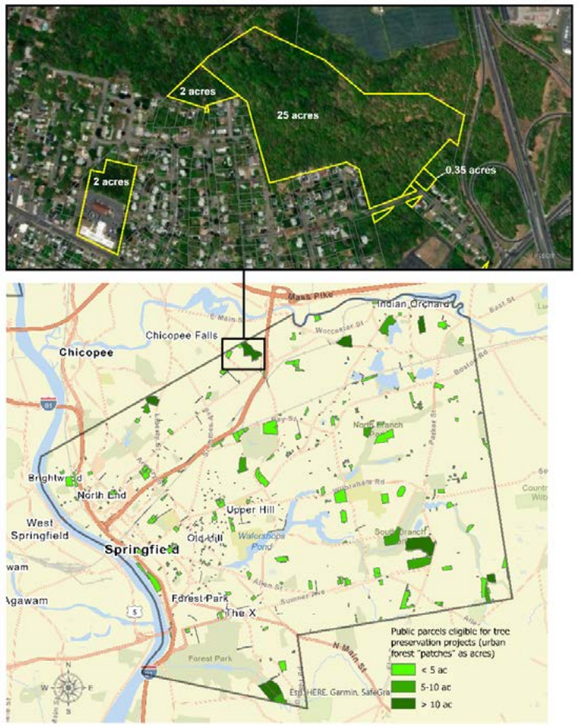
Eligible opportunities for tree preservation projects are far more limited than tree planting projects across the mini-grant communities (Table 2). While tree preservation projects totaling over 100 acres are estimated to occur in 4 out of 6 cities, there are relatively few contiguous extents of urban forest cover ("patches") greater than 5 acres across the eligible mini-grant communities.

Unlike the other mini-grant communities, Springfield has a noticeable amount of eligible medium- and larger-sized urban forest patches that may be worth further investigation as tree preservation projects (Figure 3). Holyoke, Burlington, and New Haven may also have several options worth pursuing as tree preservation projects.

Table 2. Total extent of estimated lands eligible for tree preservation, with municipal government project operators (as acres and # parcels)

			Total # of Parcels with Small-Medium-Larger Urban Forest Patches (as acres)		
		Total Eligible Tree Canopy Cover	Small < 5 acres	Medium 5-10 acres	Larger 10+ acres
CT	Hartford	42 ac (167 parcels)	166	1	-
	New Haven	173 ac (728 parcels)	722	4	2
MA	Lawrence	47 ac (133 parcels)	131	1	1
	Holyoke	480 ac (245 parcels)	236	4	5
	Springfield	356 ac (755 parcels)	738	10	8
VT	Burlington	143 ac (80 parcels)	73	4	3

Figure 3. Example of tree preservation project opportunities in Springfield, Massachusetts. Unlike other mini-grant communities, Springfield has several opportunities for higher-acre contiguous urban forest cover, aka "patches" (below); the analysis isolated urban forest cover from other land uses within the same parcel (above).



Based on the findings of this spatial analysis, the Urban Forest Carbon Credit Program could be a viable pathway for each of the six mini-grant communities in pursuit of a more robust urban forest. Individual Project Operators in the mini-grant communities can use this analysis as a starting point for identifying pilot project locations if they choose to participate in the Urban Forest Carbon Credit Program. More broadly, the findings of this spatial analysis are demonstrative of the types and quantities of planting and preservation sites that are commonly found in small- and mid-sized cities and can serve as point of reference for other communities that are considering involvement in the Urban Forest Carbon Credit Program. While specific place-based priorities, opportunities, and constraints will inform the individual decisions of potential Project Operators, this spatial analysis is an encouraging first step in proving the viability of the concept.

Conclusion

Growing the urban tree canopy in New England is a well-tested method to reduce the impacts of climate change, including the effects of extreme heat and increased precipitation that are projected to increasingly affect the region. It may also serve as a climate mitigation strategy to help sequester carbon and offset emissions. It is CLF's intent that *Advancing Climate Resilience and Health through Urban Forestry* provides a robust synthesis of the current state of urban forestry in New England and elsewhere in the country and serves as a roadmap for urban foresters looking to preserve, maintain, or expand the urban forest in their communities. This report identifies real, implementable solutions that urban foresters in New England and beyond will be able to overcome the shared challenges they face.

Through our own research and conversations with stakeholders, CLF has identified an implementation roadmap for successful urban forestry. Some communities may need to start at the beginning of the roadmap, while others have successfully completed the initial planning steps and may find the implementation steps helpful as they look for ways to accelerate their initiatives or overcome specific challenges. This report will be a helpful resource in either case.

Urban Forestry Implementation Roadmap

Step 1: Inventory and Analysis

It is increasingly clear that successful urban forestry programs must have a thorough understanding of the existing conditions of urban forests in their communities. A comprehensive and complete inventory is a prerequisite for maintaining equitable canopy coverage across the community, ensuring that the forest is diverse in age, species, and relevant management practices. For many new programs, creating a comprehensive and complete inventory of the urban forest is the first step. Though initially a daunting task, communities have used satellite imagery, drones, institutional and community volunteers, and computer databases to ease the financial and labor burden.

Developing and documenting a low-cost process for communities to generate a complete tree inventory with a baseline level of detail (canopy coverage, age, and species estimates) would significantly increase the number of communities that could have access to this tool.

Step 2: Visioning and Planning

With a thorough understanding of the existing condition of the urban forest provided by the inventory, it becomes possible to engage in a data-driven planning process that responds to the specific needs, priorities, opportunities, and constraints of a community. An urban forest plan:

- identifies a community's urban forestry goals relative to aesthetics, performance, equity, and other considerations;
- incorporates spatial analysis and community feedback to identify local relative strengths, weaknesses, opportunities, and constraints;
- includes species recommendations, planting strategies, and planting locations that address local site constraints, climate change threats, species diversity goals;
- recommends policies to address tree protection and preservation challenges at their root causes;
- suggests procedural changes that maximize resource efficiency and limit the time and financial costs of policy enforcement;
- and outlines a timeline and process for implementation based on known resource flows and limitations.

The planning process itself is a critical opportunity to bring together stakeholders. Many of the common challenges urban foresters face are best resolved by uniting and educating the stakeholders involved in urban forestry in a community: local government departments, mission-aligned non-profits, utility companies, institutional partners, volunteers, property owners, and residents. The planning process provides an opportunity to meet with each stakeholder group to understand their concerns and share opportunities for coordination, partnership, and collaboration. An effective and inclusive engagement strategy for residents, property owners, institutions, and other stakeholders is critical because they all have a role to play in stewardship of the urban forest. The planning process itself is an opportunity to educate stakeholders on the benefits of urban forests as well as ways they can support urban forest efforts using best practices. For example, meetings with utility companies may lead to agreements on tree- pruning techniques that address conflicts with overhead electric wires while maintaining the health of the pruned tree, reducing the maintenance burden of the urban foresters while simultaneously making progress on preservation of the urban forest.

At the conclusion of the planning process, a community will have a robust urban forest plan in place. The value of the urban forest plan extends beyond the document itself, and even beyond the unifying benefits afforded by the planning process. Many non-recurring sources of funding, from federal initiatives, state programs, and philanthropic grants look favorably upon or even require applicants to have approved plans in place in order to receive funds. As funding urban forestry is one of the most common challenges communities face, the value of having an urban forest plan should not be discounted. Today, most available urban forestry funding supports using awarded monies to develop an urban forest plan, though the administrative burden of doing so can be high.

Developing a guided, streamlined template for creating an urban forest plan could help offset this administrative burden, and could potentially offer regional urban forest planning benefits if certain components were standardized and the process had widespread use.

Step 3: Implementation

Implementation of a formal urban forest plan or informal urban forestry goals can often be expedited by increasing capacity and improving efficiency. Capacity can be added exponentially if a municipal urban forest team is able to engage with a local mission-aligned non-profit organization or organized groups of volunteers. Managing relationships with external partners can draw limited administrative resources away from other urban forestry tasks, so the success of this strategy relies on strong leadership and commitment from the non-profit organizations and volunteer groups. If roles and responsibilities are clearly defined, the extra support can help increase the operational scale. More formal non-profit partner organizations can often help at any stage of the planting, preservation, or maintenance process. Less formal groups of organized volunteers may be more limited in the types of tasks they can accomplish – less skilled work that doesn't require special equipment is more appropriate for these groups, but can be very impactful in addressing common challenges like stump removal (as part of site preparation for new plantings), watering, and planting of bare-root trees.

Efforts can be further expedited by working with other stakeholders to maximize efficiency. One example of this is collaborating with utility companies on using best practices for tree maintenance, so that only one team (the utility company) rather than two teams (the utility company and the urban forestry team) is maintaining certain trees. Another example of improving efficiency through collaboration with stakeholders is through inter-departmental coordination. Many other municipal departments interact with the urban forest as part of their jurisdiction. In many instances, these other departments are able incorporate urban forestry goals into their own areas of oversight if best practices are codified. For example, planning departments can assist with tree preservation if development permits are required to incorporate a tree preservation or tree replacement plan.

Creating specific tree-maintenance standards for utility companies to follow, or drafting policy templates to codify other urban forestry best practices, could help reduce the administrative burden for individual urban foresters.

Step 4: Funding

One of the biggest challenges in accelerating the growth of urban forests in communities is insufficient funding. This can come in the form of inadequate staff capacity, insufficient funds for purchasing trees or other necessary planting supplies and equipment, or unavailable funds to support necessary enabling steps, such as site preparation. To overcome these challenges, it is necessary to reduce costs, increase funds, or both.

Opportunities for cost reduction include reducing the cost of labor and reducing the cost of materials. While reducing labor

costs should not come at the expense of fair labor practices, engaging other stakeholders is a valid and valuable strategy to reduce costs.

There are many ways to reduce the costs of planting and caring for new trees. This includes reducing the cost of site preparation, reducing the cost of trees, and reducing the costs associated with caring for new trees. As documented earlier in this report, there are many ways communities have found to reduce these costs. Many of these strategies can be used in parallel, though there are occasionally tradeoffs when used in tandem. Individual communities will need to evaluate when and where these tradeoffs can be most beneficial. Communities with low capital funds but high volunteer rates may benefit from bare-root tree procurement, where volunteers can plant the lower-cost trees and help with young tree maintenance, offsetting the higher care costs. Communities that have more funding available for tree procurement but insufficient funding for tree maintenance and a smaller cohort of volunteers may find it more economical to plant more mature, balled-and-burlapped trees that have lower care costs. Identifying sites that are planting-ready (potentially through spatial analysis), or requiring tree plans for new development projects, can reduce site preparation costs by avoiding costly site remediation or planting materials, such as suspended pavement systems, necessary to retrofit sites to accommodate trees.

Securing additional funding is possible through non-recurring sources like grants or recurring sources like the voluntary carbon credit market. Additional funding may come with increased administrative requirements, require political capital and/or public support, or have limitations on the specific purposes for which the funding can be used. Here, too, urban foresters must decide which tradeoffs make the most sense for their communities. Easing the administrative burden of applying for additional funding would certainly help accelerate urban forestry initiatives, though care must be taken to ensure that suddenly increasing the supply of funds without simultaneously increasing the available labor or materials will likely result in the new funding being absorbed by higher labor and materials costs, rather than an increase in urban forestry implementation.

Finally, minimizing the conflicts that urban trees and urban forestry initiatives create or encounter can also accelerate urban forestry initiatives by reducing costs. In densely built communities, integrating urban forestry into capital projects during early project stages can reduce competition for space at later stages when it is more expensive to accommodate tree planting, eliminating the need for expensive site redesigns, structural soil, or suspended pavement systems. In areas with complex underground utility systems, comprehensive utility mapping can be used to identify available sites for tree planting. Selection of smaller tree species can play a critical role in reducing conflicts with overhead electric utilities or solar arrays. New policies that require the clustering of utilities on one side of the right-of-way can also free up space for trees over time.

Identified Gaps and Next Steps

Enterprising urban foresters have developed solutions to many of the common challenges they face. Combining these tested solutions with additional research and sharing them in this report can help urban foresters accelerate their efforts. However, beyond these proposed solutions, some additional questions remain for further research and study as there are still gaps in knowledge and practice. Further investigation into potential solutions through a combination of academic research or fieldwork projects could help identify solutions for these unsolved, commonly-occurring problems.

A follow-up assessment of the impacts and lessons learned from our mini-grantees during the implementation of their projects could yield new piloted solutions to some of these challenges, or at least uncover new information that suggests a next course of action. In addition, providing further financial or technical support to the mini-grant recipients may enable their pilot projects to have a bigger impact in the mini-grant communities, or allow the work to be replicated in other communities across New England and the United States.

Finally, though we were unable to identify and stand up a pilot carbon credit project during the grant term, in part because of perceived administrative and legal burdens, several partner communities expressed interest in further exploring the idea in the future. Other communities may also be interested in pursuing a carbon credit program, with technical assistance, based on the findings in this report.

Even as the goals of this research initiative have been met, ample opportunities to support New England's urban foresters remain.

Appendices

Appendix A: Mini-Grant Recipients

City of Burlington, Vermont

City of Holyoke, Massachusetts

City of New Haven, Connecticut

Groundwork Lawrence

Keney Park Sustainability Project

KNOX, INC.

ReGreen Springfield

City of Burlington, Vermont

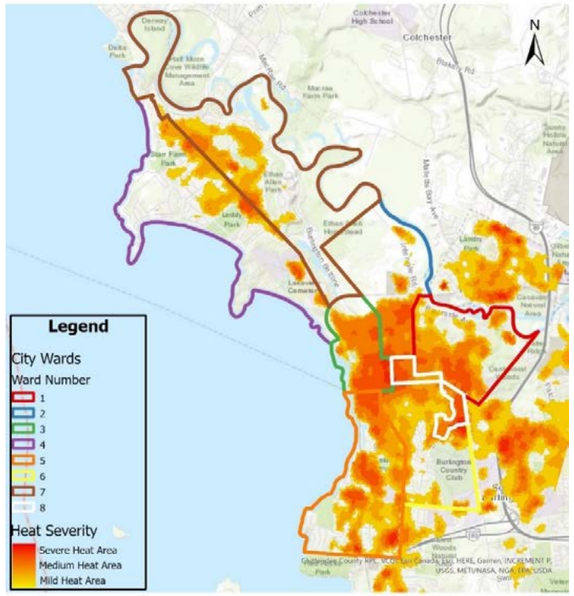
Community Overview

Burlington, VT, is that state's largest city with approximately 45,000 residents. Approximately 84% of Burlington residents identify as non-Hispanic white. The city's median household income is $59,331, compared to the State of Vermont's median household income of $67,674. The city's overall canopy is estimated at 42%, falling below its goal of 50%. However, tree canopy cover varies greatly from ward to ward; for example, Ward 8's canopy cover is estimated to be as low as 18%. Ward 8's median household income, excluding the area of UVM's campus, is $31,415, significantly lower than the city's average. Additionally, over 86% of housing units are renter-occupied in Ward 8, compared to 60% citywide. The map below shows heat severity throughout the city; typically, areas with lower tree canopy experience more severe heat than those with greater amounts of tree canopy. For example, all of Ward 8 (outlined in white) is shown as a severe heat area.

Unique Characteristics of City/Organization

The City of Burlington is able to acquire and plant trees at a much lower cost than many of their peer cities in New England. These cost savings are due to the city's partnership with a local nonprofit, Branch Out Burlington (BOB). BOB operates a bare root nursery and is able to provide trees at about $100 per tree, compared to the $200 to $300 charged by a commercial nursery. This partnership is estimated to save the City of Burlington over $20,000 annually, greatly increasing the impact of their urban forestry efforts. We believe others New England communities can learn from Burlington's success in reducing planting costs.

Burlington, VT Heat Severity by City Ward



Data from UVM, VT Center for Geographic Information, and American Forests (2019)

City of Holyoke, MA

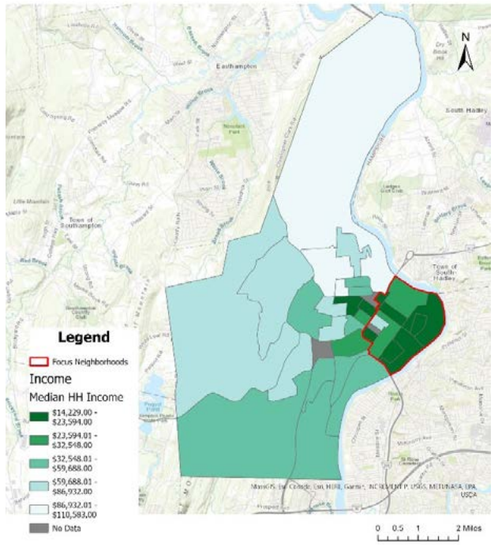
Community Overview

Holyoke, MA is a city of nearly 40,000 people but the city's population has been in decline in recent years. More than 75% of Holyoke residents live in environmental justice (EJ) communities as defined by the Commonwealth. An EJ community is a block group that meets one or more of the following criteria: 1) annual median household income is 65% or less of the state's median, 2) minorities make up 40% or more of the population, 3) 25% or more of households speak English less than "very well", and/or 4) minorities make up 25% or more of the population and the median household income of the municipality does not exceed 150% of the state's median. Holyoke's EJ communities experience much greater heat severity than the rest of the city, something that is likely attributable to low tree canopy and high rates of impervious surface. The immediate focus of Holyoke's urban forestry efforts is to prioritize canopy expansion in these areas dominated by impervious surfaces. In particular, there are four priority neighborhoods: Churchill, Downtown, the Flats, and South Holyoke.

Unique Characteristics of City/Organization

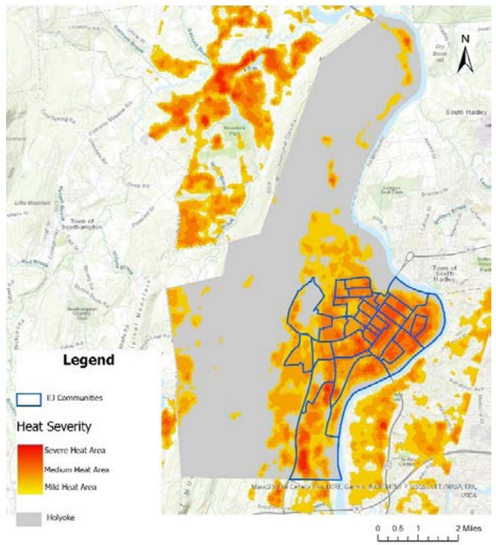
The City of Holyoke has been actively working to improve its urban forest. Holyoke is an active participant in the state's Greening the Gateway Cities program and, August 2021, the city completed its Urban Forest Equity Plan and a partial public tree inventory. The project focused on four priority neighborhoods of the city; these neighborhoods were prioritized since they have lower existing canopy, lower incomes, and a larger non-white population than other areas of Holyoke.

Holyoke, MA Median Household Income



Data from MassGIS (2020), the US Census Bureau (2020), & City of Holyoke

Heat Severity in Holyoke, MA Environmental Justice Communities



Data from MassGIS (2020), the US Census Bureau (2020), & Trust for Public Land (2019)

City of New Haven, CT

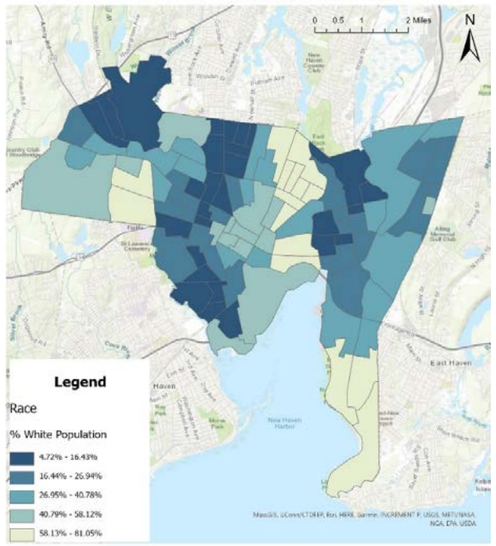
Community Overview

New Haven, CT is a coastal city of about 135,000 residents. Over 70% of New Haven's residents are non-white; 34% of residents identify as Black and 30% identify as Hispanic or Latino. The city's median income is $48,973, compared to the statewide median of $83,572. 24.6% of New Haven residents are in poverty, while the statewide poverty rate is 10%.

Unique Characteristics of City/Organization

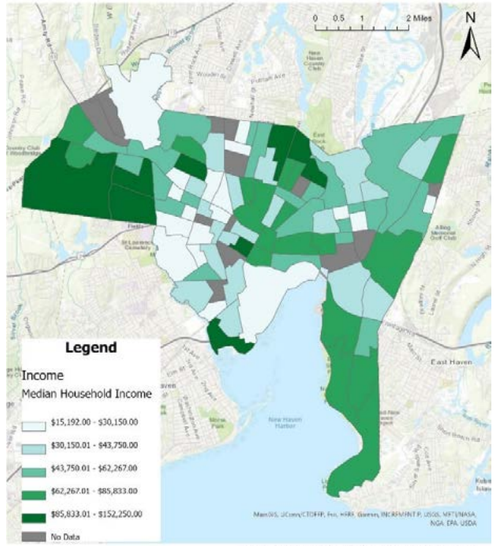
An analysis from the University of Vermont suggests that tree canopy is inequitably distributed throughout the city, with canopy cover ranging from 6-64% by neighborhood. This inequitable distribution of canopy results in inequitable access to the associated benefits of the urban forest such as improved air quality and mental health. The mission of New Haven's Tree Division is to ensure fair access to trees and their benefits for all current and future residents.

New Haven, CT Race by Block Group



Data from US Census Bureau (2020) and the State of Connecticut

New Haven, CT Income by Block Group



Data from US Census Bureau (2020) and the State of Connecticut

Groundwork Lawrence (GWL)

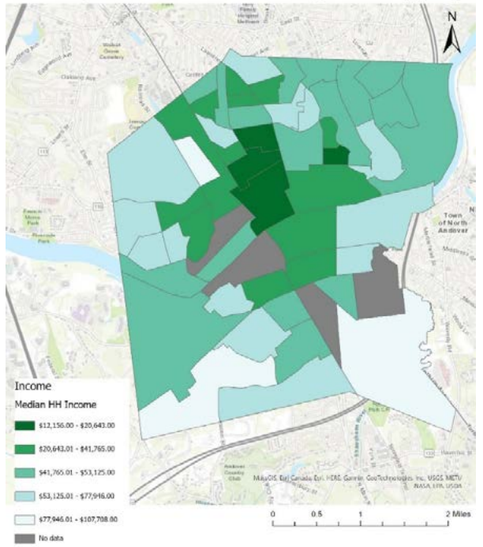
Community Overview

Lawrence, MA is home to over 88,000 residents. Approximately 81% of Lawrence residents are Hispanic and 40% of residents are foreign-born; statewide, almost 80% of Massachusetts residents are white. The poverty rate is 21%, which is significantly greater than MA's overall rate of 9.4%. Likewise, Lawrence's median household income is $45,045, compared to $84,385 for the state's median. 31% of Lawrence youth live in poverty and many children and their families struggle with economic, environmental, and public health disparities.

Unique Characteristics of City/Organization

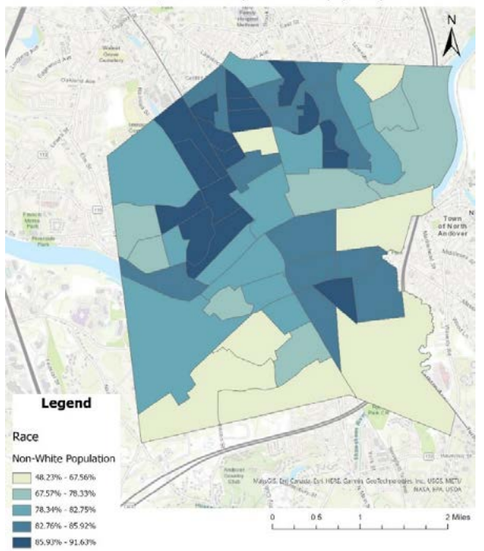
GWL works to improve Lawrence residents' lives by improving their physical surroundings. GWL deploys a collaborative, community-wide, and people-centered approach in the development of green spaces and the restoration of the environment in the city, ensuring all stakeholders are invested in the project. They are primarily responsible for planting new trees in the city and are also responsible for many of the city's parks, trails, and green spaces. The core of GWL's work is listening to residents and designing programs that meet their needs.

Lawrence, MA Median Household Income by Block Group (2020)



Data from MassGIS and US Census Bureau (2020)

Lawrence, MA Race by Block Group (2020)



Data from MassGIS and US Census Bureau (2020)

Keney Park Sustainability Project (KPSP)

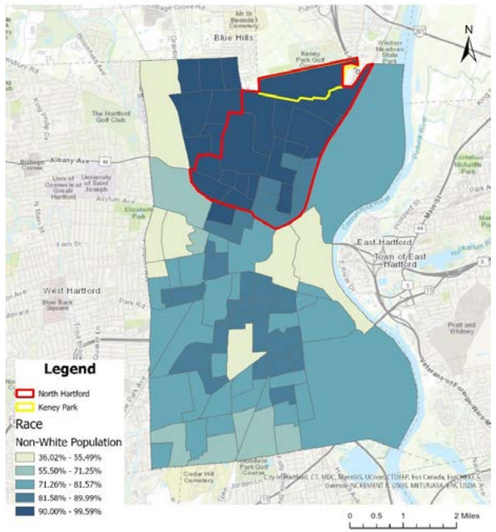
Community Overview

Keney Park is located in North Hartford, a neighborhood of Hartford, CT. North Hartford is a federally-designated Promise Zone. HUD reports that North Hartford has extremely high rates of unemployment, violent crime, and food insecurity. This area is one of the poorest in the country – 50% of North Hartford residents live in poverty, a stark contrast to Connecticut's overall poverty rate of 10%. The neighborhood's residents are predominately Black and Latino. The construction of Interstate 84 after World War II led to a sharp decline of the neighborhood and its residents have faced severe challenges since.

Unique Characteristics of City/Organization

KPSP works to mindfully engage the community with the park and conducts a wide range of activities to help residents discover the healing power of nature. KPSP engages youth in trail maintenance, including milling and selling the wood gathered, distributes fresh locally grown food, and distributes garden kits to Hartford residents. KPSP is an active partner with the City of Hartford, Riverfront Recapture, UConn, Yale, and the CT Department of Energy and Environmental Protection. With these partners, KPSP has been involved in developing and implementing city afforestation plans and other large-scale climate and farming initiatives.

Hartford, CT Race by Block Group



Data from City of Hartford and the US Census Bureau (2020)

KNOX, INC.

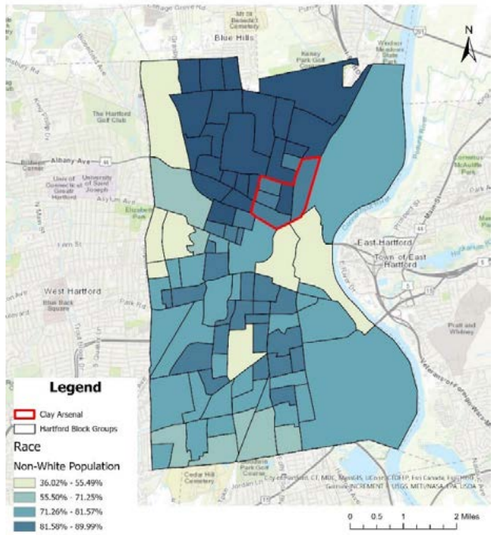
Community Overview

KNOX, Inc. serves the City of Hartford, Connecticut where 45% of residents identify as Hispanic or Latino and 37% identify as Black. Hartford is a distinct outlier in Connecticut regarding its racial makeup – over 80% of residents are non-white, compared to only 20% statewide. 45% of Hartford residents speak a language other than English at home which is significantly greater than the 22% reported across the state. Hartford's poverty rate is 28%, while the state's is 10%. Clay Arsenal, where planting efforts are focused, is primarily Latino/Hispanic.

Unique Characteristics of City/Organization

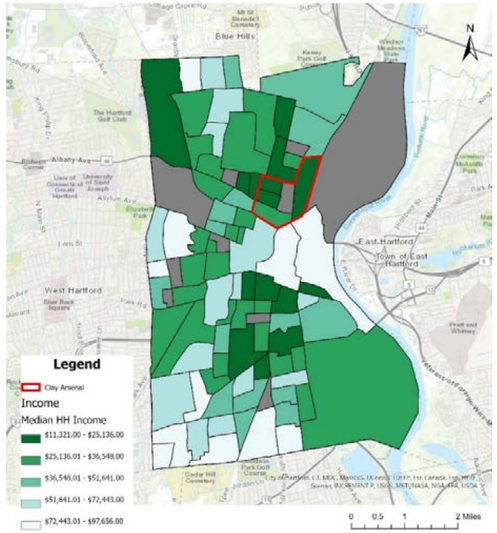
The City of Hartford released its Tree Canopy Action Plan in 2020, which identifies KNOX as a key partner in strengthening the city's canopy and training residents in tree care. KNOX has decades of experience growing and protecting Hartford's urban forest. Since 2004, KNOX has planted and maintained over 6,000 trees in Hartford, including about 500 in 2022. KNOX sustains a 93% survival rate for all trees they plant. Equity is not only a driving factor for KNOX's tree planting, but it is also a key component of its workforce development program. Much of their tree planting work is done through KNOX's Green Jobs Apprenticeship program which is primarily participated in by Black or Latinx/Hispanic residents between the ages of 18 and 35.

Hartford, CT Race by Block Group



Data from City of Hartford and the US Census Bureau (2020)

Hartford, CT Median Household Income



Data from City of Hartford and the US Census Bureau (2020)

ReGreen Springfield

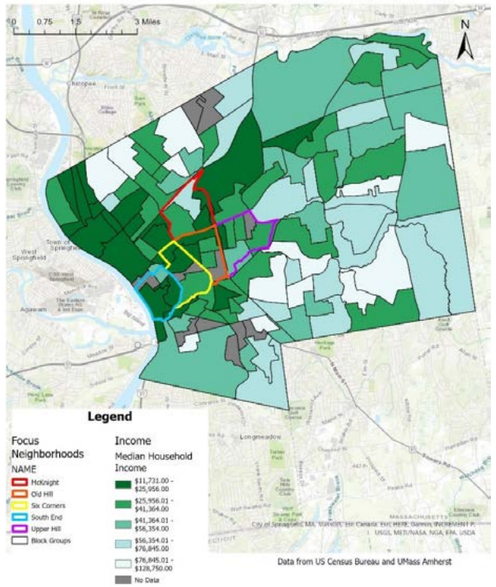
Community Overview

ReGreen Springfield is a nonprofit working in Springfield, Massachusetts. They undertake a wide range of projects related to urban forestry and environmental justice. Their efforts focus on some of the city's lowest-income neighborhoods: Upper Hill, Old Hill, South End, Six Corners, and McKnight. These neighborhoods are also home to large communities of color. More than 75% of residents in these neighborhoods are people of color, compared to the citywide average of 70%. The median household income across these neighborhoods is $29,058, compared to $43,308 citywide.

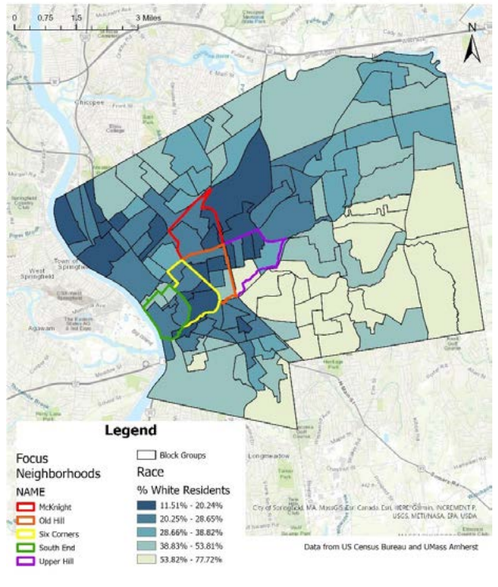
Unique Characteristics of City/Organization

Although ReGreen Springfield is an organization focused on tree advocacy efforts in Springfield, they partner and build strong relationships with many organizations including US HUD, US Fish & Wildlife, the City of Springfield, and UMass Amherst. In their environmental justice initiative, they use skills and knowledge of their partners whenever possible. In return, ReGreen Springfield shares all data and findings that result from their work. In addition to their organizational network, ReGreen Springfield has developed a strong and diverse network in the Springfield community. For most of their projects, they work with translators from Springfield Technical Community College to provide outreach in a variety of languages.

Household Income by Block Group (2020)



Race by Block Group (2020)



Appendix B: What We Heard: Mini-Grant Surveys

As part of the *Advancing Climate Resilience and Health through Urban Forestry* mini-grant program, municipal governments and community groups participated in a short online survey and 60-minute interview conducted over Zoom. The survey and interviews helped CLF and UConn staff to ground truth desk research on urban forestry efforts and supplement with important on-the-ground community perspectives. The survey and interviews were conducted in the spirit of fostering peer-to-peer learning and collaborative dialogue with other New England entities focused on accelerating urban forestry in their communities. The following pages contain the synthesized results from the online survey.

Survey Results

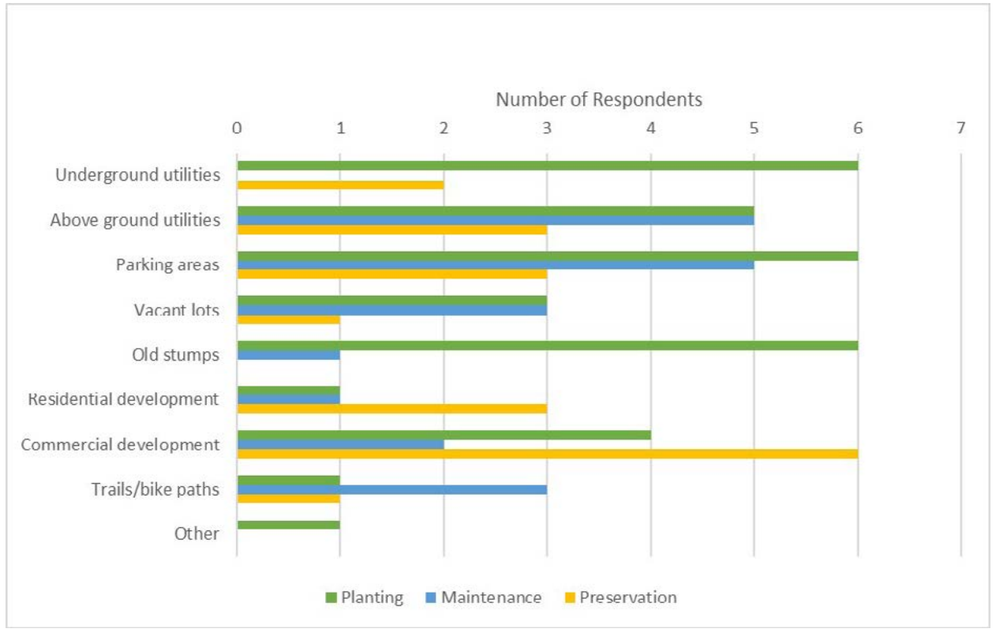
All participants of the mini-grant program completed a short-form survey about their experiences with urban forestry in New England. The surveys were distributed to grant recipients in February, and they were given approximately two weeks to complete their responses. Below, we synthesized survey responses from all participants.

General Urban Forest Activities

Urban Forest Conflicts

6 out of 7 respondents reported underground utilities, above ground utilities, and old stumps as barriers to tree planting. 1 respondent (GWL) noted an additional planting barrier being "insufficient size and soil volume in tree pits and planting strips." 5 out of 7 respondents reported above ground utilities and parking areas as barriers to tree maintenance. 6 out of 7 respondents reported commercial development as a barrier to tree preservation. This was an interesting result since many tree ordinances and urban forest plans focus on residential development as a major issue, rather than commercial development.

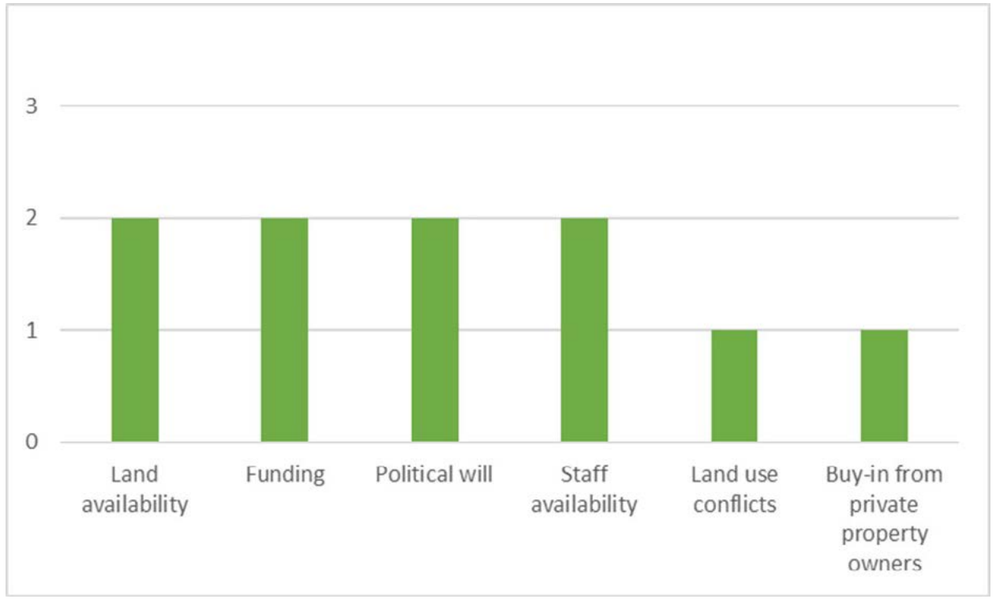
Chart 1. Urban Forest Conflicts



CBOs – Biggest Barriers to More Tree Planting

Land availability, funding, political will, and staff availability were the most commonly reported barriers across respondents.

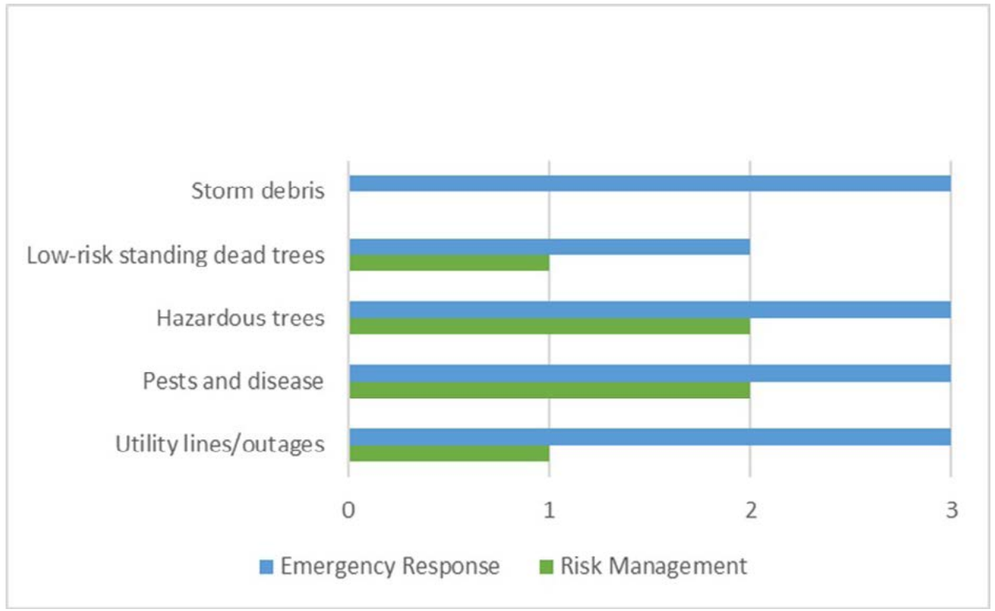
Chart 2. Barriers to More Tree Planting



Municipalities – Risk Management & Emergency Response

Risk management is work done proactively to prepare for and/or prevent circumstances such as pest infestations or utility conflicts. Emergency response is reactive work done in order to recover from an event or circumstance such as pest infestations or storms. Emergency response protocols were more common than risk management protocols for our municipal respondents.

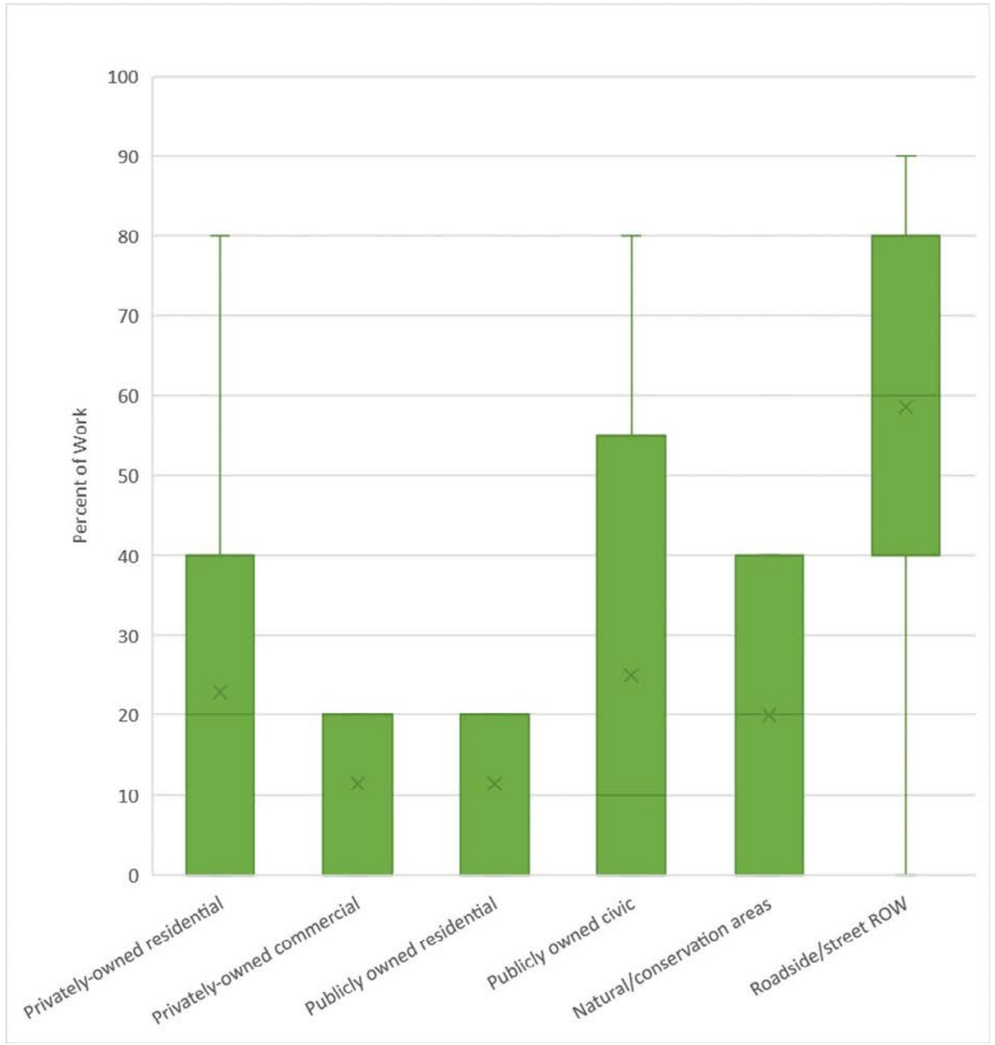
Chart 3. Risk Management & Emergency Response Protocols in Place



Focus of Urban Forestry Work

All respondents were asked how much of their work is focused on different categories of land. On average, respondents' work, including both municipalities and nonprofit planting partners, is mostly focused on trees along the road and in the ROW. Planting on publicly owned land was the second most common category of land.

Chart 4. Focus of Urban Forestry Work by Land Type



Legal Responsibility of the Urban Forest

Since the urban forest is located across many different categories of land, legal responsibility is often shared among several stakeholders. For all survey respondents, municipalities hold the greatest share of the legal responsibility (63%).

All of the grantees reported that property owners are responsible for the trees located on private residential and commercial property. Joint responsibility, shared between the municipality and property owner, was uncommon.

Chart 5. Share of Legal Responsibility

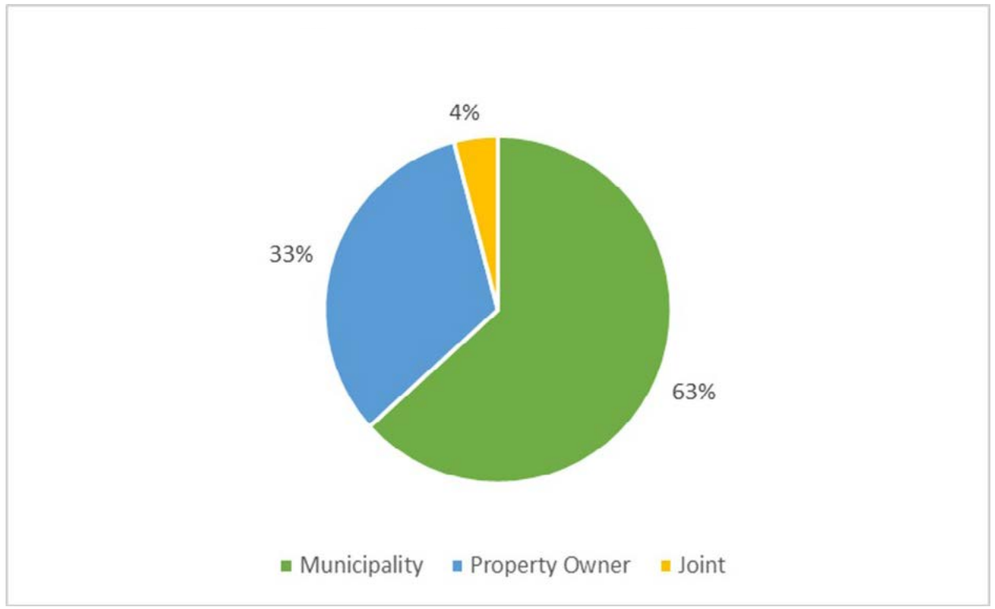
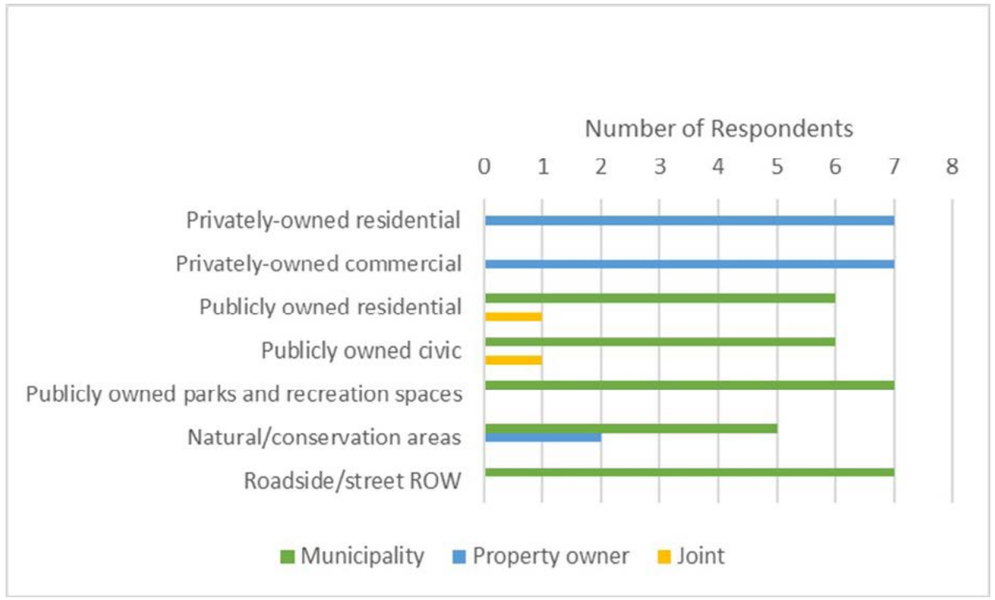


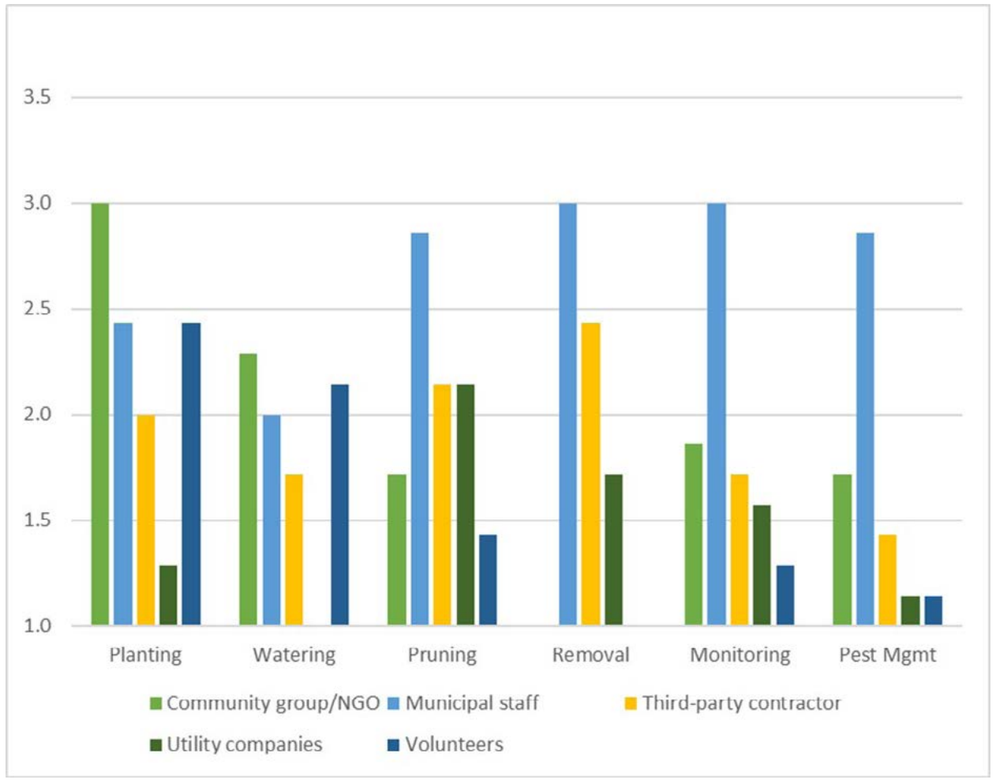
Chart 6. Who is Legally Responsible?



Division of Responsibility Across Urban Forest Stakeholders

e level of responsibility of each urban forest stakeholder varies by community and task. For all activities other than planting and watering, municipal staff have, on average, the greatest degree of responsibility. Community groups/NGOs, on average, have the greatest degree of responsibility for tree planting and watering in our grantees' cities. On the graph below, responsibility is shown on a scale of 1 to 4, with 1 representing the lowest degree and 4 the highest degree of responsibility.

Chart 7. Division of Responsibilities



Urban Forest Stakeholder Partnerships

3 of 7 respondents assigned primary responsibility of the urban forest to the municipality. In all 3 cases, this was specifically in reference to trees on public property and in the right-of-way. The City of New Haven is primarily responsible for tree maintenance on public property and in the right-of-way, but a community partner is responsible for tree planting. In Hartford, CT, and Lawrence, MA, the corresponding CBOs and/or third-party contractors are primarily responsible for the urban forest (KPSP, KNOX, GWL).

All respondents other than Groundwork Lawrence and KPSP reported having a partner. Surveyed municipalities indicated they partner with CBOs (Burlington, New Haven) or state agencies (Holyoke). CBOs indicated they partner with their respective municipality.

All of our CBO respondents have permission to plant on public property. Each CBO has a formal arrangement with the municipality including MOUs, license agreements, and planting contracts. With the exception of Groundwork Lawrence, all CBO respondents primarily plant on public land (70-100%).

Municipal Tree Inventory

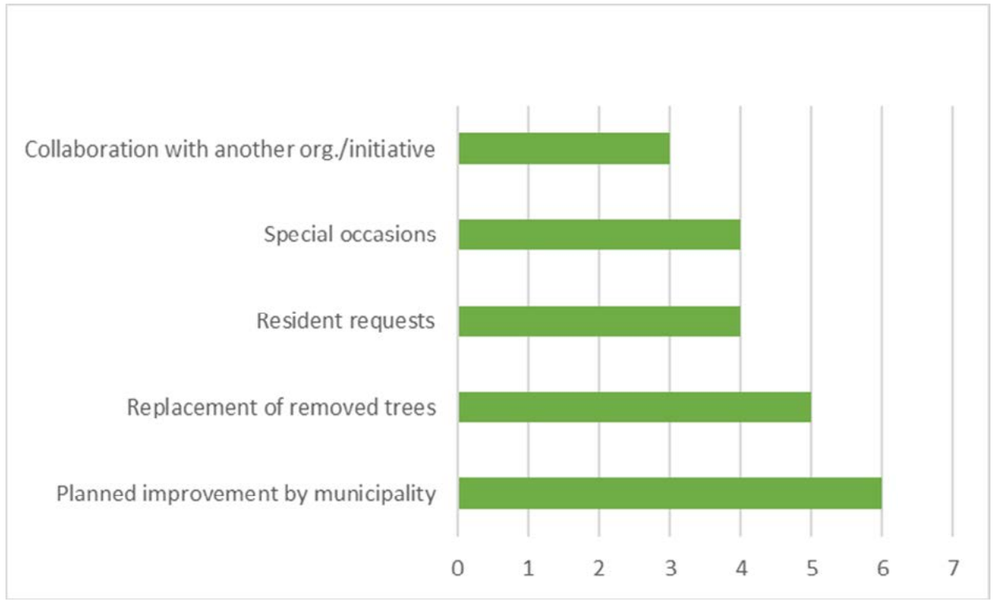
All of the respondents operate in municipalities with a tree inventory. The City of Burlington and City of Holyoke reported a current inventory, while the City of New Haven reported a developing inventory. However, none of the inventories include trees on private property.

Tree Planting Details

Approach to Planting Trees

Tree planting is motivated by a variety of factors. The most common factor cited by grantees was planned improvement by the municipality (all except Holyoke). Replacement of removed trees was also a common motivation, reported by 5 of the 7 respondents.

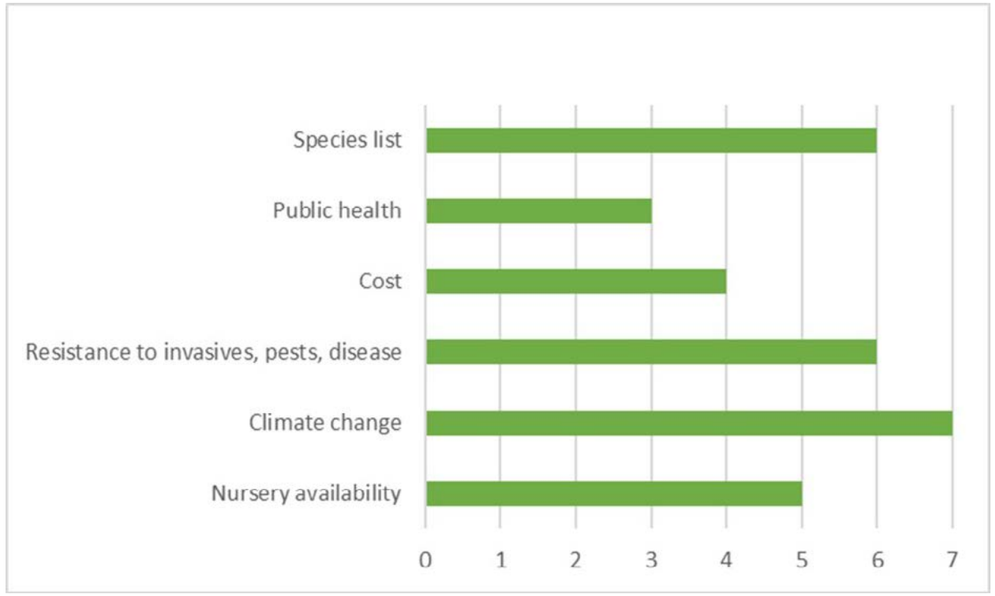
Chart 8. Approach to Tree Planting



Selecting Tree Species to Plant

Multiple factors contribute to our grantees' decisions on which trees to plant. Climate change was the only factor that all 7 grantees cited as contributing to their decision. Public health impact was cited the least frequently, with only 3 grantees taking it into consideration (GWL, KPSP, ReGreen Springfield).

Chart 9. Species Selection Factors



Planting Records

The City of Burlington, GWL, City of New Haven, and ReGreen Springfield have pre-2018 planting records and records for the past 5 years. The City of Holyoke has estimates for pre-2018 and the past 5 years. KPSP and KNOX do not have records or estimates.

Tree Planting (2018-2022) - Top 3 Reported Genera

	Municipal Planting in Parks	Municipal Planting in Streets/ROW	Municipal Planting in Other Public Places	CBO Planting
1	Quercus	Gleditsia	Liquidambar	Tie: Acer/Betula/ Platanus/Quercus/ Zelkova
2	Platanus	Malus	Acer	
3	Acer	Tie: Acer/Syringa/ Ulmus	Tilia	

Note: not all respondents provided numbers, so this data is incomplete

Tree Preservation Details

Municipalities – Land & Tree Preservation Initiatives

Each municipality has more than one entity leading land and tree preservation initiatives. The Department of Parks and Recreation, Department of Public Works, and Natural Resources/Conservation Commission were each mentioned twice.

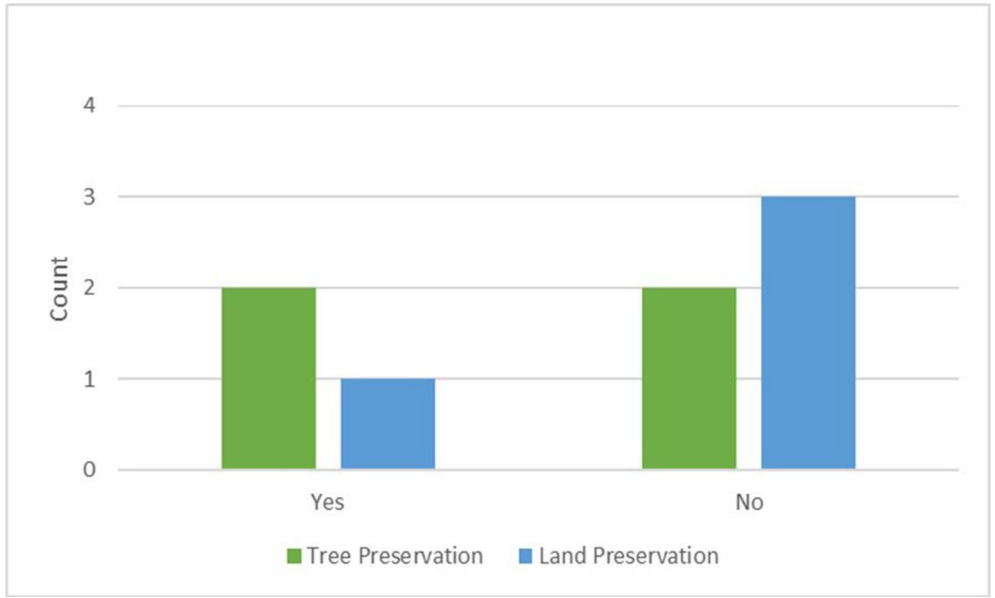
The City of Burlington and City of Holyoke both had land protection projects in the last 5 years.

City	Project	Acres	Time
Burlington	N/A	35	2-3 years
Holyoke	Gloutak Woods	51.72	1.5 years
Holyoke	Anniversary Hill Park	14.1	2 years

CBOs – Land & Tree Preservation Initiatives

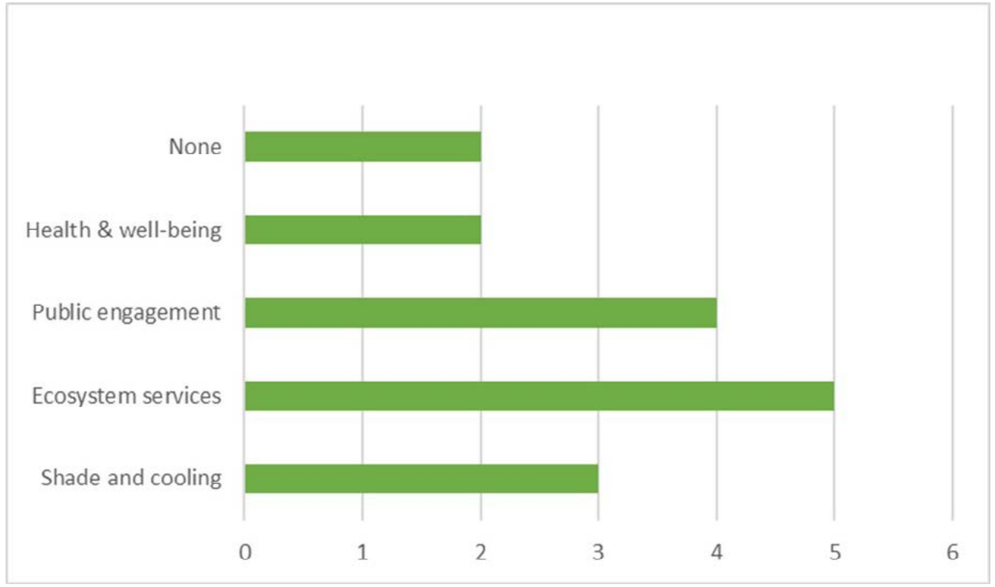
GWL and KNOX do not participate in land or tree preservation efforts. KPSP participates in both. ReGreen Springfield participates in tree preservation efforts, but not land preservation efforts.

Chart 10. CBO - Preservation Efforts



Equity in the Urban Forest

Chart 11. Tracked Benefits and Outcomes



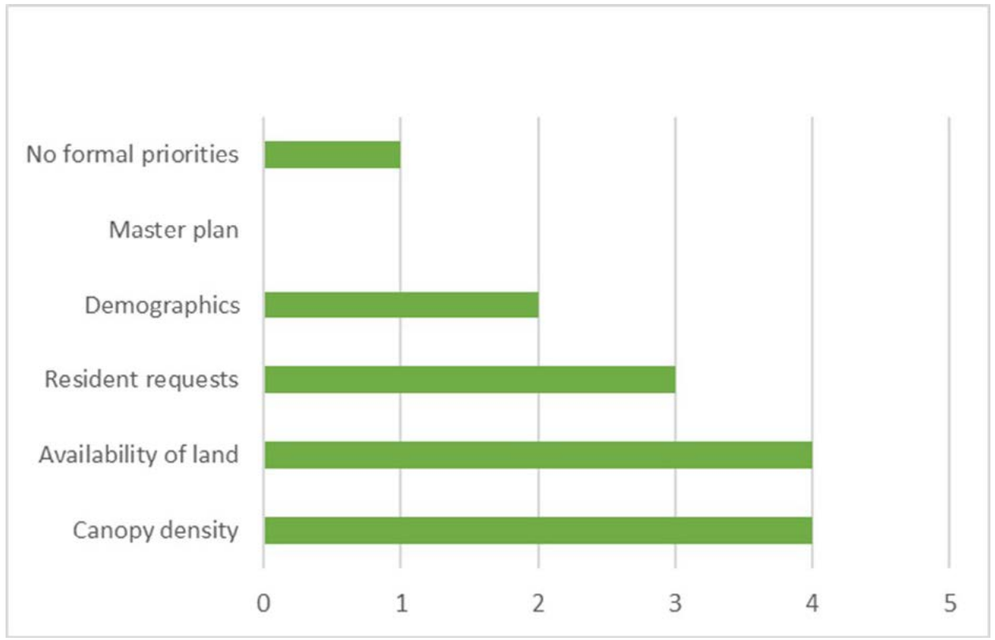
Tracking Urban Forest Co-benefits

A healthy urban forest provides many co-benefits to the surrounding community. 5 of our 7 respondents reported that they somehow track certain co-benefits. There is no standard or universally-accepted way of tracking/accounting for these benefits, so further information should be sought in the interviews.

Prioritizing Budget for Tree Planting and Maintenance

6 of 7 respondents have a formal way of prioritizing their urban forest budget (KPSP does not). All but one (GWL) of the respondents that reported a prioritization approach incorporate multiple factors. Land availability and existing canopy density were the most frequently cited factors. No respondent selected an existing master plan as a contributing factor. All respondents other than KNOX have assessed the relationship between neighborhood demographics and tree canopy.

Chart 12. Budget Prioritization Factors



Rental Properties and the Urban Forest

In general, renters are more likely to live in areas with low canopy cover than homeowners. Growing, maintaining, and preserving trees on rental properties can be a challenge for urban forest stakeholders. Three respondents (ReGreen, New Haven, and GWL) indicated they have a method for engaging renters and/or rental property owners.

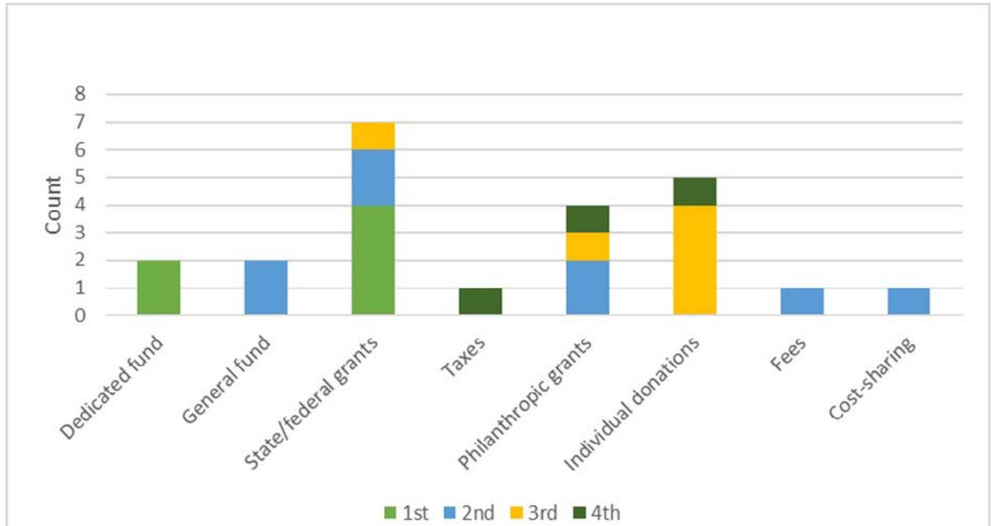
Greatest Opportunities and Barriers for Growing and Preserving the Urban Forest

	Opportunities	Barriers
Canopy Growth	Private land; undeveloped land; streets; small parks; strategic master plan; road diets; low canopy areas; new construction requirements	High density development; not enough staff; lack of municipal support; old stumps; standing dead trees; lack of funding; inadequate capacity for watering
Canopy Preservation	Strategic master plan; private land	Lack of stewardship; lack of municipal support; lack of resources for tree care on private land; lack of funding; inadequate capacity for watering

Finance and Budget

Funding Sources for Tree Planting & Maintenance

Chart 13. Urban Forest Funding Sources Ranked

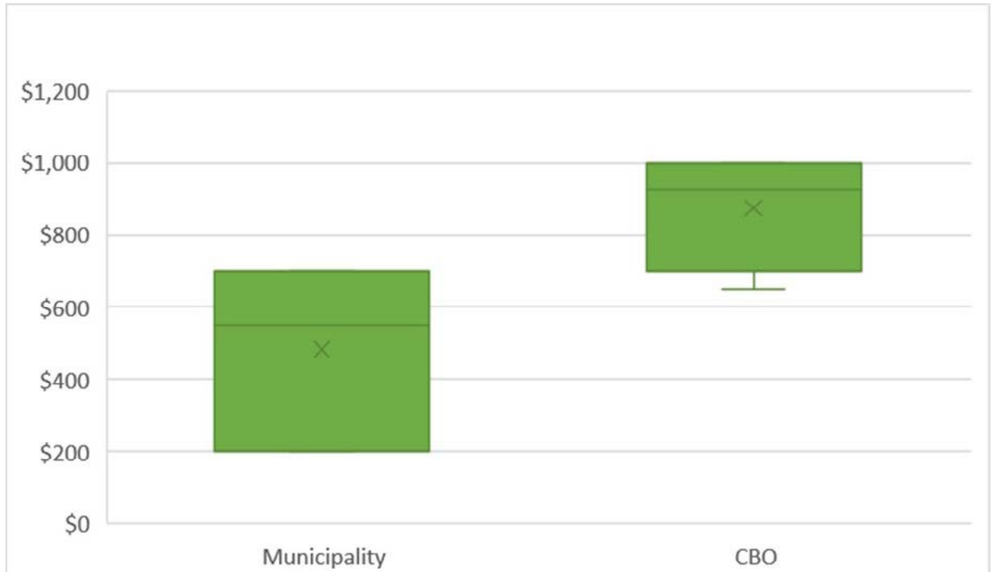


Respondents were asked to rank various revenue sources in order of their contribution to the overall budget for tree planting and maintenance. No respondent selected the following options: assessment district, emergency management/hazard mitigation fund, endowment, revenue sharing, and wood product sales.

All respondents other than KNOX said they are aware of IRA funding for urban forestry activities. Respondents that were aware of the funding opportunities are planning to apply, except for the City of Holyoke who are hoping to learn more about available funding opportunities.

Planting Costs

Chart 14. Planting Cost Per Tree



The cost of planting one tree varied among respondents. It also varied between the two respondent groups, with CBOs reporting a higher average cost than the municipalities.

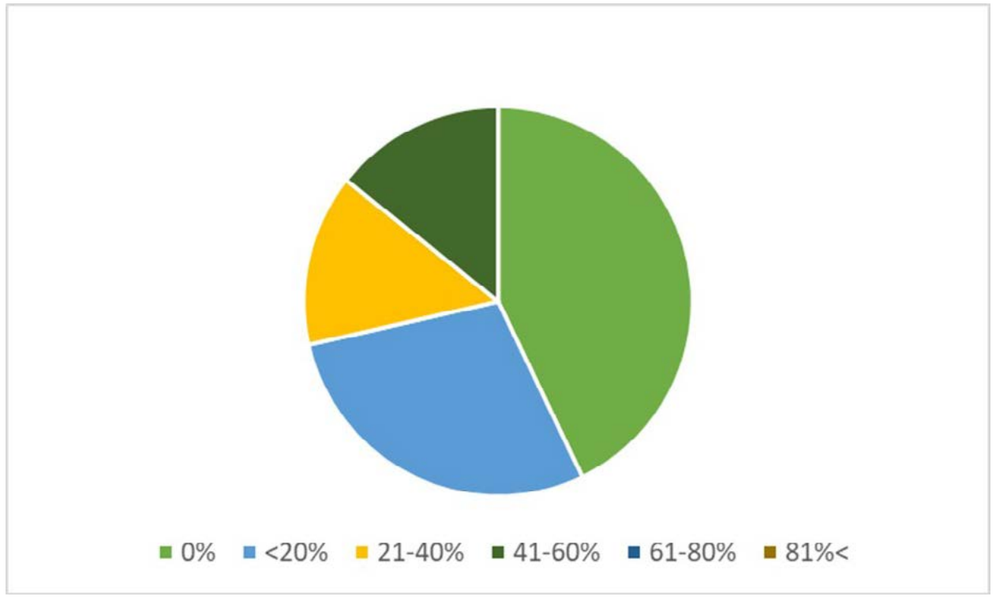
Maintenance Costs

There is wide variation between the maintenance costs reported by respondents.

Respondent	Annual Cost per Tree	Maintenance & Age of Tree
City of Burlington	$40	New trees require more water, but no significant cost difference
Groundwork Lawrence	N/A	N/A
Keney Park Sustainability Project	$250	Older trees need less watering but more pruning – no significant cost difference
City of New Haven	$25 ($75 every fifth year)	N/A
ReGreen Springfield	$175	Org. mainly maintains new trees, so unsure
City of Holyoke	N/A	Older trees have more expensive pruning needs – not sure of maintenance costs
KNOX, Inc.	$140	No relationship

Current Budget

Chart 15. Gap in Urban Forest Budget Relative to Need



3 of 7 respondents reported that their budget is adequate to meet current needs (City of Burlington, GWL, KNOX). The greatest budget deficit was reported by the City of New Haven (41-60%).

Respondents said more funding is needed to increase staff, access resources for tree planting, proactive maintenance, improved equipment, and address maintenance backlogs.

Appendix C: State Urban Forestry Program Research Summary

Based on interviews with state coordinators funded through the USFS Urban and Community Forestry program) updated 3/8/23

	ME	VT	NH	MA	RI	CT
Urban and Community Forestry coordinator	Jan Santerre	Elise Shadler	AJ Dupere	Julie Coop	Lou Allard	Danica Doroski
State UF program funded by USFS	Project Canopy	Caring for Canopy Resilient Urban Forests For All	NH Community Forestry program	MA Urban and Community Forestry Challenge Grants	RI Urban and Community Forestry Program	CT Urban Forestry program
UCF Partners		UVM Extension, VT Urban & Community Forestry Council	Community Forestry Advisory Council, UNH Extension	MA Tree Wardens' and Foresters' Association	RI Tree Council	UConn Extension CT Urban Forest Council
Annual amount of USFS UCF funding	$200K		$200-250K	$350K	$300K	
State Match of USFS Funding			State trust supporting NH Urban Forestry Center			RGGI auction proceeds; ARPA funding

	ME	VT	NH	MA	RI	CT
Urban Forestry staffing	1 FTE coordinator + 1 FT outreach coordinator	1 FTE coordinator + 1 TA coordinator	1 FTE coordinator + 1 other FT and some $ to UNH Extension	1 FTE coordinator + 1 FT Community Action Forester	1 FTE coordinator + 2 PT volunteer coordinators at RI Tree Council	1 FTE coordinator
# of Communities Managing Urban Forest Resources	46/519 8.8%	20/246 8.1%	23/234 9.8%	60/351 17.1%	7/39 17.9%	39/169 23.1%
# of Communities Developing Urban Forest Resources 2022	134/519 25.8%	82/246 33.3%	48/234 20.5%	114/351 32.5%	18/39 46.2%	41/169 24.3%

	ME	VT	NH	MA	RI	CT
Other sources of UF funding	$1M ARPA funding thru governor's office for Burlington. Tied to VT climate action plan Plant 5000 trees in VT to combat climate change		$50K of federal bipartisan infra. law (BIL) is being directed toward supporting urban forestry in underserved communities	Greening the Gateway Cites is a separate $3M state funded program	RI received a $100K USFS State Urban Forests Resilience Program grant for "Incorporating Equity into Tree Planting" using AF Tree Equity Analyzer. An Energy Saving Tree program is funded through the Arbor Day Foundation and state RGGI proceeds. GW Rhode Island received a $477,000 USFS Landscape Scale Restoration Grant for riparian forest planning along the Blackstone River	

	ME	VT	NH	MA	RI	CT
Grants made to communities and NGOs?	Yes, $100K of funding passed through to communities. Grant size up to $12K for planning and education; $10K for planting and maintenance.	Yes, $80K to Growing Urban Forests; $30K to Caring for Canopy in Face of Emerald Ash Borer (EAB) = US Forest Service's Sustainable Urban Forest Resilience Program	No – NH provides TA support only	$230K goes to community challenge grants ($1 – 40K) with reduced match for EJ communities. Grants reimburse costs of projects and do not provide up front funding.	Yes, competitive matching grants of $2-10K, reimbursement only. Tree planting grants limited to $3K for Tree City USA communities and $1.5K for others. Cities tend to raise own funds for tree planting. Both Providence and Warwick have established tree trusts.	Yes, Urban Forestry Climate Change Grant Program ($10-37K grants); America the Beautiful planning grants
EJ / Low income community focus?	No specific scoring for EJ communities in grant program	Planting For Impact Using research from the Vermont Department of Health, we selected partner communities in Vermont that are most vulnerable to heat-related illness.	Not previously. In 2023, $50K of federal infrastructure $ (BIL) is being directed toward supporting urban forestry in underserved communities	Reduced 25/75 match in grant program for EJ communities		Increased focus coming from DEEP. Urban Forestry Equity through Capacity Building Grant Program designed to address environmental justice and combat the impacts of climate change

	ME	VT	NH	MA	RI	CT
Climate resilience focus in tree selection?	Grant applications are ranked by several criteria, with climate resilience added last year	TA and up to $10K grant from Resilient Urban Forests For All program. 2022 Tree Planting Guide includes selection criteria like air pollution and drought tolerance.		DCR Service Forestry program can provide TA on climate forestry		Urban Forestry Climate Change Grant Program (grants up to $37K) administered by CT Urban Forest Council.
Typical UF project size	Not aware of any 1000+ tree projects Portland has the most resources plants maybe 100 trees per year. With some additional funding from TD Bank, it was able to plant 150 trees in a year. Portland has limited space remaining on public lands.	Only 4 have cities with urban foresters Rutland VT - two staff, a lot of tree planting work needed	Not aware of any 1000+ tree projects Portsmouth has the largest city program at 400 trees per year, 50% on city property Some cities/ towns do not control the ROW between house and street	Not aware of any 1000+ tree projects Strongest city UF programs in Springfield, Worcester, Cambridge, Framingham	Not aware of any 1000+ tree projects	Not aware of any 1000+ tree projects. Biggest UF NGOs are URI; Hartford area partnership (CT River Conservancy, Riverfront Recapture, Keney Park Sustainability Project); Groundwork Bridgeport

	ME	VT	NH	MA	RI	CT
Plans for IRA funding	With additional IRA funding, she hopes to offer larger grants and more funding for tree maintenance, which is a challenge for more rural communities. The last dedicated tree maintenance funding came from recovery funds after Tropical Storm Irene. She is concerned about applying for significantly larger grants that she doesn't have the staff capacity to administer.	Unknown	Plans $200-250K grant request for the first round of IRA funds	Applying, but only to expand her current program. With limited staff, the need for a match, and a tight deadline there was no way she could come up with a larger program.	IRA funding: RI is partnering with the Green Infrastructure Center to apply for a cost-share grant through the first round of IRA Urban and Community Forests funding. The Green Infrastructure Center would work with 1-2 communities to assess current ordinances, set tree planting goals, establish an urban forestry master plan -- essentially TA for strengthening community UF plans.	Building UF capacity in EJ communities; strategic partnerships (e.g. with URI); building statewide UF database; support UF intern program

Appendix D: Spatial Planning Methodology

Methods

State- and municipal-GIS data and high-resolution (1-meter) land cover data was used to identify land that is physically suitable for tree planting and to identify areas that are covered by tree canopy; these data were compared against the CFC tree planting and tree preservation protocol and project eligibility requirements. Data was processed in ArcPro 3.1.0 using the ModelBuilder workspace. All data products were projected to the respective State Plane – Meters projection using the 'project' and 'project raster tools.

Tree Planting

Lands physically suitable for tree planting were identified with publicly available land cover/land use products (Table 1.1) . Land cover categories related to uncultivated areas of grass or open space were aggregated to depict "soft surface plantable area", or the areas that could have the fewest challenges to plant on (Table 2.2).

Five additional datasets were used to account for spatially-explicit built and environmental obstacles – building footprints, roads and road centerlines, railroads, and wetlands (Table 1.2-1.5). Roads and railroads were buffered to reflect the width of the feature; when the width data was not provided with the dataset, a consistent buffer was applied (railroads=16.5 feet, roads=24 feet) based on optical assessment of NAIP aerial imagery (2018, 1-meter resolution) and NACTO guidelines (NACTO Urban Street Design Guide 2013).

To account for areas that cannot be planted without removal of existing built features ("built environment"), roads, railroads, and building footprints spatial datasets were merged and used to reclassify land cover data and reflect a "Not plantable" category (see Limitations for further discussion). Additionally, all structural obstacles (buildings, roads, railroads) were buffered by 8 feet using the 'buffer' tool to not only offset tree growth and development of large statured deciduous trees, but to identify areas that could potentially be planted with small statured trees ("Plantable area - near built environment") (Table 2.4). The wetlands datasets were used to produce a "Plantable area - near wetlands" class using the same method (Table 2.3) (see Limitations for further discussion). Lastly, areas that may be plantable following the removal of impervious surface or pavement were identified by isolating impervious surface classes from buildings, roads, and railroads ("Plantable area – depave") (Table 2.5).

Table 1. Input Data

	Connecticut	Massachusetts	Vermont
(1) Land cover/ Land use	C-CAP Land Cover, Connecticut (2016)	Land Cover/Land Use (2016)	VT Land Cover (2016)
(2) Roads	CTDOT State Route Local Names (2022)	MassDOT Roads (2022)	VT Road Centerlines (2021)
(3) Railroads	CT DEEP Connecticut Railroads (2021)	Trains (2022)	VT Rail Lines (2020)
(4) Buildings	Microsoft Building Footprints (2022)	Building Structures 2-D (2022)	VT Data - E911 Footprints (2018)
(5) Wetlands	USFWS National Wetland Inventory (2019)		
(6) Protected Lands	Protected Areas Database of the United States (PAD-US) (2022)		
(7) Zoning	Town Parcels and CAMA data (2022) + municipal zoning codes	Property Tax Parcels (2023) + municipal zoning codes	City of Burlington (2022) + municipal zoning codes
(8) Parcels	Town Parcels and CAMA data (2022)	Property Tax Parcels (2023)	Parcel Viewer (2018)

Table 2. Data Reclassification

	Connecticut	Massachusetts	Vermont
(1) Tree Canopy Cover	value= 9, 10, 11 name= Deciduous Forest, Evergreen Forest, Mixed Forest	field name= Deciduous Forest Evergreen Forest	value= 1 name= Tree Canopy
(2) "Soft surface" plantable area	value= 3,4,5,8,12,20 name= Developed Open Space, Grassland/ Herbaceous, Scrub/Shrub, Bare Land	fieldname= Bare Land Grassland Developed Open Space Scrub/Shrub	value= 2,3 name= Bare Soil Grass/Shrubs
(3) Limited – near wetlands	100-foot wetland buffer	150-foot wetland buffer	300-foot wetland buffer
(4) Limited –near built environment	within 8-foot buffer around roads, railroads, buildings		
(5) Limited –depaving required	value=2 name=Impervious	Impervious	value=7 name= Other paved

The comparisons to CFC's Tree Planting protocol were made based on Sections 1.4 Defining the Project Area, 1.7 Ownership or Eligibility to Receive Potential Credits, and 1.8 Legal requirements test and were generalized as the mapping criteria below. To isolate plantable areas that qualify under CFC's Tree Planting Protocol, first, zones that require tree planting as part of ordinance or law were removed (Table 1.7) from the grand total of eligible plantable area. Then, unique project operators of municipal government were identified using parcel attributes related to land ownership and land use (Table 1.8).

CFC Tree Planting Protocol Section	Mapping criteria
1.4 Defining the Project Area	Can span multiple parcels
1.7 Ownership or Eligibility to Receive Potential Credits	Identify unique land owners that have oversight of the greatest amount of plantable space
1.8 Legal requirements test	Excludes areas where trees must be planted by ordinance or law

Tree Preservation

Lands physically suitable for tree preservation were identified with publicly available land cover/ land use products. Land cover categories related to deciduous and evergreen trees and forests were aggregated as existing tree canopy cover (Table 2.1).

The areas of comparison to CFC's Tree Planting protocol were based on sections 1.4 Defining the Project Area, 1.7 Ownership or Eligibility to Receive Potential Credits, 4. Demonstrating Preservation and Threat of Loss (see Limitations for this criteria) and were generalized as the mapping criteria below.

To isolate tree canopy cover that qualify for CFC's Tree Preservation Protocol, first, protected wetlands (Table 1.5), protected lands (Table 1.6), and zones that permit one or more non-forest use (Table 1.7) were removed from the grand total of eligible tree canopy cover. Then, unique project operators of municipal government were identified using parcel attributes related to land ownership and land use (Table 1.8).

Protocol Section	Mapping criteria
1.4 Defining the Project Area	Can span multiple parcels Cumulative parcels have a total of 80% canopy cover
1.7 Ownership or Eligibility to Receive Potential Credits	> Single Owners, > UTC
4. Demonstrating Preservation and Threat of Loss	No parcels protected in perpetuity (are conservation restrictions/ easements considered recorded encumbrance?) Wetlands protection area Zoning allows for one or more non-forest use Is not within an overlay district that prohibits new development (including wetlands of critical areas) AND Has 30% of the project boundary perimeter surrounded by non-forest use OR Was sold since 2020 for greater than $8k/ acre

Data Processing

Preprocessing Steps

ArcMap ModelBuilder

- Project / Project Raster* - All files reprojected to the respective StatePlane coordinate system:
- 1983 StatePlane Connecticut FIPS 0600 (Meters)
- 1983 StatePlane Massachusetts FIPS 2001 (Meters)
- 1983 StatePlane Vermont FIPS 4400 (Meters)
- Clip - all files clipped to each municipality and merged to the same state

**since most data were derived from state GIS repositories and rendered in its respective StatePlane coordinate system, all operations performed for as independent states and not under a multistate or regional projection

Tree Planting Protocol Identification – ArcMap ModelBuilder

Soft Surface Plantable Area Identification:

1. Reclassify – reclassified land cover products
   - Designated classes reclassified to '1', all other values were reclassified to 'NoData' leaving a raster with only data for "soft surface" land cover
2. Raster to Polygon – converted "soft surface" raster to a polygon feature class
3. Buffer – for each obstacle data, set a buffer
   - Roads – Buffer #1 using "road widths" data or consistent buffer width, Buffer #2 – using the 8 foot buffer
   - Railroads – Buffer #1 using 16.5 feet as an estimation of railroad widths (based on optical assessment of NAIP aerial imagery and randomly selected points along the railroads in CT), Buffer #2 -using the 8 foot buffer
   - Buildings –8 foot buffer
   - Wetlands – no buffer
4. Merge – combined all obstacles (Roads w/ Buffer #1, Railroads w/ Buffer #1, Buildings, Wetlands)
5. Merge 2 – combined all buffered obstacles (Roads w/ both buffers, Railroads w/ both buffers, and Wetlands with no buffer)
6. Erase – erased the Merge 2 output ("Buffered Obstacles") from the Soft Surface Plantable Area Polygon layer
7. Product – a shapefile representing "soft surface" plantable area for each town

Depaving Plantable Area Identification:

1. Buffer – for roads and railroads, buffered by:
    - Widths datasets (Roads)
    - 5-meter estimation of railroad widths (Railroads)
2. Merge – both buffered roads and railroads with the building footprints
3. Con – identified and reclassifies all land cover within the ("Structural obstacles") merge output to a value of '0', all other values are discarded to produce a "not plantable" area raster
4. Mosaic to New Raster – combines "not plantable" area raster with original land cover dataset
5. Reclassify – reclassifies the updated land cover dataset
    - Developed Impervious Surface (Value 2) was reclassified to '2', all other values were reclassified to 'NoData' leaving a raster with only data for "depaving" land cover
6. Raster to Polygon – converted "depaving" raster to a polygon feature class
7. Buffer – for each obstacle data, set a buffer
    - Roads – Buffer #1 using "road widths" data provided by CT DOT, Buffer #2 – using the 8 foot buffer
    - Railroads – Buffer #1 using 5 meters as an estimation of railroad widths (based on optical assessment of NAIP aerial imagery and randomly selected points along the railroads in CT), Buffer #2 -using the 8 foot buffer
    - Buildings –8 foot buffer
    - Wetlands – no buffer
8. Merge – combined all obstacles (Roads w/ Buffer #1, Railroads w/ Buffer #1, Buildings, Utilities (Lines), Utilities (Points), Wetlands)
9. Merge 2 – combined all buffered obstacles (Roads w/ both buffers, Railroads w/ both buffers, Utilities (Lines) with 8-ft buffer, Utilities (Points) with 8-ft buffer, and Wetlands with no buffer)
10. Erase – erased the Merge 2 output ("Buffered Obstacles") from the Depaving Plantable Area Polygon layer
11. Product – a shapefile representing "depaving" plantable area for each town

Full Plantable Area Identification:

1. Reclassify – reclassifies land cover data to reflect final categories (4 – environmentally limited, 5 – not plantable, 6 – tree canopy, 7 – water)
2. Feature to Raster followed by Con – run for different inputs:
    - Soft Surface Plantablee Area shapefile – converted to raster with value of '1' for soft surface plantable area
    - Depaving Plantable Area shapefile – converted to a raster with value '2' for depaving plantable area
    - Combined obstacle data including the 8-foot buffers converted to a raster with value of '3'
    - Wetlands shapefile converted to a raster with value of '4'
    - Structural obstacle including roads with width buffer, railroads with width buffer, and building footprints converted to value of '5'
3. Mosaic to New Raster – run to combine all rasters from previous two steps to produce final product
4. Product – a raster (TIF) representing plantable area with the categories 1 – soft surface plantable, 2 – depaving plantable, 3 – built environment limited plantable, 4 – wetlands limited, 5 – not plantable, 6 – tree canopy

Tree Preservation Protocol Identification

1. Reclassify – Designated classes reclassified to '1', all other values were reclassified to 'NoData' leaving a raster with only data for "tree canopy" land cover

Summary Statistics:

1. Tabulate Area – used to calculated the total area of the Tree Planting and Tree Preservation protocol for each municipality

Table 3. Total extent of existing conditions in each mini-grant community (as acres and percent of town)

		Soft Surface Plantable	Restricted Plantable Space			Tree Canopy Cover*
			Wetlands and wetlands buffer	Streets and buildings	Depaving required	
CT	Hartford	2100 ac 18%	338 ac 3%	1568 ac 14%	2397 ac 21%	2214 ac 19%
	New Haven	1843 ac 16%	603 ac 5%	1174 ac 10%	2242 ac 20%	3210 ac 28%
MA	Lawrence	216 ac 5%	91 ac 2%	233 ac 5%	76 ac 2%	1021 ac 9%
	Holyoke	1101 ac 8%	314 ac 2%	609 ac 4%	546 ac 4%	7843 ac 68%
	Springfield	2677 ac 13%	431 ac 2%	1920 ac 9%	1832 ac 9%	5730 ac 50%
VT	Burlington	1052 ac 9%	962 ac 8%	576 ac 5%	367 ac 3%	1163 ac 10%

*excludes areas of forested wetlands, which may constitute a portion of community tree canopy cover

Limitations

- Utilities data is unavailable for this extent of communities and may potentially uncover greater nuance the extent of space available for new tree planting
- Accuracy of land cover data varies within and between states (this is common for land cover products)
- Accuracy of roads and railroads is mixed when compared to national aerial imagery (NAIP) - some road lines vary significantly compared to NAIP data, some roads visible in NAIP are not captured in roads data, some railroad areas have significantly wider roads (especially at major stations where multiple railroads meet)
    - Railroad width is estimated based on visual assessment of NAIP imagery and estimating a width that seems to cover most of the railroad tracks (with the exception of the major station areas) - could not find any other justifiable information to use for widths
    - Road width data (especially in Massachusetts) appears to be an overestimate and may have classified lands as "Not plantable"
- Does not account for edge effects (ie, if a project extends beyond a town boundary or amongst multiple project operators)
- Further research should account for the following CFC Protocol:
    - **Tree Planting:**
        - 1.2 Planting Designs and Quantification Methods: The following criteria was not accounted for in this assessment
            - Areas < 5 acres = trees must be planted 10 feet apart
            - Areas > 5 acres= trees can be planted any distance apart
            - Within or across any town boundary (and other regional boundaries); Source water and watershed protection lands; ROWs
        - 1.9 Conversion out of forest before planting not eligible: The criteria excludes areas where healthy trees are cut and replanted; however it is not clear how this applied to lands with wood-producing mill operations (where hazardous or fallen trees are reclaimed and trees are planted elsewhere on-site, e.g. Keeney Park Sustainability Project, Connecticut) or for tree nurseries (where trees are relocated and not cut, per se)

- **Tree Planting and Tree Preservation**
- 1.8 Legal requirements: The between- and within-state variation to lands/buffers subject to wetlands protections creates complexity and opportunity to consider when considering ways to scale-up CFC projects.
- For example, MA and VT have statewide wetlands regulation (but CT does not?), all lands subject to municipal ordinance, where the following variation applied to each mini-grant community:
  - Vermont – Burlington subject to a 300-foot wetland/ riverfront buffer
  - Connecticut--Hartford=100-foot wetland/ riverfront buffer & New Haven=50-foot
  - Massachusetts--Springfield: from the Longmeadow Town line on the south to the Chicopee City line on the north and West Columbus Avenue on the east and the Connecticut River on the west; Holyoke: Tannery Brook, Broad Brook, Green Brook, Paucatuck Brook, Bray Brook, Serendipity Brook, Barry Brook, and Whiting Brook); Lawrence:

Lawrence has three rivers, each with unique characteristics, development densities and uses. The Shawsheen River Riverfront is predominantly undeveloped woods and wooded wetlands. The Merrimack River Riverfront is relatively undeveloped above the falls and is dominated by Historic Mill Complexes, largely Zoned I-2. The Spicket River Riverfront is dominated by high-density residential and commercial structures, R-4, B-3 and I-2 Zoning districts. 310 CMR 10.58(2)(a)(3) designates a 25 foot Riverfront to the entire city. This is not sufficient to protect the interests of the act. Therefore 4 types of riverfront areas will be assigned to the City's three rivers 200 foot, 100 foot, 50 foot and 25 foot. In addition, perennial streams including all tertiary tributaries, are protected with a 50 ' riverfront area. The locations of those riverfront areas is outlined in the table below and the restrictions of each riverfront area are outlined in the sections which follow:

Table 7-1

River	From	To	Riverfront Area
Merrimack North Shore	The geographic boundary with the City of Methuen	Easterly point of the intersection with Doyle St.	200 ft.
	Easterly point of the intersection with Doyle St.	Easterly point of the intersection with Baystate Rd.	100 ft.
	Easterly point of the intersection with Baystate Rd.	Westerly point of the intersection with Broadway	25 ft.
	Entranceway to the North Canal	Terminus of North Canal at the Merrimack River Channel	100 ft.
	Westerly point of the intersection with Broadway	175 ft. East of O'Leary Bridge	100 ft.
	175 ft East of O'Leary Bridge	Casey Bridge	200 ft.
	Casey Bridge	500 ft. West of West bank Spicket River	25 ft.
	500 ft. West of West bank Spicket River	Westerly point of intersection with the O'Reilly Bridge	100 ft.
	Westerly point of intersection with the O'Reilly Bridge	The geographic boundary with the City of Methuen	200 ft
Merrimack South Shore	The geographic boundary with the City of Methuen	Easterly point of the intersection with Burke St.	200 ft.
	Easterly point of the intersection with Burke St.	Easterly point of the intersection with Newton St.	100 ft.
	Easterly point of the intersection with Newton St.	Easterly point of the intersection with Broadway.	200 ft.
	Easterly point of the intersection with Broadway.	300 ft east of Casey Bridge	25 ft.
	300 ft. east of Casey Bridge	Easterly point of the intersection with the Casey Bridge	50 ft.
	Easterly point of the intersection with the Casey Bridge	300 ft. West of O'Reilly Bridge	25 ft.
	300 ft. west of O'Reilly Bridge	Easterly point of the intersection with the O'Reilly Bridge	100 ft.

	Easterly point of the intersection with the O'Reilly Bridge	The geographic boundary with the Town of North Andover	200 ft.
Shawsheen River	The geographic boundary with the Town of Andover	Merrimack St.	200 ft.
Spicket River	The geographic boundary with the City of Methuen line	West shore of Stevens Pond	
Spicket River Both Banks	West Shore of Stevens Pond	southerly point of the intersection with Broadway	25 ft.
Spicket River North Bank	southerly point of the intersection with Broadway	easterly point of the intersection with Wells Street	200 ft
Spicket River North Bank	easterly point of the intersection with Wells St.	easterly point of the intersection with Hampshire St.	25 ft.
Spicket River North Bank	easterly point of the intersection with Hampshire St.	easterly point of the intersection with Bunkerhill St.	50 ft.
Hayden Schofield Playground	easterly point of the intersection with Bunkerhill Street	easterly point of the intersection with Lawrence St.	200 ft.
Spicket River North Bank	easterly point of the intersection with Lawrence St.	easterly point of the intersection with Jackson St.	50 ft.
Spicket River North Bank	easterly point of the intersection with Jackson St.	easterly point of the intersection with East Haverhill St.	25 ft.
Spicket River North Bank	easterly point of the intersection with East Haverhill St.	200.33 feet north of the northerly point of the intersection with Fulton Street	50 ft.
Spicket River North Bank	200.33 feet north of the northerly point of the intersection with Fulton Street	232.97 feet north of the northerly point of the intersection with Haverhill Street	25 ft.
Spicket River North Bank	232.97 feet north of the northerly point of the intersection with Haverhill Street	150 ft. north of General St.	50 ft.
Spicket River North Bank	150 ft. north of General St	Easterly point of the intersection with General St.	25 ft.
Spicket River North Bank	Easterly point of the intersection with General St.	northerly point of the intersection with Canal St.	30 ft.
Spicket River North Bank	northerly point of the intersection with Canal St.	Confluence with the Merrimack River	50 ft.
Spicket River South Bank	southerly point of the intersection with Broadway	easterly point of the intersection with Holly Street	25 ft.
Spicket River South Bank	easterly point of the intersection with Holly St.	easterly point of the intersection with Hampshire St.	50 ft.
Spicket River South Bank	easterly point of the intersection with Hampshire St.	easterly point of the intersection with Lawrence St.	50 ft.
Spicket River South Bank	easterly point of the intersection with Lawrence St.	easterly point of the intersection with Jackson St.	100 ft.
Spicket River South Bank	easterly point of the intersection with Jackson Street	easterly point of the intersection with East Haverhill St.	50 ft.
Spicket River South Bank	easterly point of the intersection with East Haverhill St.	southerly point of the intersection with Brook St.	200 ft.
Spicket River South Bank	southerly point of the intersection with Brook St.	easterly point of the intersection with Haverhill St.	50 ft.
Spicket River South Bank	easterly point of the intersection with Haverhill St.	easterly point of the intersection with General St.	50 ft.
Spicket River South Bank	easterly point of the intersection with General St	easterly point of the intersection with the Old Rail Road Bridge	25 ft.
	easterly point of the intersection with the Old Rail Road Bridge	northerly point of the intersection with Canal St.	50 ft.
Spicket River South Bank	northerly point of the intersection with Canal St.	Confluence with the Merrimack River	100 ft.

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