Boston Tree Equity Analysis

Applied Economics Clinic

Prepared on behalf of GreenRoots and Speak for the Trees

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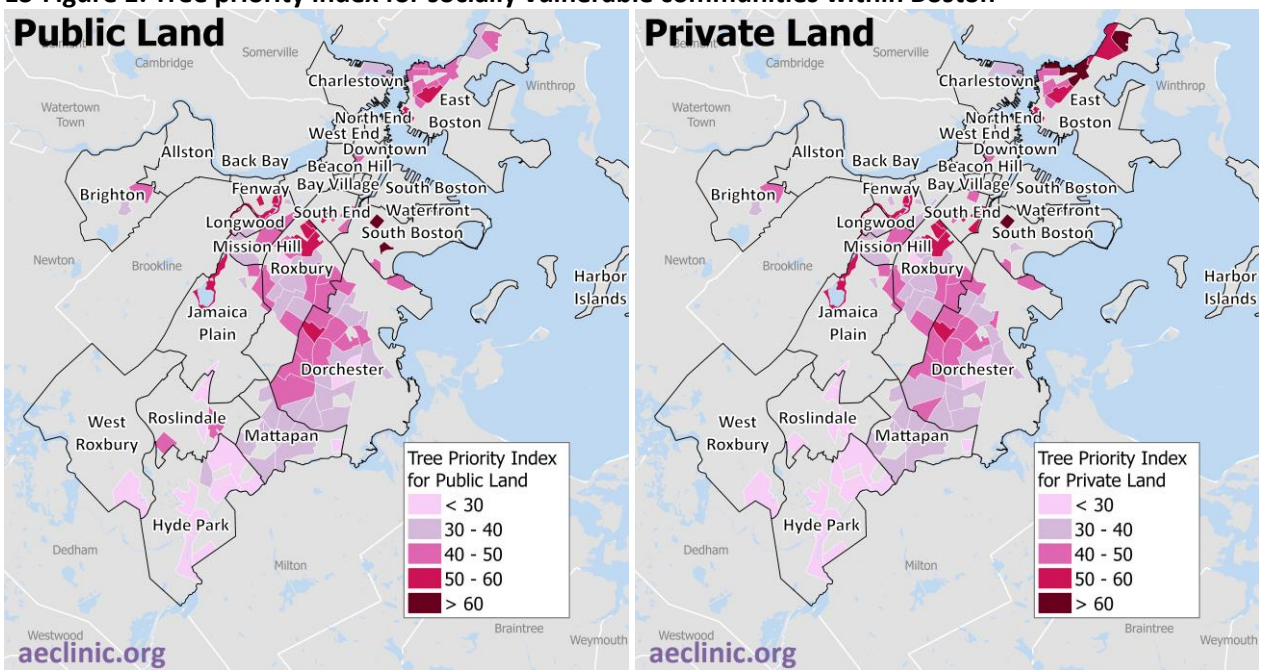
Executive Summary

Tree canopies and other green spaces can alleviate the impacts of climate change by providing shade, cooling, and flood protection. The location of tree coverage plays a critical role in determining which communities bear the brunt of severe temperatures and flooding and which benefit from the shade and flood mitigation that green spaces offer. On behalf of GreenRoots and Speak for the Trees, this AEC report examines the distribution of tree coverage, pollution, heat, and selected demographics across the City of Boston to identify communities where tree planting efforts would be most equitable.

Due to the effects of climate change, Boston faces ongoing temperatures increases, changes to precipitation patterns, flooding, and sea-level rise. Tree canopy—which can act as a shield for ground-level exposure to heat, rain and snow—is not evenly distributed across Boston, exposing the communities that live in tree-sparse areas subject to higher temperatures and worse air quality.

To increase equity in access to tree-dense areas, AEC recommends investment in tree planting be focused in the areas in which two characteristics (represented in our "Tree Priority Index") coincide: (1) the greatest opportunity for planting trees, either public or private, and (2) the highest concentration of overburdened populations. The Boston neighborhoods that fit these criteria, for both public and private tree planting efforts, are concentrated within Dorchester, East Boston, and Roxbury (see ES-Figure 1 where darker pinks indicate a greater priority for tree planting).

ES-Figure 1. Tree priority index for socially vulnerable communities within Boston



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I. Introduction

Green space—or land covered by vegetation like trees or grass—can alleviate some of the adverse effects of climate change by providing shade, cooling, and flood protection.[1] The location of green spaces plays a critical role in determining which communities bear the brunt of severe temperatures and flooding and which benefit from the shade and flood mitigation that green spaces offer. Unfortunately, several studies show that across the country, green spaces are disproportionately located in high-income communities, rendering low-income communities more vulnerable to extreme heat.[2] Under-resourced and underserved communities, or those with high BIPOC[3] and/or low-income populations, tend to be affected by climate change "first and worst," meaning that these communities face the most significant climate change impacts and experience these impacts long before they are felt in more affluent areas.

According to the City's 2022 *Heat Resilience Solutions for Boston* report, systemic inequities and racism have left Boston's hottest neighborhoods more vulnerable to climate risks like increasing temperatures. As a highly developed urban environment, Boston is subject to the "urban heat island effect."[4] According to the U.S. Environmental Protection Agency (EPA), the urban heat island effect is the disproportionate accumulation of heat in developed areas with minimal tree coverage.[5] This happens because buildings, pavement, and concrete absorb heat from the sun and re-emit it at a greater rate than natural landscapes do. In other words, humanmade materials like pavement and roofing absorb and emit more heat than grass, trees or bodies of water.[6]

Additional benefits of trees

Beyond the environmental benefits, researchers have found psychological benefits such as improved academic performance, self-esteem, mood, reduced anger, and general well-being linked to time spent in nature.[7] Time spent in nature has also been demonstrated to increase positive social interaction and decrease incidence of crime and violence in urban settings.[8] According to a 2001 study in the *Journal of Urban Design* on the links of parks and urban neighborhoods, areas next to parks in Boston experienced less crime than those adjacent to streets or buildings.[9] A 2013 article published in the *International Journal*

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[1] City of Boston. April 2022. *Heat Resilience Solutions for Boston.* Available at: https://www.boston.gov/departments/environment/preparing-climate-change.

[2] 1) Nesbitt. L., et al. January 2019. "Who has access to urban vegetation? A spatial analysis of distributional green equity in 10 US cities." *Landscape and Urban Planning, Volume 181*, p. 51-79. Available at: https://www.sciencedirect.com/science/article/pii/S0169204618307710; 2) Albuja, C. et al. December 6, 2020. "The Inequity of Green Space: How green space access reflects the discrepancies in our cities." Story Maps ArcGIS. Available at: https://storymaps.arcgis.com/stories/ca45484d674841ca84c88890061f4cac

[3] Black, Indigenous, and Persons of Color

[4] City of Boston. April 2022. *Heat Resilience Solutions for Boston.*

[5] United States Environmental Protection Agency. N.d. "Heat Island Effect." Available at: https://www.epa.gov/heatislands

[6] Ibid.

[7] Keniger, L. et al. 2013. What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health, Volume 10* (3), p. 913-935. Available at: https://doi:10.3390/ijerph10030913, p. 917-918

[8] Ibid, p. 918

[9] *Crewe, K. 2001. Linear Parks and Urban Neighbourhoods: A Study of the Crime Impact of the Boston South-West Corridor.* Journal of Urban Design *6(3), p. 245-264. Available at: https://doi.org/10.1080/13574800120105779*

of Environmental Research and Public Health confirms that the benefits of interactions with nature are experienced across all age groups.[10]

Funding trees

Securing funding for tree planting efforts can be challenging. However, due to increasing awareness of the mental health and climate change mitigation benefits of tree coverage, there are several state and local programs that assist with financing what is often called "green infrastructure." A 2018 meta-analysis of tree coverage found the benefits of urban forests, such as shading, water regulation, carbon reduction, and improved air quality, substantially outweigh the costs of implementing and maintaining them in an urban environment.[11] According to EPA, there are multiple sources of federal and state funding that can be used for developing and maintaining tree canopy:[12]

- The **Clean Water State Revolving Fund** and the **Drinking Water State Revolving Fund**, both federal-state partnerships funded by EPA grants, provide low-cost financing for green infrastructure associated with water quality and stormwater;
- The EPA's **Superfund Redevelopment Program** supports the development of green infrastructure projects to transform formerly contaminated spaces;
- The EPA's **Environmental Justice Small Grants program** supports community-scale projects that address environmental risks; [13] and,
- The U.S. Forest Service's **Urban and Community Forestry Program** supports community-scale tree coverage expansion and urban forest restoration.[14]

In addition, the U.S. Department of Energy (DOE) provides weatherization assistance to states, local governments, community action agencies, tribal communities, and utilities that can be used for green infrastructure projects.[15] Through the Federal Emergency Management Agency (FEMA), funding is available for hazard mitigation projects and flood mitigation projects, which includes green infrastructure implementation.[16]

Beyond federal funding, there are several additional state and community-level organizations available to support tree-planting projects in Massachusetts.[17] Non-profit organizations like *Speak for the Trees* have been working to close the urban green gap in overburdened communities through advocacy campaigns, tree plantings, and education programs aimed at pushing the City to address the issue through

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[10] Keniger, L. et al. 2013. What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health, Volume 10* (3), p. 913-935. Available at: https://doi:10.3390/ijerph10030913, p. 921
[11] Song, X. P., Tan, P. Y., Edwards, P., Richards, D., 2018. "The economic benefits and costs of trees in urban forest stewardship: A systematic review." *Urban Forestry and Urban Greening, Volume 29*, p. 162-170, p. 166
[12] Environmental Protection Agency. N.d. "Green Infrastructure Funding Opportunities." *Green Infrastructure.* Available at: https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities
[13] Ibid.
[14] U.S. Department of Agriculture. "Urban and Community Forestry Program." *Forest Service*. Available at: https://www.fs.usda.gov/managing-land/urban-forests/ucf
[15] Environmental Protection Agency. N.d. "Green Infrastructure Funding Opportunities." *Green Infrastructure.*
[16] Ibid.
[17] Ibid.

legislation.[18] Over the summer of 2021, the City partnered with the Boston Public Library and the Mayor's Office of New Urban Mechanics to develop two "Cool Spots" at libraries in East Boston and Egleston Square for heat relief and educational outreach about the benefits of increased shading and vegetation on heat relief.[19]

In 2022, Trust for Public Land, a national conservation organization supporting communities by helping them design and develop green spaces,[20] has developed a ParkScore Index designed to measure the accessibility, investment, acreage, amenities, and equity of park systems across the 100 most populous cities in the United States.[21] According to this index, 100 percent of Boston residents live within a 10-minute proximity to a park, compared to a 65 percent median for all cities evaluated.[22] Low-income neighborhoods, however, have access to 19 percent less park space than high-income neighborhoods; in other words, high-income neighborhoods are more likely to have larger parks.[23]

In addition, American Forests, an advocacy group that aims to reduce the impacts of climate change, improves public health, and promote social equity, has developed a Tree Equity Score (TES) to assist cities in assessing the distribution of tree canopy cover relative to surface temperature and socioeconomic factors, such as income, employment, race, age, and health. The TES tool gives a score between 0 and 100 (where 0 is the lowest score possible and 100 is the best score possible) for each of the 150,000 census block groups in the United States, including in the City of Boston.[24] Boston has an average TES of 91; only 17 of Boston's 550 census block groups have a TES below 75. These lower scoring communities are located in Dorchester, Roxbury and South Boston.[25]

The City of Boston's 2022 Urban Forest Plan is designed to protect and increase the canopy of trees across Boston for climate mitigation and adaption, heat relief, and health and wellbeing of Boston residents.[26] The plan addresses historic disparities like redlining[27] and inequitable distributions of tree coverage by calling for engagement strategies to account for the voices of historically excluded communities, and an analysis of the intersection of environmental justice and existing disparities.[28] The City of Boston is also in the midst of updating its seven-year open space plan (last updated in 2015), and is seeking comments from Boston

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[18] Speak for the Trees. 2021. "2021 Annual Report: Bringing Tree Equity to Boston." Available at: https://treeboston.org/wp-content/uploads/2022/03/SFTT-Annual-Report-2021.pdf
[19] City of Boston. April 2022. *Heat Resilience Solutions for Boston*, p. 23
[20] Trust for Public Land. 2022. "Boston, MA: 2022 Trust for Public Land ParkScore Ranking: #12." Available at: https://www.tpl.org/city/boston-massachusetts
[21] Ibid.
[22] Ibid.
[23] Ibid.
[24] (1) American Forests. 2021. "Tree Equity Score Methodology." *Tree Equity Score*. Available at: https://treeequityscore.org/methodology/; (2) American Forests. 2021. "About." *Tree Equity Score*. Available at: https://treeequityscore.org/about/.
[25] Tree Equity Score. N.d. "Municipality Tree Equity Score: Boston." *Tree Equity Score*. Available at: https://treeequityscore.org/reports/place/boston-ma/.
[26] City of Boston. 2022. "Urban Forest Plan: Commonly Asked Questions." Available at: https://www.boston.gov/departments/parks-and-recreation/urban-forest-plan/urban-forest-plan-commonly-asked-questions
[27] Redlining is a color-coded system used in the mid-20th century to rank neighborhoods by perceived riskiness of providing a mortgage loan, which unfairly impacted low-income neighborhoods, those with a high-BIPOC population, and those with a high immigrant population by frequently assigning them the lowest rank.
[28] Ibid.

residents to ensure updates are aligned with community desires.[29]

On behalf of GreenRoots and Speaks for the Trees, this Applied Economics Clinic (AEC) report identifies communities within Boston that stand to benefit most from an increase in tree advocacy work and planting efforts. To do this, AEC combines information on existing tree canopy coverage, land available for tree planting, and socioeconomic characteristics to determine which Boston neighborhoods face more significant burdens and have space for more trees. Section II describes the current distribution of trees in Boston. Section III includes an equity analysis examining the social vulnerability of Boston communities. Section IV examines the intersection of social vulnerability and health impacts in Boston communities. Section V identifies communities that are a priority for increasing tree coverage due to their high social vulnerability, lack of trees, and/or lack of space for adding trees.

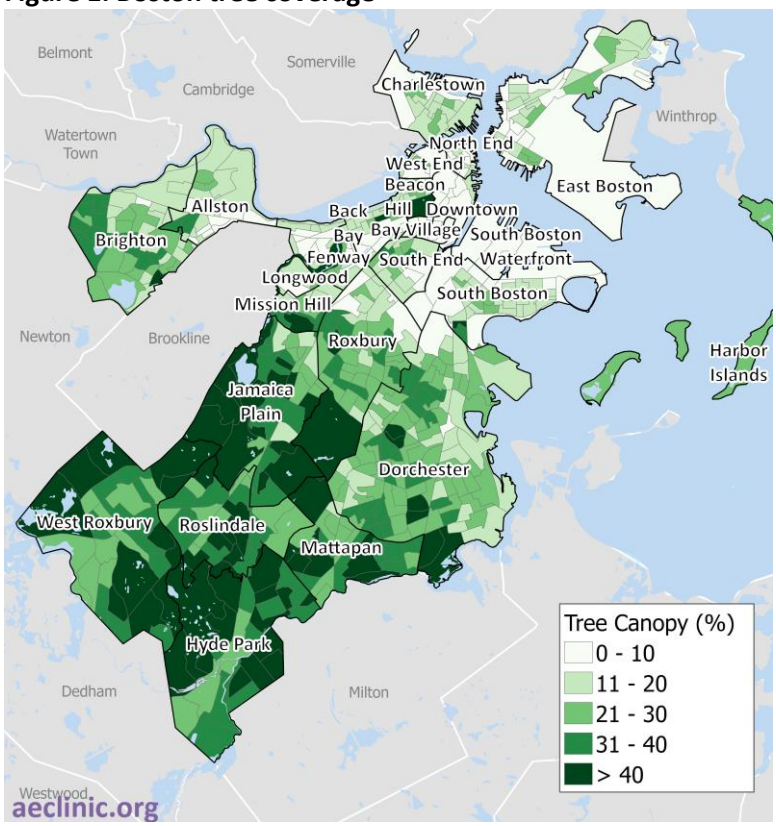
[29] City of Boston. 2022. "Updating the Seven-Year Open Space Plan." Available at: https://www.boston.gov/departments/parks-and-recreation/updating-seven-year-open-space-plan

II. Boston Tree Coverage

The 1858 New York City's Olmsted and Vaux Plan for Central Park was developed to bring aspects of rural nature to the urban environment.[30] In the 1870s and 1880s Frederick Olmstead designed several urban parks through the early 1900s, including the development of the ten-mile greenway in Massachusetts, called the Emerald Necklace, which winds through multiple Boston neighborhoods. Olmstead's predecessor, Charles Eliot developed a framework for Boston greenway planning, which has since been utilized in the design of Massachusetts state parks and other protected areas.[31]

As these tree-dense areas were planted throughout Boston, property values increased, reducing the affordability of homes closer to greener areas and making it less likely that Boston's lower income residents would benefit from the increased tree coverage. Tree canopy, or the percentage of an area covered by trees,[32] is not evenly distributed across Boston (see Figure 1 where darker greens mean more dense tree coverage).

Figure 1. Boston tree coverage



Data source: Speak for the Trees Boston. 2016. "Exploring Tree Equity in Boston."

[30] University of Massachusetts. N.d. "New England Greenway: Greenway History." Available at: https://www.umass.edu/greenway/Greenways/2GR-his.html

[31] Ibid.

[32] Speak for the Trees Boston. 2016. "Exploring Tree Equity in Boston." Available at: https://bucas.maps.arcgis.com/apps/MapSeries/index.html?appid=34e653bf29e64b72a64e78a175732b34#

High tree canopy areas are primarily in the City's western neighborhoods, but there are also some areas of dense cover in Beacon Hill and the Fenway. Currently there is little to no tree canopy in the majority of East Boston and South Boston, leaving the communities that live there subject to higher temperatures and worse air quality.

Air pollution and climate change impacts, like increased temperatures and flooding, can be mitigated by a denser tree canopy, or in other words, more trees, especially mature trees that provide more canopy coverage. To understand which communities are most vulnerable to climate impacts, this section examines the distribution of air pollution, temperature, and flood risk across the City of Boston.

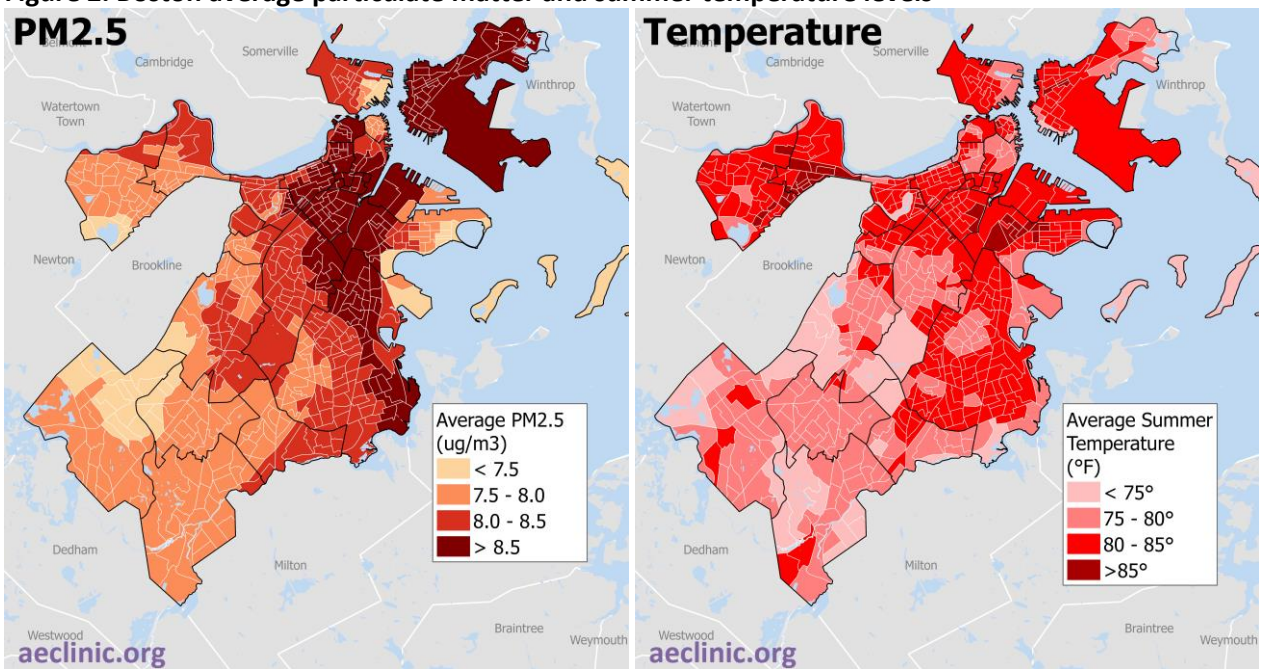
Air pollution and extreme heat

Particulate matter, or PM2.5, consists of microscopic particles, like dirt or sand, that are inhalable and pose a greater immediate risk to health compared to other criteria pollutants like carbon monoxide and ozone.[33] Among Boston neighborhoods, the highest average levels of PM2.5 are in East Boston, Beacon Hill, Downtown, the South End, as well as parts of Roxbury and Dorchester (see the left panel of Figure 2 below). As Boston stretches towards the west and south average levels of PM2.5 are lower.

Extreme heat provokes more frequent power outages, compromises air and water quality, disrupts transportation infrastructure (e.g., railroad delays as a result of expansion and buckling of hot tracks[34]), damages tree canopy and green space, and presents a significant threat to public health.[35] According to the City of Boston's *Heat Resilience Solutions for Boston* report, the annual number of days over 90 degrees, which currently stands at 10 days, could increase to 60 or 70 days by the 2070s.[36] A 2019 study by climate researchers at Northeastern University revealed that neighborhoods central to the Boston area, including South End, South Boston, Roxbury, and Dorchester, experienced heat accumulation during the day at a much greater level than outlying neighborhoods such as Brighton and Jamaica Plain (see the right panel of Figure 2 below).[37]

[33] U.S. EPA. "Particulate Matter (PM) Basics." Available at: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics
[34] BBC News. July 2015. "Who, What, Why: Why does hot weather cause rail delays?" Available at: https://www.bbc.com/news/magazine-33342481
[35] City of Boston. 2022. "Preparing for Heat." Available at: https://www.boston.gov/departments/environment/preparing-heat
[36] Under the business-as-usual scenario. See: City of Boston. April 2022. *Heat Resilience Solutions for Boston.* Available at: https://www.boston.gov/sites/default/files/file/2022/04/04212022_Boston%20Heat%20Resilience%20Plan_highres-with%20Appendix%20%281%29.pdf, p. 54
[37] Hong, J. May 2020. "Boston Neighborhoods Impacted by Urban Heat." Available at: https://storymaps.arcgis.com/stories/1548beb5360e48648a43a595239fe3c5

Figure 2. Boston average particulate matter and summer temperature levels



Data source: Speak for the Trees Boston. 2016. "Exploring Tree Equity in Boston."

Sea-level rise and storm surge

According to National Oceanic and Atmospheric Administration (NOAA), in the event of a three-foot increase in sea level (which at the current rate of global greenhouse gas emissions, is likely to occur by the end of this century[38]) the South End, South Boston, and East Boston would face significant flood risk (see Figure 3, below, for a map of flood risk). Flooding of this degree can cause communities and in particular, low-income communities, to have to completely uproot while high-income communities are more equipped to cover the costs of damage.[39]

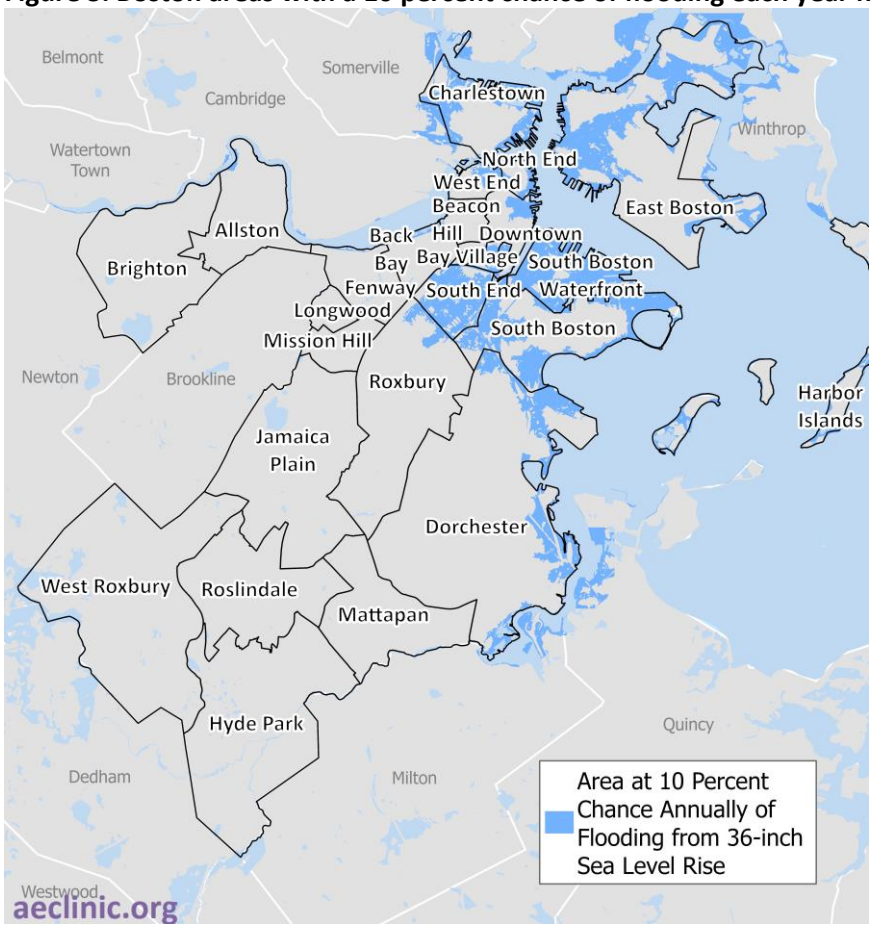
Over the next 30 years, NOAA predicts that sea levels will rise 10-12 inches along the Atlantic Coast from Maine to Virginia, which demonstrates a substantial acceleration in sea level rise from the last century: U.S. sea levels rose 10-12 inches over the 100 years from 1920 to 2020.[40] According to NOAA, one-foot of sea-level rise above the average height of the daily highest tide will result in significant flooding into Boston neighborhoods, particularly those along rivers, bays, or the Atlantic Ocean, such as West End, the South Boston Waterfront, Beacon Hill, Back Bay, and Allston.[41] NOAA predicts that the Charles River Reservation in the neighborhood of West End would be almost completely inundated by storm surge flooding in the event of a one-foot rise in sea level.[42]

In addition, the jetties and piers in the Harbor along the southern coast of East Boston would be severely

[38] Ibid.
[39] Walsh, M. J. N.d. *Climate Vulnerability Assessment*. Prepared for the City of Boston. Available at: https://www.boston.gov/sites/default/files/imce-uploads/2017-01/crb_-_focus_area_va.pdf, p. 67
[40] NOAA. 2022. "Sea Level Rise Technical Report." Available at: https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report.html
[41] NOAA. 2022. "Massachusetts Sea Level Rise and Coastal Flooding Viewer." Available at: https://mass-eoeea.maps.arcgis.com/apps/MapSeries/index.html?appid=6f2797652f8f48eaa09759ea6b2c4a95
[42] NOAA. 2022. "Massachusetts Sea Level Rise and Coastal Flooding Viewer."

impacted by a one-foot rise in sea level, as would major roads like Storrow Drive, which follows the Charles River along the shoreline of Fenway, Back Bay and Beacon Hill. Harvard University properties in the neighborhood of Allston would be severely impacted as well, with a majority of its athletic fields completely underwater.[43]

Figure 3. Boston areas with a 10 percent chance of flooding each year from 3-foot sea level rise



Data Source: Climate Ready Boston. 2020. "Geospatial." Available at: https://data.boston.gov/group/geospatial?q=coastal+flooding&sort=score+desc%2C+metadata_modified+desc

[43] Ibid.

III. Equity Analysis

Beyond environmental vulnerability, social vulnerabilities such as language barriers, income-level, age, and/or ability impact tree equity in Boston. This section provides an overview of Massachusetts' environmental justice (EJ) communities and presents a social vulnerability index (SVI) for the City's block groups in order to identify areas that are at the greatest disadvantage. (An important caveat: While the U.S. Census Bureau purports to report data for both citizens and noncitizens, analysis by Pew Research Center indicates that there are an additional 250,000 undocumented individuals living in Massachusetts whose statistics are not being included in Census data.[44] Where our analysis is based on Census data, the characteristics and experiences of undocumented individuals missing from the original data skews our results by suggesting that more people are native-born, white, higher-income, and not living in poverty than is actually the case.)

Communities that have historically been placed at greater risk of environmental hazards are often termed EJ communities. EJ communities bear the brunt of climate change impacts and air and water pollution exposure,[45] putting these communities at higher risk for a myriad of health conditions such as severe COVID-19 infections[46] and other respiratory illnesses.[47]

According to EPA, environmental justice is:

> *"the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."*[48]

In Massachusetts, an EJ community is defined as a neighborhood in which one or more of the following criteria are met:

- the annual median household income is less than or equal to 65 percent of the statewide annual median household income (i.e., $55,000 in 2020[49]);

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[44] (1) U.S. Census Bureau. 2021. "Frequently Asked Questions." Available at: https://www.census.gov/topics/public-sector/congressional-apportionment/about/faqs.html#:~:text=Are%20unauthorized%20immigrants%20included%20in,resident%20population%20for%20the%20census; (2) Pew Research Center. 2019. "U.S. unauthorized immigrant population estimates by state, 2016." Available at: https://www.pewresearch.org/hispanic/interactives/u-s-unauthorized-immigrants-by-state/

[45] (1) Island, S.N. and Winkel, J. October 2017. Climate Change and Social Inequality. DESA Working Paper No. 152. Available at: https://www.un.org/esa/desa/papers/2017/wp152_2017.pdf; (2) ikati, I., Benson, A.F., Luben, T. J. Sacks, J.D, and Richmond-Bryant, J. 2018. "Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status." American Journal of Public Health, 108,480-485. https://doi.org/10.2105/AJPH.2017.304297; (3) Banzhaf, S., Ma, L., and Timmins, C. 2019. "Environmental Justice: The Economics of Race, Place, and Pollution." *Journal of Economic Perspectives, 33 (1),*185-208. Available at: https://www.aeaweb.org/articles?id=10.1257/jep.33.1.185

[46] Alisalad, S., Tavares, E., Stasio, T., and Majumder, M. 2021. "What the COVID-19 Pandemic Can Teach Us About Climate Justice." Applied Economics Clinic. Available at: https://aeclinic.org/publicationpages/2021/02/03/what-the-covid19-pandemic-can-teach-us-about-climate-justice

[47] Miranda, L. M., Edwards, S. E., Keating, M. H., and Paul, C. J. 2011. "Making the Environmental Justice Grade: The Relative Burden of Air Pollution Exposure in the United States." *International Journal of Environmental Research and Public Health, 8(6),*1755-1771. https://doi.org/10.3390/ijerph8061755

[48] U.S. EPA. n.d. "Environmental Justice." Available at: https://www.epa.gov/environmentaljustice

[49] U.S. Census. 2020. American Community Survey 5-Year Subject Tables [Table: S1901]. Available at: https://data.census.gov/cedsci/table?q=median%20income&g=0400000US25&tid=ACSST5Y2020.S1901

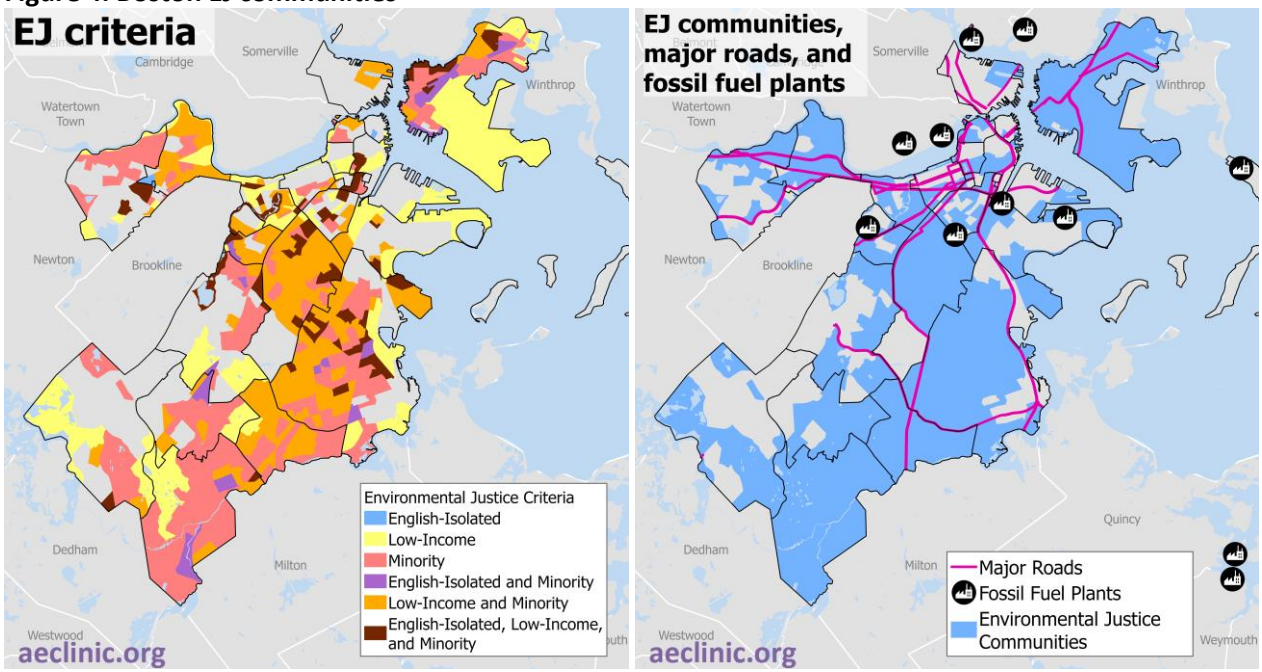
- minorities comprise 40 percent or more of the population;
- 25 percent or more of households lack English language proficiency; and/or
- racial/ethnic minorities comprise 25 percent or more of the population and the annual median household income of the municipality is not more than 150 percent of the statewide annual median household income.[50]

Most of Boston is considered an EJ community, with the majority of communities falling into one or more of the criteria mentioned above (see the left panel of Figure 4). Ethnic/racial minority populations are clustered in the Hyde Park and Dorchester areas, and in the Northern section of East Boston and Brighton (shown in light red). Clusters of low-income populations are seen throughout Boston (shown in yellow). Almost 9 out of 10 of Boston block groups are considered English-isolated communities; English-isolated areas in Boston always coincide with areas that also have high minority and/or low-income populations (these areas are purple and orange in the left panel of Figure 4). Especially overburdened communities, or those that meet all three EJ criteria (shown in brown), are most prevalent in Dorchester and Roxbury.

According to EPA, hazardous facilities like fossil fuel plants compromise air quality and subsequently increase the risk for negative health impacts for those living, going to school, and working nearby.[51] Being located near a major roadway, and therefore subject to traffic congestion, also puts nearby residents at risk for higher exposure to air pollution.[52] Air pollution from roadways has been linked to premature births and low birth weight outcomes, asthma, cardiovascular disease, and impaired lung development in children.[53] Major roadways cut through East Boston, Allston-Brighton, Roxbury, Dorchester, and Mattapan-- neighborhoods are composed almost entirely of EJ communities (see the right panel of Figure 4).

[50] Executive Office of Energy and Environmental Affairs. June 2021. *Environmental Justice Policy*. Prepared for the Commonwealth of Massachusetts. Available at: https://www.mass.gov/doc/environmental-justice-policy6242021-update/download, p. 4
[51] Ibid.
[52] U.S. Department of Transportation. 2015. "Proximity to Major Roadways." Available at: https://www.transportation.gov/mission/health/proximity-major-roadways
[53] U.S. EPA. 2014. *Near Roadway Air Pollution and Health: Frequently Asked Questions*. Available at: https://www.epa.gov/sites/default/files/2015-11/documents/420f14044_0.pdf

Figure 4. Boston EJ communities



Note: "B" refers to communities that meet the EJ criteria for minority, or BIPOC, population; "LI" refers to those that meet the low-income EJ criteria, and "EI" refers to those that meet the English-isolation EJ criteria. Communities may meet more than one criterion; the layering order in this map places EI on top followed by LI and B.
Data Source: (1) U.S. Census. 2020. American Community Survey 5-Year Estimates [Tables: B03002, B19013_001E, S1602]; (2) U.S. EIA. 2020. Form EIA-860 Data [Schedules 2, 3]. Available at: https://www.eia.gov/electricity/data/eia860/

While the Massachusetts EJ community definition includes criteria based on race-ethnicity, language, and income, it does not consider community demographics like age and ability-level. Using the methodology AEC employed in the as the *Social Equity Analysis for Carbon Free Boston*,[54] we calculated a SVI for each census block group[55] within Boston using U.S. Census American Community Survey data for 2020.

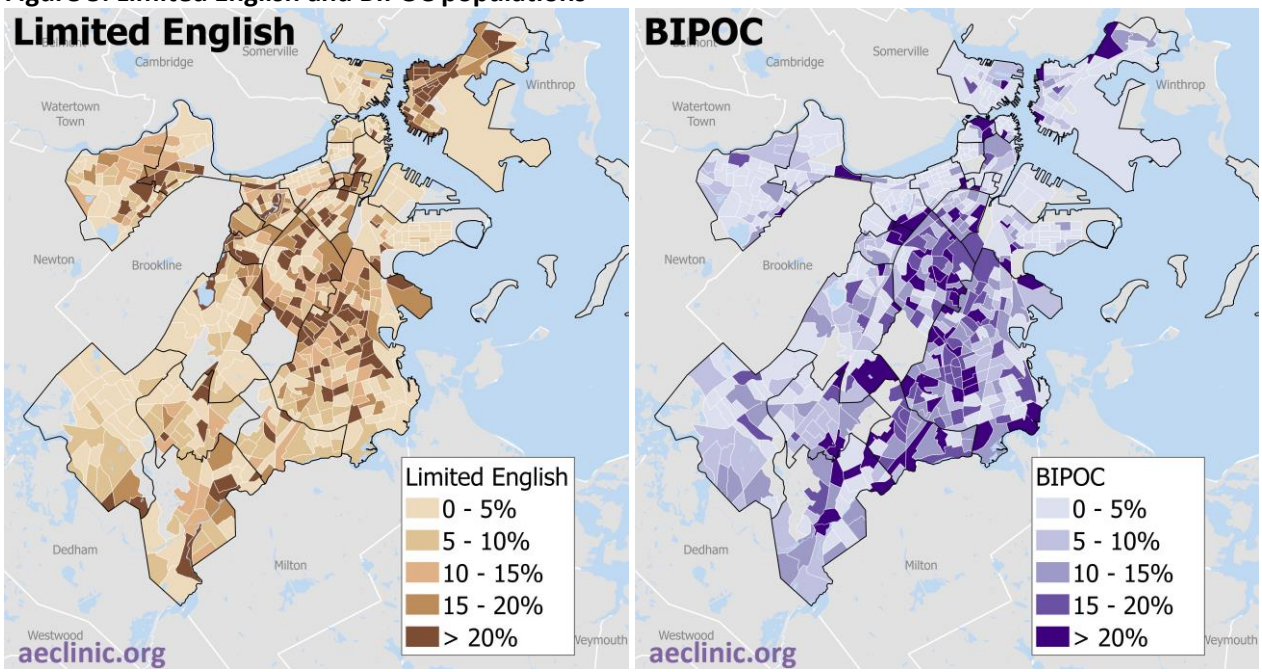
English isolation

Many communities within Boston experience some level of limited English proficiency in their populations. Areas with high concentrations of individuals or families with language barriers are at risk of being left out of state and local decision making, while English-isolated communities are able to advocate for themselves without translation services. Across Boston, the percentage of English-isolated households within a census block group ranges from 0 to 73 percent. Most communities with greater than 20 percent limited English-speaking households are located in Roxbury, Dorchester, Mission Hill, Longwood, and South End (see the left panel of Figure 5).

[54] Woods, B. and Stanton, E. A. 2019. *Social Equity Analysis of Carbon Free Boston.* Prepared on behalf of Green Ribbon Commission. Applied Economics Clinic. Available at: https://aeclinic.org/publicationpages/2019/4/12/social-equity-analysis-of-carbon-free-boston

[55] A census block group is the smallest geographic area that the U.S. Census Bureau uses to tabulate data. Each block group contains between 600 and 3,000 people.

Figure 5. Limited English and BIPOC populations



Data Source: U.S. Census. 2020. American Community Survey 5-Year Estimates [Tables: B03002, B19013_001E, S1602]

BIPOC populations

High BIPOC populations, defined as non-white and/or Hispanic individuals are most densely concentrated within the neighborhoods of East Boston, Roxbury, Dorchester, Mission Hill, and Allston-Brighton (see the right panel of Figure 5 above). In Boston as a whole, the percentage of BIPOC individuals ranges from 0 all the way to 100 percent of a census block group. The clustering of BIPOC communities is largely attributed to historical racism in Boston. In particular, redlining practices used in the mid-20th century, where neighborhoods were ranked by perceived "riskiness" for providing home loans, left low-income, BIPOC areas out of home buying opportunities in Boston's wealthier neighborhoods by frequently assigning them with the lowest rank.[56]

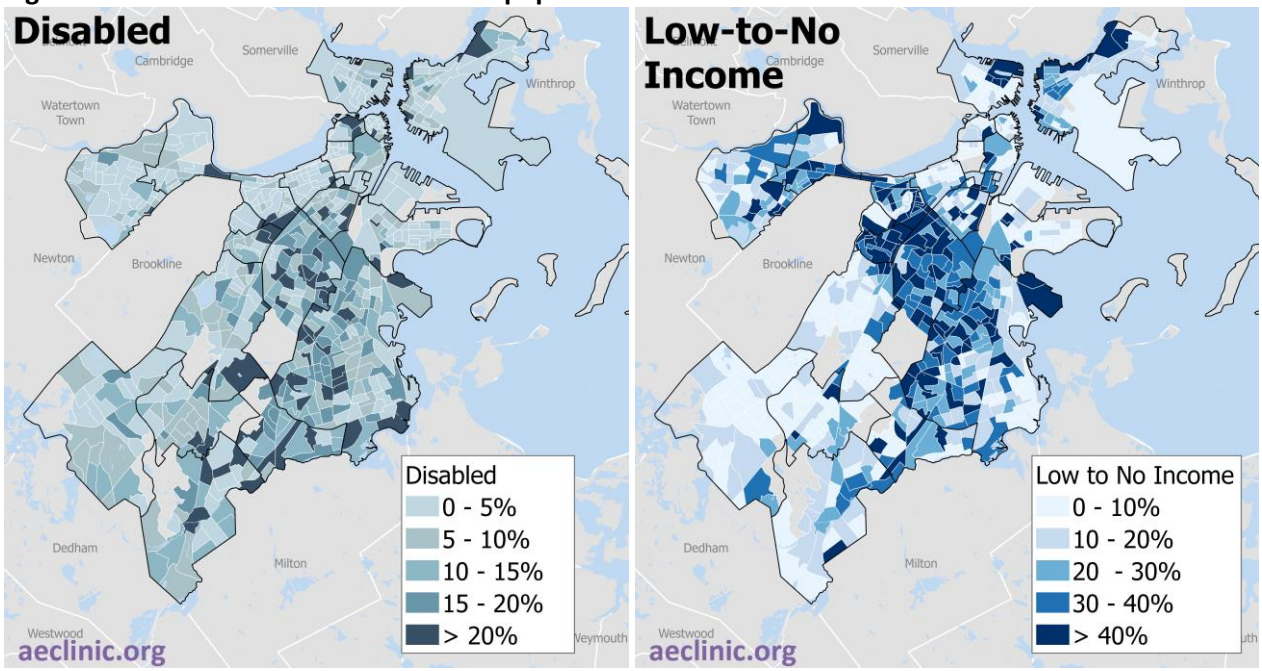
Population living with disabilities

Members of the community living with disabilities that compromise their ability to walk long distances would benefit from the increased shade that nearby trees could provide and, like all communities, benefit from the mental health benefits of tree coverage. The share of disabled persons—defined as an individual with one of the six following disabilities: hearing difficulty, vision difficulty, cognitive difficulty, self-care difficulty, and/or independent-living difficulty[57]—within a census block group ranges from 0 to 63 percent within Boston. Areas with a disabled population of over 20 percent are predominantly located in Jamaica Plain, Roxbury, Dorchester, Mattapan, Hyde Park, West End, and South End (see Figure 6). Areas with a low

[56] Executive Office of Energy and Environmental Affairs. June 2021. *Environmental Justice Policy*. p. 4
[57] U.S. Census Bureau. 2021. "How Disability Data Are Collected from The American Community Survey." Available at: https://www.census.gov/topics/health/disability/guidance/data-collection-acs.html#:~:text=All%20three%20surveys%20ask%20about,Each%20survey%20has%20unique%20advantages.

percentage of disabled people are more scattered throughout the neighborhoods of Boston, but are most prevalent in Charlestown, East Boston, South Boston, Fenway, Back Bay, and Allston-Brighton.

Figure 6. Disabled and low-to-no income populations



Data Source: U.S. Census. 2020. American Community Survey 5-Year Estimates [Table: B18101, C17002].

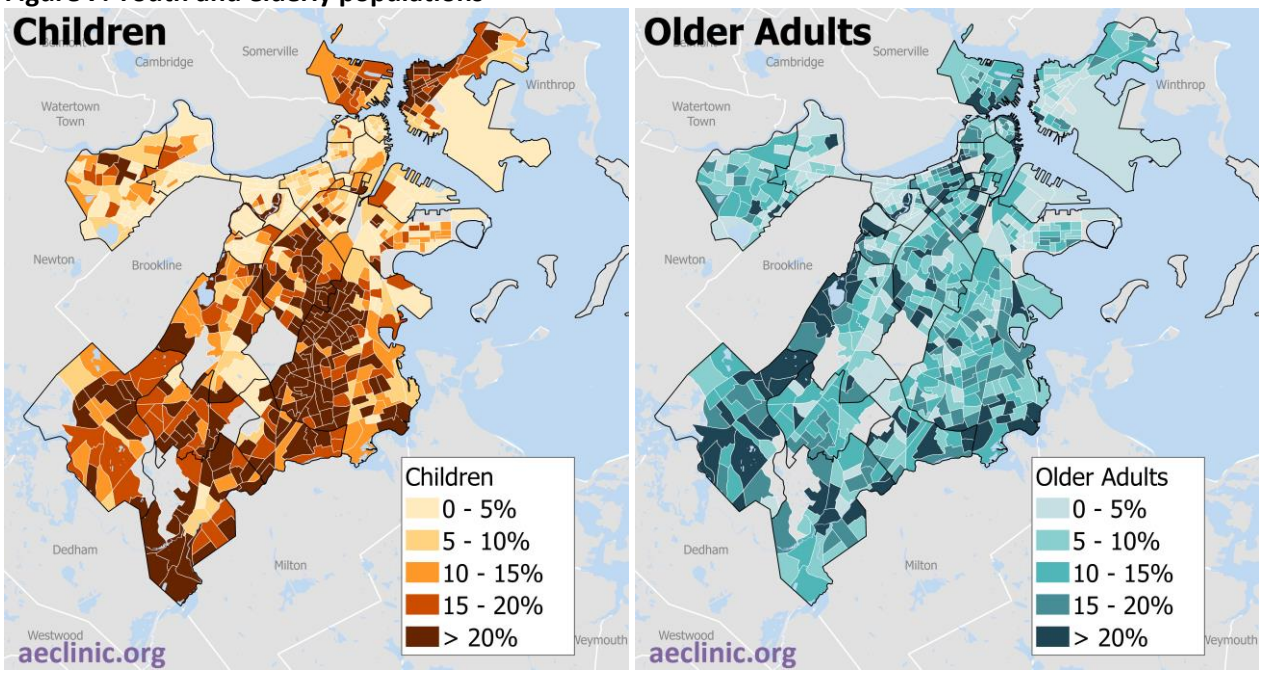
Low-to-no income

The share of low-to-no income population within a census block group ranges from 0 to 100 percent within the City of Boston. The percentage of the population that is low-to-no income (i.e., those that make 1.5 times the federal poverty level or less) is highest in Longwood, Mission Hill, Roxbury, Dorchester, Allston, Fenway, and Mattapan (see Figure 6 above). Low-income populations are disproportionately exposed to pollution,[58] and more likely to struggle with mental and/or physical health, and therefore would benefit from increased tree canopy for air purification and health benefits.[59]

Youth and elderly

Children and elderly populations are especially vulnerable to extreme heat and air pollution due to time spent outdoors, lack of mobility, and pre-existing health conditions.[60] In Boston, the share of the population within a block group that is under 18 years ranges from 0 percent to 63 percent and the share of population over 65 years ranges from 0 percent to 53 percent.

Figure 7. Youth and elderly populations



Data Source: U.S. Census. 2020. American Community Survey 5-Year Estimates [Table: B01001].

Dorchester, Roxbury, Roslindale, West Roxbury, and Mattapan all have high child populations and West Roxbury, Jamaica Plain, Hyde Park, and Dorchester have high elderly populations (see Figure 7 above).

[58] Office of Massachusetts Attorney General Maura Healey. 2020. *Building toward racial justice and equity in health: A call to action*. Available at: https://www.mass.gov/info-details/building-towardracial-justice-and-equity-in-health-a-call-to-action#read-the-report

[59] Woolf, S. et al. 2015. "How are income and wealth linked to health and longevity?" Available at: https://www.urban.org/sites/default/files/publication/49116/2000178-How-are-Income-and-Wealth-Linked-to-Health-and-Longevity.pdf

[60] U.S. EPA. n.d. "Heat Island Impacts." Available at: https://www.epa.gov/heatislands/heat-island-impacts

Given that children and elderly are particularly vulnerable to heat and air pollution,[61] planting trees in these areas would reduce vulnerability to the impacts of climate change.

Social Vulnerability Index

The SVI combines values from these six measures of vulnerability according to a formula discussed in *Social Equity Analysis of Carbon Free Boston*[62]:

- **Limited English:** the share of households that speak limited English.
- **BIPOC:** the share of the population that identifies as Black, Indigenous, or Persons of Color.
- **Disabled:** the share of the population that is disabled.
- **Low-to-no Income:** the share of the population that earns 150 percent or less of the federal poverty level.
- **Children:** the share of the population that is under the age of 18.
- **Older Adults:** the share of the population that is over the age of 65.[63]

The SVI for each community in Boston is illustrated in the map below (see Figure 8 below where darker oranges indicted higher social vulnerability). Communities with the highest (most vulnerable) SVI are depicted in orange and red and are most often observed in the neighborhoods of Dorchester and Roxbury. Communities with the lowest SVI, depicted in yellow, are concentrated in Boston's more affluent communities in the Back Bay, South Boston, Jamaica Plain, Allston-Brighton and West Roxbury neighborhoods. Health disparities, social inequities, and environmental injustice cumulatively impact individuals and the neighborhoods they live in, compounding negative outcomes for already overburdened communities.

Communities with high SVIs are not only more vulnerable to the impacts of climate change, but are also closely correlated with lower tree coverage than other Boston neighborhoods. The right-hand panel of Figure 8 below shows the overlap of high SVI scores (indicating more vulnerability) and low tree canopy (indicating that there is space for trees) in light red:

- red indicated a high social vulnerability index,
- white or light green indicates low levels of tree canopy, and
- light red areas combine these two characteristics: high vulnerability and low tree canopy levels (note that darker reds are the coincidence of high SVIs with high tree canopy levels).

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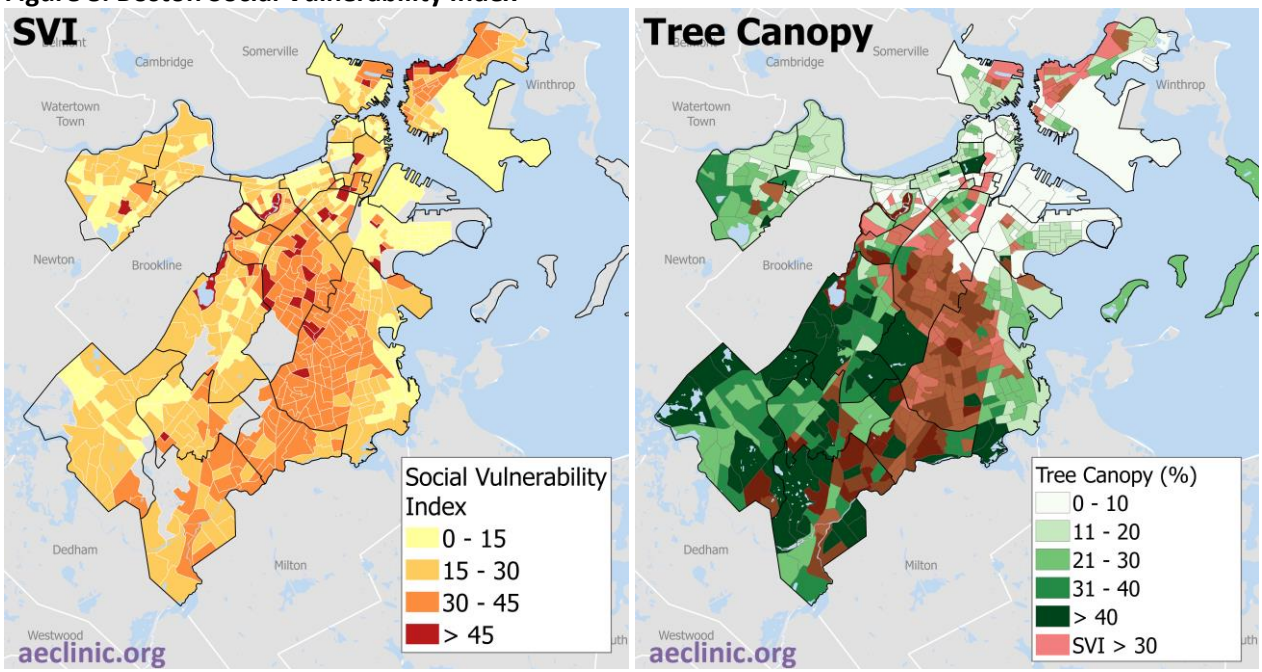
[61] Ibid.

[62] Woods, B. and Stanton, E. A. 2019. *Social Equity Analysis of Carbon Free Boston*. Prepared on behalf of the Green Ribbon Commission. Applied Economics Clinic. Available at: https://aeclinic.org/publicationpages/2019/4/12/social-equity-analysis-of-carbon-free-boston

[63] For each census block group or neighborhood, population shares for the six vulnerable groups are converted into six component indices, each ranging from 0 to 100/6 (or 16.7) in value. A higher score indicates a greater degree of vulnerability. The SVI is the sum of these component indices.

Figure 8. Boston Social Vulnerability Index



Note: The left panel shows the SVI across Boston Census block groups; the darker the color, the higher the SVI. The right panel shows the tree canopy percentage across Boston Census block groups with a transparent red layer that indicates a high SVI (SVI >30). Census block groups that appear in light red are those that are low tree canopy areas with a high social vulnerability.
Data source: AEC calculation

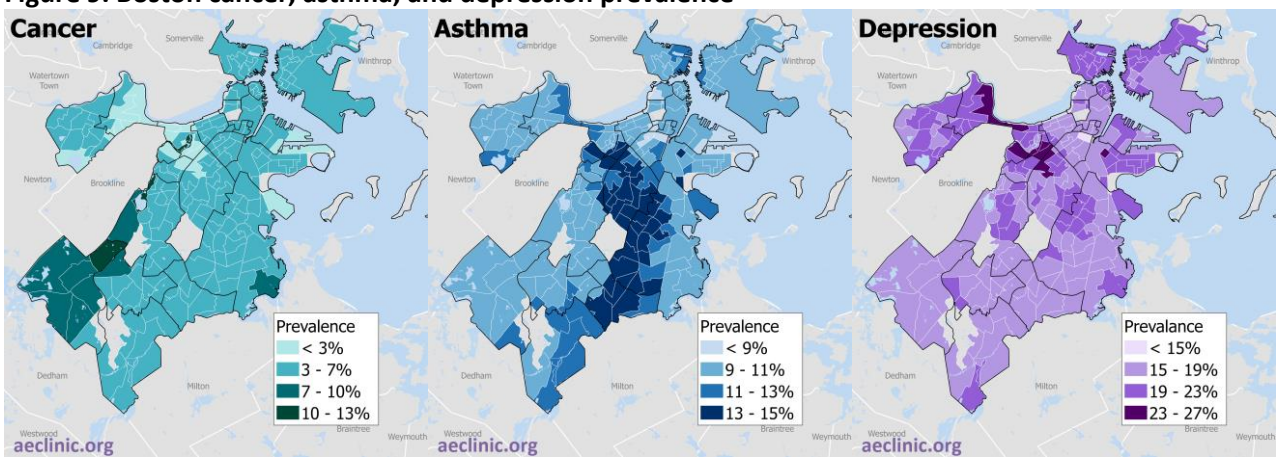
IV. Health Disparities

Neighborhoods with high levels of cancer, asthma, depression, and pollution exposure coincide with high levels of social vulnerability. Health disparities can be positively impacted by increased tree coverage through air purification, reduced risk for heat-related illnesses, and improved mental health.

To investigate the relationship between social vulnerability and health disparities, we examined the average prevalence of cancer, asthma, and depression per census tract[64] across Boston neighborhoods using the 2021 Center for Disease Control (CDC) PLACES dataset:

- Allston, Fenway, and Longwood have the lowest prevalence of cancer, while West Roxbury has the greatest prevalence (see Figure 9 and Table 1 below; lighter colors in Figure 9 indicate a lower rate of incidence, and darker colors indicate a higher rate of incidence). The average rate of incidence ranges from 2 to 13 percent across Boston neighborhoods. For context, the U.S. census tract average rate of incidence for cancer is 6.6 percent.
- For asthma, the South Boston Waterfront and West End have the lowest average prevalence, and Roxbury has the greatest prevalence. The average rate of incidence ranges from 8 to 14 percent across Boston neighborhoods, and the U.S. average rate of incidence for asthma is 9.5 percent.
- For depression, Mattapan and West End have the lowest prevalence, and Longwood has the greatest prevalence. The average rate of incidence ranges from 17 to 24 percent across Boston neighborhoods, and the U.S. average rate of incidence for depression is 20.1 percent.

Figure 9. Boston cancer, asthma, and depression prevalence



Data source: CDC. 2021. PLACES: Census Tract Data (GIS Friendly Format), 2021 release. Available at: https://chronicdata.cdc.gov/500-Cities-Places/PLACES-Census-Tract-Data-GIS-Friendly-Format-2021-/yjkw-uj5s

[64] A census tract is a geographic unit used by the U.S. Census to tabulate data. Census tracts contain between 1,200 and 8,000 people.

Several Boston neighborhoods recorded greater than average shares of people with these illnesses including Dorchester, Longwood, Mattapan, and Roxbury. In addition, Boston communities with the greatest prevalence of cancer, asthma, and/or depression also appear to line up with those that have higher SVIs, with Mattapan and Roxbury having the greatest SVIs. (Note: As with U.S. Census Bureau data, undocumented immigrants are not likely to be included in CDC reporting skewing the results of our analysis to better represent the characteristics and experiences of documented communities.)

Table 1. Cancer, asthma, and depression prevalence by neighborhood in 2019

Neighborhood	Cancer prevalence (%)	Asthma prevalence (%)	Depression prevalence (%)	SVI
Allston	2	11	21	33
Back Bay	5	9	19	32
Beacon Hill	5	9	19	34
Brighton	4	10	20	37
Charlestown	6	10	20	42
Chinatown	4	11	18	56
Dorchester	5	13	19	67
Downtown	6	10	18	27
East Boston	5	10	20	58
Fenway	2	12	22	38
Hyde Park	6	12	18	63
Jamaica Plain	6	10	19	52
Longwood	3	13	24	59
Mattapan	5	13	17	76
Mission Hill	4	12	21	45
North End	5	10	20	17
Roslindale	6	11	19	45
Roxbury	5	14	20	75
South Boston	5	11	21	29
South Boston Waterfront	3	8	18	0
South End	5	10	18	58
West End	5	9	17	46
West Roxbury	8	10	18	42

Data Source: CDC. 2021. PLACES: Census Tract Data (GIS Friendly Format), 2021 release. Available at: https://chronicdata.cdc.gov/500-Cities-Places/PLACES-Census-Tract-Data-GIS-Friendly-Format-2021-/yjkw-uj5s

Table 2. Neighborhood health indicators for 2011- 2015

Neighborhood	Skin Cancer	Lung Cancer	Ozone	PM2.5	SVI
Allston	290	627	5,879	1,013	33
Back Bay	1,031	375	3,834	1,577	32
Beacon Hill	503	292	3,156	2,268	34
Brighton	991	1,004	5,575	2,498	37
Charlestown	1,345	1,036	3,847	1,768	42
Chinatown	N/A	125	7,211	N/A	56
Dorchester	1,176	2,628	5,431	2,243	67
Downtown	242	153	8,929	4,019	27
East Boston	536	1,213	4,443	1,686	58
Fenway	458	813	5,321	2,605	38
Hyde Park	395	618	6,688	3,439	63
Jamaica Plain	1,350	945	3,787	1,426	52
Longwood	0	122	5,918	3,518	59
Mattapan	37	420	5,098	2,747	76
Mission Hill	18	265	5,568	2,678	45
North End	517	529	3,140	1,576	17
Roslindale	444	734	4,538	2,040	45
Roxbury	135	1,360	4,341	1,946	75
South Boston	1,596	1,339	3,959	2,136	29
South Boston Waterfront	87	162	1,924	217	0
South End	530	747	4,788	1,725	58
West End	323	191	4,204	834	46
West Roxbury	475	579	6,433	2,234	42

Note: Skin cancer and lung cancer values are the standardized incidence ratio (SIR), or the number of cases expected in the neighborhood based on observed survey responses. Ozone and PM2.5 values are measured in person-days over pollution limits, or in other words, a population adjusted measure of poor air quality. Data source: MA DPH. 2015. "Massachusetts Environmental Public Health Tracking." Available at: https://matracking.ehs.state.ma.us/Health-Data/index.html#MyPopup

In addition, the Massachusetts Department of Public Health (DPH) Environmental Public Health Tracking (EPHT) system[65] reports the incidence of several health metrics by census tract including, skin and lung cancer prevalence, ozone and PM2.5 pollution levels. Skin and lung cancer prevalence are highest in Dorchester; followed by South Boston and Charlestown. Outside of these neighborhoods, lung cancer alone is more prevalent in Roxbury and East Boston, both of which also have high social vulnerability (see Table 2 above where neighborhoods with higher SVIs are shown in red). Comparison of data from 2006 to 2015 reveals that both ozone and PM2.5 pollution have decreased substantially across Boston. Pollution levels in Downtown Boston—where there is a high concentration of residents, businesses, and construction work—fallen the least over time.[66]

[65] Massachusetts Department of Public Health (DPH). 2022. "Health Data." Available at: https://matracking.ehs.state.ma.us/Health-Data/index.html
[66] Ibid.

V. Tree Priority Communities

To identify communities that should be a priority for increasing tree canopy coverage, AEC examined existing tree canopy, the amount of space available for small trees,[67] together with the location of Boston's most vulnerable residents[68] to create a "tree priority community" index that will help prioritize communities that could benefit the most from investments in tree equity. In recognition of the difference between tree planting efforts on public compared to private spaces, AEC examined public and private land separately, identifying two sets of priority communities for tree planting.

Public Space

The City of Boston's Open Space and Recreation Plan calls for the expansion of the tree canopy in both public and private spaces throughout the city, as well as the protection of planted trees.[69] Shade trees planted in city-owned spaces, such as sidewalks in front of homes and businesses, are regulated by state and city laws and maintained by the Parks Department.[70] Any Boston resident can request for a tree to be planted on the sidewalk edge in front of their home or business, but the success of the application depends on stringent requirements for sidewalk spacing and neighborhood aesthetics.[71]

Public space for trees is most available in Hyde Park, Jamaica Plain, and Roslindale.[72] Unfortunately, our analysis shows that communities with high social vulnerability have little public space for trees, and vice versa. Boston neighborhoods that are home to the City's most overburdened communities, or those with a high SVI, such as Dorchester, Mattapan, and Roxbury, have space available for less than 25,000 additional small trees per square kilometer (km^2) (or less than 64,750 per square mile (mi^2) compared to low SVI neighborhoods like Jamaica Plain, Roslindale and Hyde Park where four times that number (more than 100,000 small trees per km^2 (259,000 per mi^2)) could be planted (see Figure 10 where, as above in Figure 8, light red indicates an area with low tree canopy coverage and high vulnerability).

Private Space

Private space for trees includes any space on private property that is suitable for tree-planting. For the average single-family home, this may include a front or back yard, or the green verge next to the sidewalk in front of the home. According to the City of Boston's Open Space and Recreation Plan, public funding is available for planting *public* shade trees (i.e., planting a tree next to the sidewalk or in the front-yard if the sidewalk verge is not wide enough).[73] In contrast, according to the Massachusetts Department of Conservation and Recreation (DCR), planting trees on *private* property comes with potential confusion over

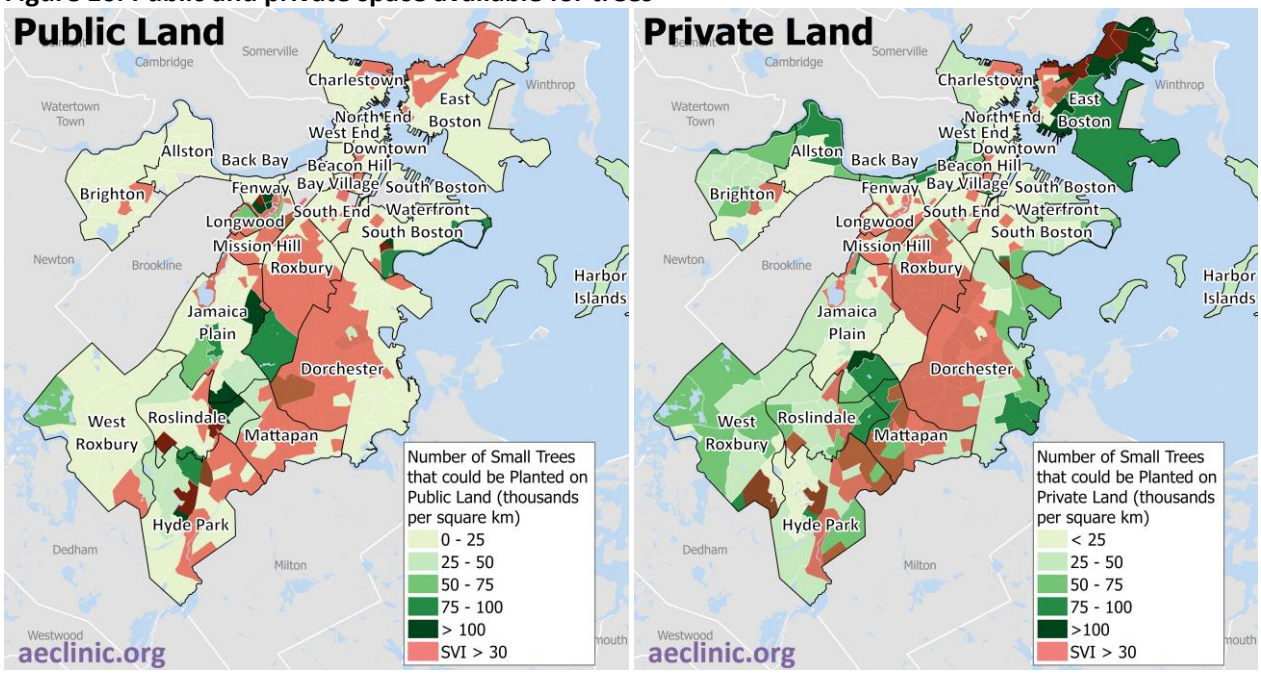
[67] We use "small trees" as the measure for space available for trees (as opposed to medium or large trees) because this value represents the maximum number of trees that could be planted and does not exclude areas without large areas of land open for planting.
[68] Defined as census block groups with a SVI greater than 30.
[69] City of Boston. 2015. Open Space & Recreation Plan. Available at: https://documents.boston.gov/parks/pdfs/OSRP_2015-2021.pdf, p. 48
[70] Ibid, p. 48
[71] City of Boston. N.d. "How to Get a Tree Planted on City Land." Available at: https://www.boston.gov/departments/parks-and-recreation/how-get-tree-planted-city-land
[72] Data source: Speak for the Trees Boston. 2016. "Exploring Tree Equity in Boston."
[73] City of Boston. 2015. Open Space & Recreation Plan. Available at: https://documents.boston.gov/parks/pdfs/OSRP_2015-2021.pdf

responsibility for the tree (i.e., DCR or the owner of the property).[74]

Available private space for trees is concentrated in West Roxbury, Hyde Park, Mattapan, Roslindale, Jamaica Plain, and East Boston (see Figure 10). These neighborhoods have census tracts with space for more than 50,000 small trees per km^2 (129,500 per mi^2) on private lands. Areas with the least private space for trees (i.e., less than 25,000 per km^2 or 64,750 per mi^2) are concentrated in the centermost part of Boston, including Roxbury, Mission Hill, Longwood, Fenway, Bay Village, Beacon Hill, West End, North End, Charlestown, Downtown, South Boston, South Boston Waterfront, and South End.

Communities with a high SVI index and more private space available for trees are located in East Boston, Dorchester, Mattapan and Hyde Park. At the same time, many socially vulnerable communities also have the least private space availability for trees (i.e., there is less opportunity for tree planting on private land). Examples of this are most clearly illustrated in the Dorchester, Roxbury, Longwood, Mission Hill, and South End communities.

Figure 10. Public and private space available for trees



Data source: Speak for the Trees Boston. 2016. "Exploring Tree Equity in Boston."

Identifying priority communities

To identify areas that are a priority for planting trees—with the goal of improving equity outcomes—AEC considered three criteria: current tree scarcity, public space for trees, and the social vulnerability of the area. Tree scarcity is the percentage of land that is not covered by trees (i.e., it is one minus the percentage of tree canopy coverage). Public space for trees is the amount of space available for planting small, medium, or large sized trees divided by tract area. To calculate the Tree Priority Index, tree scarcity,

[74] Massachusetts Department of Conservation and Recreation. 2021. *Guide to Local Tree Bylaws for Communities in Massachusetts*. Available at: https://www.mass.gov/doc/tree-bylaw-and-ordinance-guide/download

space for small trees (chosen as a simple metric to represent all tree sizes), and the SVI are converted into three component indices, each ranging from 0 to 100 in value, where 0 is the census tract with the lowest value component index value and 100 is the census tract with the highest value component index value. the census tract with the most vulnerability for that index. The three component indices are then summed and divided by three. If a census block group had the highest value for all three categories—its Tree Priority Index would be 100.0; If it had the lowest value for all three categories—its Tree Priority Index would be 0.0. Tree Priority Index was calculated separately for tree planting opportunities on public and private land (see Table 3 for public land and Table 4 for private land).

Tree Priority Index values for Boston's 207 census tracts range from 11 to 75 in value. Out of over 90 high-SVI census tracts (those containing one or more block groups scoring over 30 on the SVI), AEC calculated the highest Tree Priority Index for tree planting on public land for a census tract within South Boston, with 86 percent of land without tree coverage, space for thousands of trees, and a high SVI (see Table 3 which includes public space for trees measured in the number of trees per thousand square meters and Table 4 which includes public space for trees measured as the number of total trees that can be planted). The remaining top 9 priority communities are within Roxbury, Fenway, Dorchester, East Boston, and Charlestown.

Table 3. Top 10 priority communities for planting trees on public land

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (trees per thousand square meters)			SVI	Tree Priority Index
			Small	Medium	Large		
61000	South Boston	86%	629.3	25.6	14.4	31	**72**
60700	South Boston	88%	6.7	0.3	0.2	55	**63**
80401	Roxbury	84%	4.7	0.2	0.1	50	**55**
981800	Fenway	76%	37.8	1.5	0.9	55	**55**
80500	Roxbury	86%	36.9	1.5	0.9	45	**54**
90200	Dorchester	75%	5.7	0.2	0.1	56	**53**
10205	Fenway	83%	422.6	17.2	9.7	24	**53**
70901	Roxbury	87%	3.1	0.1	0.1	44	**51**
50700	East Boston	88%	0.8	< 0.1	< 0.1	43	**51**
50300	Charlestown	90%	31.2	1.3	0.7	39	**51**

Source: AEC calculations.
Note: For an entire list of high-SVI census tracts, or those that contain block groups with an SVI greater than 30, within the City of Boston, see Table 7 and Table 8 in the Appendix. To identify where a particular census tract is located, see the 2020 U.S. Census map for Suffolk County available here:
https://www2.census.gov/geo/maps/DC2020/PL20/st25_ma/censustract_maps/c25025_suffolk/DC20CT_C25025.pdf

Table 4. Number of trees that could be planted on public land in priority communities

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (number of potential trees)		
			Small	Medium	Large
61000	South Boston	86%	59,380	2,419	1,361
60700	South Boston	88%	864	35	20
80401	Roxbury	84%	2,068	85	50
981800	Fenway	76%	41,071	1,674	941
80500	Roxbury	86%	5,167	210	119
90200	Dorchester	75%	1,553	64	34
10205	Fenway	83%	25,091	1,022	575
70901	Roxbury	87%	177	7	4
50700	East Boston	88%	215	9	5
50300	Charlestown	90%	3,704	150	85

Source: AEC calculations.

Like the Tree Planting Index for tree planting on public land, the census tracts with the highest Tree Planting Index for planting on private land are within East Boston, South Boston, Roxbury and Fenway (see

Table 5 which includes private space for trees measured in the number of trees per square kilometer and Table 6 which includes public space for trees measured as the number of total trees that can be planted). In East Boston alone, there are four top ten priority communities located along the Chelsea Creek near Belle Isle Marsh and Constitution Beach (see Figure 11).

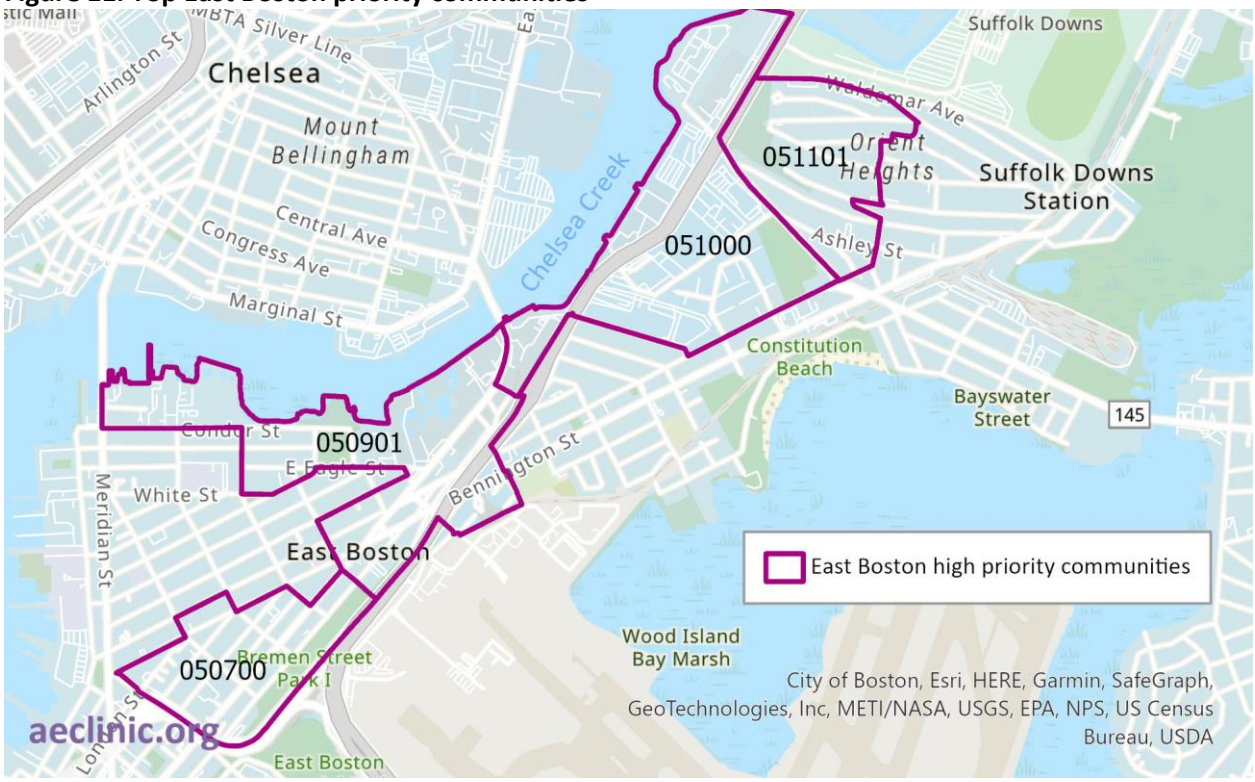
Table 5. Top 10 priority communities for planting trees on private land

Tract	Neighborhood	Tree Scarcity (%)	Private Space for Trees (trees per thousand square meters)			SVI	Tree Priority Index
			Small	Medium	Large		
51101	East Boston	88%	25.5	1.0	0.5	30	**72**
60700	South Boston	88%	21.5	0.9	0.5	55	**63**
50901	East Boston	86%	26.9	1.1	0.6	39	**62**
80401	Roxbury	84%	7.3	0.3	0.2	50	**55**
51000	East Boston	87%	52.8	2.1	1.2	29	**54**
90200	Dorchester	75%	22.2	0.9	0.5	56	**53**
981800	Fenway	76%	10.2	0.4	0.2	55	**53**
80500	Roxbury	86%	13.9	0.5	0.3	45	**53**
50700	East Boston	88%	58.3	2.3	1.2	43	**52**
70901	Roxbury	87%	114.1	4.6	2.6	44	**51**

Source: AEC calculations. For an entire list of high-SVI census tracts, or those that contain block groups with an SVI greater than 30, within the City of Boston, see Table 7 and Table 8 in the Appendix. To identify where a particular census tract is located, see the 2020 U.S. Census map for Suffolk County:

https://www2.census.gov/geo/maps/DC2020/PL20/st25_ma/censustract_maps/c25025_suffolk/DC20CT_C25025.pdf

Figure 11. Top East Boston priority communities



Source: AEC calculations.

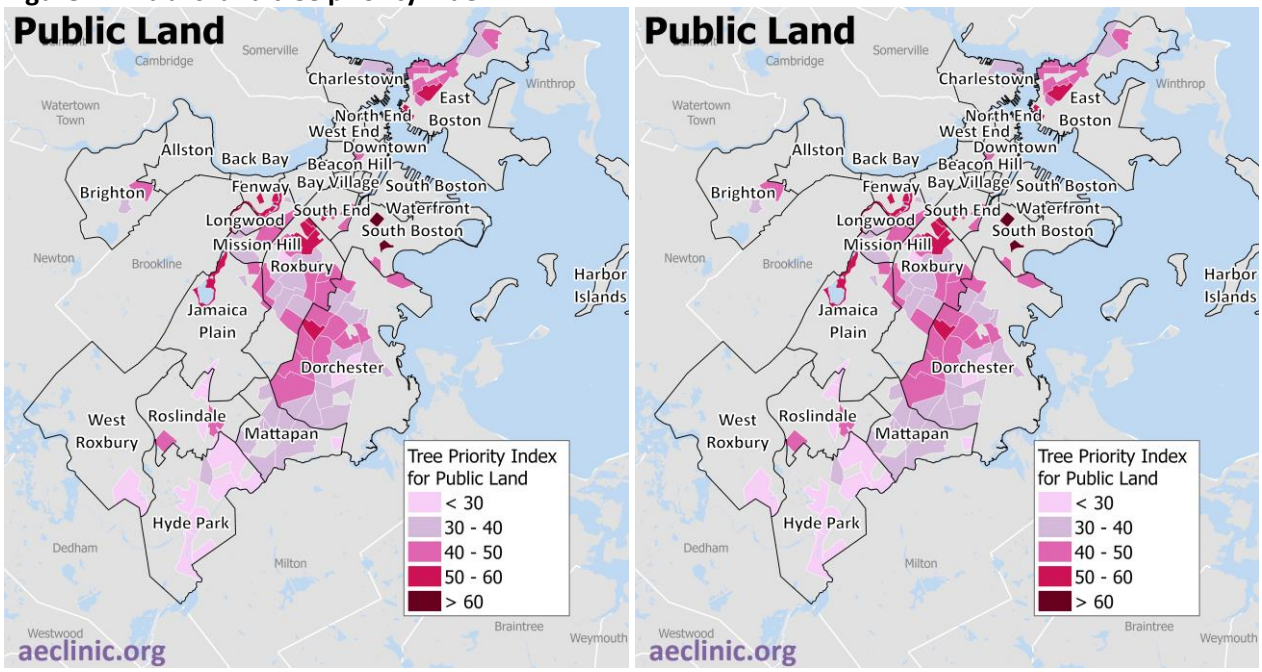
Table 6. Number of trees that could be planted on private land in priority communities

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (number of potential trees)		
			Small	Medium	Large
51101	East Boston	88%	5,423	221	122
60700	South Boston	88%	864	35	20
50901	East Boston	86%	4,775	193	108
80401	Roxbury	84%	2,068	85	50
51000	East Boston	87%	10,792	439	247
90200	Dorchester	75%	1,553	64	34
981800	Fenway	76%	41,071	1,674	941
80500	Roxbury	86%	5,167	210	119
50700	East Boston	88%	215	9	5
70901	Roxbury	87%	177	7	4

Source: AEC calculations.

AEC recommends that investment in tree planting be focused in the areas in which two characteristics coincide: (1) the greatest opportunity, or space, for planting trees, either public or private, and (2) the highest concentration of overburdened populations. The Boston neighborhoods that fit these criteria, for both public and private tree planting efforts, are within South Boston, East Boston, Dorchester and Roxbury (see Figure 12 below where darker pinks indicate areas with a high Tree Priority Index).

Figure 12. Public land tree priority index



In summary, the most vulnerable communities in Boston are located in Dorchester and Roxbury, where many communities also have less tree coverage than in other Boston neighborhoods. Less tree coverage means fewer tree benefits and worse health outcomes:

- Many of Boston's most overburdened neighborhoods lack the benefits associated with tree coverage.
- Neighborhoods without adequate tree coverage do not get the same air purification and cooling benefits as neighborhoods with plentiful tree coverage.
- Less air purification and cooling increase the risk of greater heat accumulation from the urban heat index and greater exposure to harmful air pollutants.
- Worse air and greater heat lead to poorer health outcomes.

To improve tree equity in the City of Boston, tree planting efforts should be focused on the priority communities identified in this report where there are both a large share of overburdened households and a lack of tree coverage. In future work, a more in-depth analysis of the correlation between the socioeconomic factors and tree canopy coverage would be instrumental in developing a full understand the relationship between tree coverage and temperature, air pollution, race/ethnicity, age, and other community characteristics.

Next steps

This preliminary analysis of tree canopy in relation to the social, health, and environmental disparities within Boston suggest that there are several communities, particularly within Dorchester, Roxbury, and East Boston, that face significant social disparities and less tree canopy coverage. The result is that local communities are more vulnerable to climate change impacts.

A more in-depth analysis of the correlation between measures of climate, environmental, and social vulnerability and tree coverage would shed light on the overall relationship between existing disparities and tree canopy in the City of Boston. For example, our preliminary spatial analysis reveals that neighborhoods with more low-income families and more English-isolated families have less tree cover.

Future work on the selection of tree species relative to climate resiliency would lend helpful insight in the development of strategies to plant trees in overburdened communities. As greenhouse gas emissions rise and temperature, rainfall, storm surges and other weather-related impacts become less predictable and more severe, Boston's environment may become less suitable for certain tree species and more suitable for others.[75] Sustainable tree planting efforts should take into account the tree species that would be most suitable in Boston's climate future (e.g., higher temperatures, increased rainfall) while also maintaining species diversity.[76] For instance, according to the Massachusetts Department of Environmental Protection, choosing certain hickory, oak, and beech tree species over coniferous species like pine and spruce trees will support forest resilience against shifts in soil and climate conditions.

[75] Massachusetts Department of Conservation and Recreation. 2022. *Managing Forests for Climate Change in Massachusetts.* Available at: https://www.mass.gov/doc/managing-forests-for-climate-change-in-massachusetts-forester-guide/download, p. 7
[76] Ibid, p. 6

VI. Appendix

Table 7. Tree priority communities

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (numbers of trees per thousand square meters)			Private Space for Trees (numbers of trees per thousand square meters)			SVI*	Tree Priority Index	
			Small	Medium	Large	Small	Medium	Large		Public	Private
401	Brighton	76%	3.6	0.2	0.1	70.7	2.8	1.5	30.6	31	32
603	Allston	77%	14.3	0.6	0.3	38.8	1.6	0.9	41.3	42	42
10205	Fenway	83%	422.6	17.2	9.7	10.2	0.4	0.2	24.4	53	30
10403	Back Bay	88%	2.1	0.1	0.1	8.9	0.4	0.2	28.3	37	37
10405	Back Bay	84%	91.9	3.7	2.1	16.3	0.7	0.4	30.3	41	36
10500	Back Bay	88%	<0.1	<0.1	<0.1	60.1	2.4	1.3	28.5	37	38
40200	Charlestown	84%	37.7	1.5	0.9	18.6	0.7	0.3	31.0	39	37
40300	Charlestown	85%	50.0	2.0	1.2	31.4	1.1	0.4	20.1	30	28
40801	Charlestown	86%	13.1	0.5	0.3	36.8	1.5	0.8	30.3	38	38
50101	Charlestown	87%	5.6	0.2	0.1	20.0	0.8	0.3	39.6	47	47
50200	East Boston	87%	1.1	<0.1	<0.1	13.8	0.5	0.3	36.7	44	44
50300	Charlestown	90%	31.2	1.3	0.7	114.1	4.6	2.6	39.2	51	51
50600	East Boston	89%	11.7	0.5	0.3	12.7	0.4	0.2	30.8	41	41
50700	East Boston	88%	0.8	<0.1	<0.1	58.3	2.3	1.2	43.0	51	52
50901	East Boston	86%	9.3	0.4	0.2	1,047.8	42.6	23.9	38.7	46	62
51000	East Boston	87%	19.0	0.8	0.4	1,021.0	41.6	23.3	29.4	39	54
51101	East Boston	88%	19.1	0.8	0.4	2,200.8	89.6	50.3	29.9	40	72
60700	South Boston	88%	6.7	0.3	0.2	21.5	0.9	0.5	55.1	63	63
61000	South Boston	86%	629.3	25.6	14.4	25.5	1.0	0.5	30.8	72	39
61101	Dorchester	80%	0.1	<0.1	<0.1	107.6	4.4	2.5	45.2	47	49
70102	Beacon Hill	92%	4.0	0.2	0.1	0.1	<0.1	<0.1	33.9	46	46
70201	Beacon Hill	89%	8.7	0.4	0.2	7.7	0.3	0.2	32.7	43	42
70302	Back Bay	85%	2.4	0.1	0.1	9.4	0.3	0.2	20.0	28	28
70402	Chinatown	87%	<0.1	<0.1	<0.1	37.6	1.5	0.9	34.4	42	43
70502	South End	79%	15.7	0.6	0.4	7.9	0.3	0.2	48.3	50	49
70901	Roxbury	87%	3.1	0.1	0.1	13.9	0.5	0.3	44.4	51	51

Note: SVI index may be less than 30 at the census tract level because SVI calculation to identify priority areas was calculated at the block group level; several block groups are within each census tract. To identify where a particular census tract is located, see the 2020 U.S. Census map for Suffolk County Available here:
https://www2.census.gov/geo/maps/DC2020/PL20/st25_ma/censustract_maps/c25025_suffolk/DC20CT_C25025.pdf

Table 7 (cont'd)

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (numbers of trees per thousand square meters)			Private Space for Trees (numbers of trees per thousand square meters)			SVI*	Tree Priority Index	
			Small	Medium	Large	Small	Medium	Large		Public	Private
71201	Roxbury	86%	3.0	0.1	0.1	32.4	1.3	0.7	44	50	50
80100	Dorchester	85%	106.0	4.3	2.4	192.8	7.7	4.1	35	47	44
80300	Roxbury	77%	11.6	0.5	0.3	23.2	0.9	0.5	37	38	37
80401	Roxbury	84%	4.7	0.2	0.1	26.9	1.1	0.6	50	55	55
80500	Roxbury	86%	36.9	1.5	0.9	52.8	2.1	1.2	45	54	53
80601	Fenway	81%	27.8	1.1	0.6	41.8	1.7	0.9	35	40	39
80801	Fenway	82%	8.9	0.4	0.2	26.7	1.1	0.6	38	43	43
81001	Fenway	75%	1.1	0.0	0.0	16.9	0.7	0.3	39	37	38
81102	Jamaica Plain	74%	15.5	0.6	0.4	22.6	0.9	0.5	35	33	33
81200	Jamaica Plain	73%	16.2	0.7	0.4	36.3	1.4	0.8	44	42	41
81301	Jamaica Plain	72%	0.8	0.0	0.0	28.3	1.1	0.6	47	42	43
81302	Jamaica Plain	67%	16.1	0.7	0.4	30.8	1.3	0.7	56	47	47
81400	Jamaica Plain	74%	35.9	1.5	0.8	90.7	3.6	2.0	27	28	27
81500	Roxbury	69%	7.7	0.3	0.2	34.4	1.4	0.8	39	33	33
81700	Roxbury	72%	13.5	0.5	0.3	28.4	1.1	0.6	43	40	40
81800	Dorchester	74%	3.7	0.1	0.1	38.8	1.6	0.8	47	44	44
81900	Jamaica Plain	70%	10.5	0.4	0.2	37.6	1.5	0.8	39	34	34
82000	Dorchester	73%	10.2	0.4	0.2	27.6	1.1	0.6	40	38	38
82100	Dorchester	72%	0.5	0.0	0.0	26.8	1.1	0.6	46	42	42
90100	Dorchester	72%	3.1	0.1	0.1	22.7	0.9	0.5	46	42	42
90200	Dorchester	75%	5.7	0.2	0.1	22.2	0.9	0.5	56	53	53
90300	Dorchester	74%	25.0	1.0	0.6	24.9	1.0	0.5	45	43	42
90400	Dorchester	75%	9.7	0.4	0.2	48.3	1.9	1.0	43	41	41
90600	Dorchester	80%	7.8	0.3	0.2	40.3	1.6	0.8	42	45	45
90901	Dorchester	82%	7.8	0.3	0.2	277.8	11.3	6.4	39	43	47
91001	Dorchester	80%	91.1	3.7	2.1	784.5	31.9	17.8	27	34	41
91200	Dorchester	76%	20.3	0.8	0.5	66.8	2.6	1.4	31	32	32
91300	Dorchester	79%	4.2	0.2	0.1	27.9	1.1	0.6	42	43	43
91400	Dorchester	72%	4.6	0.2	0.1	41.3	1.7	0.9	43	39	39
91500	Dorchester	72%	3.3	0.1	0.1	22.6	0.9	0.5	44	40	40

Note: SVI index may be less than 30 at the census tract level because SVI calculation to identify priority areas was calculated at the block group level; several block groups are within each census tract. To identify where a particular census tract is located, see the 2020 U.S. Census map for Suffolk County Available here:
https://www2.census.gov/geo/maps/DC2020/PL20/st25_ma/censustract_maps/c25025_suffolk/DC20CT_C25025.pdf

Table 7 (cont'd)

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (numbers of trees per thousand square meters)			Private Space for Trees (numbers of trees per thousand square meters)			SVI*	Tree Priority Index	
			Small	Medium	Large	Small	Medium	Large		Public	Private
91600	Dorchester	77%	51.0	2.1	1.2	30.1	1.2	0.6	39	42	40
91700	Dorchester	74%	33.9	1.4	0.8	25.4	1.0	0.5	43	42	41
91800	Dorchester	73%	7.5	0.3	0.2	27.3	1.1	0.6	44	40	40
91900	Dorchester	71%	6.3	0.3	0.1	29.4	1.2	0.6	45	40	40
92000	Dorchester	73%	5.9	0.2	0.1	22.6	0.9	0.5	38	34	35
92101	Dorchester	78%	3.1	0.1	0.1	83.5	3.4	1.8	37	38	39
92200	Dorchester	73%	12.1	0.5	0.3	32.3	1.3	0.7	32	29	29
92300	Dorchester	71%	2.1	0.1	0.0	33.8	1.3	0.7	40	35	35
92400	Dorchester	72%	3.3	0.1	0.1	33.6	1.3	0.7	47	42	42
100100	Dorchester	71%	56.5	2.3	1.3	47.2	1.9	1.0	43	41	39
100200	Dorchester	74%	4.7	0.2	0.1	31.2	1.2	0.7	43	40	40
100300	Dorchester	68%	5.3	0.2	0.1	27.3	1.1	0.6	42	35	35
100400	Dorchester	65%	1.6	0.1	0.0	29.4	1.2	0.6	41	32	32
100500	Dorchester	69%	12.7	0.5	0.3	35.9	1.4	0.8	40	34	34
100900	Dorchester	64%	51.9	2.1	1.2	253.1	10.2	5.5	35	27	28
101001	Hyde Park	62%	11.7	0.5	0.3	91.0	3.7	2.0	42	30	31
101002	Dorchester	64%	10.1	0.4	0.2	40.5	1.6	0.9	43	33	33
101101	Dorchester	67%	1.8	0.1	0.0	70.9	2.9	1.6	40	31	32
101102	Dorchester	70%	13.3	0.5	0.3	22.9	0.9	0.5	44	38	38
110104	Jamaica Plain	62%	2.9	0.1	0.1	54.8	2.2	1.1	39	27	28
110201	Hyde Park	63%	275.1	11.2	6.3	40.2	1.6	0.9	39	43	29
110401	Jamaica Plain	64%	41.5	1.7	1.0	64.3	2.5	1.4	35	28	26
110403	Hyde Park	54%	3.2	0.1	0.1	271.9	11.0	6.0	28	11	15
120500	Jamaica Plain	71%	6.1	0.2	0.2	78.9	3.1	1.7	34	30	31
130406	Hyde Park	50%	5.5	0.2	0.1	93.6	3.8	2.1	43	21	22
140105	Hyde Park	54%	349.5	14.2	8.0	146.7	5.9	3.3	32	33	17
140106	Hyde Park	57%	345.0	14.1	7.9	71.2	2.9	1.6	41	43	26
140107	Hyde Park	55%	198.5	8.1	4.5	118.6	4.8	2.7	35	29	20
140201	Hyde Park	66%	0.6	0.0	0.0	79.2	3.2	1.8	31	23	24
140202	Hyde Park	58%	2.2	0.1	0.1	324.7	13.1	7.3	32	17	22
140300	Hyde Park	61%	18.1	0.7	0.4	61.8	2.5	1.4	37	26	26
140400	Hyde Park	58%	0.4	0.0	0.0	74.4	3.0	1.7	39	24	25
981800	Fenway	76%	37.8	1.5	0.9	7.3	0.3	0.2	55	55	53

Note: SVI index may be less than 30 at the census tract level because SVI calculation to identify priority areas was calculated at the block group level; several block groups are within each census tract. To identify where a particular census tract is located, see the 2020 U.S. Census map for Suffolk County Available here:
https://www2.census.gov/geo/maps/DC2020/PL20/st25_ma/censustract_maps/c25025_suffolk/DC20CT_C25025.pdf

Table 8. Public space available for trees

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (total number of potential trees)			Private Space for Trees (total number of potential trees)		
			Small	Medium	Large	Small	Medium	Large
401	Beacon Hill	76%	543	23	12	10788	425	235
603	Charlestown	77%	4455	181	102	12109	492	276
10205	East Boston	83%	25091	1022	575	607	26	12
10403	Beacon Hill	88%	77	3	2	327	14	8
10405	South Boston	84%	25773	1050	590	4566	185	104
10500	East Boston	88%	0	0	0	2349	94	52
40200	East Boston	84%	2083	83	48	1028	39	18
40300	Back Bay	85%	2468	100	58	1551	52	22
40801	Back Bay	86%	7640	310	176	21519	877	496
50101	East Boston	87%	1168	47	27	4212	163	71
50200	Charlestown	87%	260	10	6	3369	132	61
50300	Chinatown	90%	3704	150	85	13558	551	311
50600	East Boston	89%	1039	42	24	1128	33	17
50700	Roxbury	88%	215	9	5	15613	622	322
50901	Roxbury	86%	4775	193	108	538064	21900	12296
51000	East Boston	87%	10792	439	247	580386	23634	13254
51101	South Boston	88%	5423	221	122	626348	25501	14312
60700	Charlestown	88%	864	35	20	2756	112	62
61000	Roxbury	86%	59380	2419	1361	2404	94	49
61101	Back Bay	80%	13	1	0	12435	505	285
70102	Charlestown	92%	381	16	9	5	0	0
70201	Dorchester	89%	289	12	7	256	10	7
70302	Roxbury	85%	198	8	5	785	29	18
70402	Back Bay	87%	0	0	0	4714	191	109
70502	Charlestown	79%	1967	79	45	991	38	20
70901	Fenway	87%	177	7	4	801	30	17

Table 8 cont'd

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (total number of potential trees)			Private Space for Trees (total number of potential trees)		
			Small	Medium	Large	Small	Medium	Large
71201	Dorchester	86%	836	33	18	9104	369	205
80100	Fenway	85%	9587	390	221	17440	693	367
80300	Fenway	77%	3131	127	71	6239	245	138
80401	Dorchester	84%	2068	85	50	11849	476	266
80500	Dorchester	86%	5167	210	119	7383	297	167
80601	Dorchester	81%	9175	374	210	13796	559	311
80801	South End	82%	3252	131	75	9753	394	221
81001	Dorchester	75%	448	19	10	6588	259	134
81102	Dorchester	74%	5849	238	134	8508	342	192
81200	Roxbury	73%	2477	102	55	5553	220	125
81301	Dorchester	72%	193	8	4	6667	268	146
81302	Allston	67%	5550	225	126	10609	435	236
81400	Brighton	74%	6265	256	143	15850	633	343
81500	Dorchester	69%	2597	103	62	11563	462	253
81700	Fenway	72%	8556	346	196	18012	721	395
81800	Fenway	74%	1383	56	28	14501	581	313
81900	Dorchester	70%	4541	184	105	16293	657	357
82000	Dorchester	73%	3999	163	92	10820	428	228
82100	Dorchester	72%	194	8	5	9913	399	214
90100	Jamaica Plain	72%	1367	54	33	10130	400	206
90200	Dorchester	75%	1553	64	34	6079	237	138
90300	Dorchester	74%	9503	385	220	9458	383	196
90400	Dorchester	75%	4110	164	93	20553	817	436
90600	Jamaica Plain	80%	2367	93	52	12143	471	253
90901	Dorchester	82%	2158	88	49	76815	3130	1760
91001	Jamaica Plain	80%	8824	360	202	76012	3087	1725
91200	Dorchester	76%	2116	86	48	6954	266	144
91300	Dorchester	79%	1106	44	26	7316	286	146
91400	Dorchester	72%	1503	61	33	13415	538	294
91500	Roxbury	72%	1332	55	32	9150	362	189

Table 8 cont'd

Tract	Neighborhood	Tree Scarcity (%)	Public Space for Trees (total number of potential trees)			Private Space for Trees (total number of potential trees)		
			Small	Medium	Large	Small	Medium	Large
91600	Dorchester	77%	10900	443	249	6438	253	134
91700	Dorchester	74%	9792	400	223	7350	293	155
91800	Dorchester	73%	3237	132	73	11813	467	246
91900	Dorchester	71%	3026	123	67	14168	570	292
92000	Dorchester	73%	2881	120	65	11069	430	224
92101	Jamaica Plain	78%	1840	75	42	49157	1982	1089
92200	Jamaica Plain	73%	5762	235	132	15375	613	332
92300	Dorchester	71%	721	29	16	11588	460	244
92400	Dorchester	72%	1978	80	46	19997	790	429
100100	Dorchester	71%	58573	2389	1343	48945	1963	1087
100200	Dorchester	74%	1658	67	35	10929	433	231
100300	Jamaica Plain	68%	2599	107	62	13436	533	298
100400	Dorchester	65%	978	39	22	18422	727	402
100500	Roxbury	69%	8521	347	195	24096	957	515
100900	Dorchester	64%	7080	288	162	34508	1391	752
101001	Dorchester	62%	10937	445	248	84906	3458	1905
101002	Jamaica Plain	64%	11825	480	272	47144	1911	1060
101101	Hyde Park	67%	1084	44	25	41648	1687	938
101102	Dorchester	70%	7444	301	169	12856	510	268
110104	Dorchester	62%	499	20	12	9557	391	198
110201	Jamaica Plain	63%	95787	3902	2195	14008	574	323
110401	Dorchester	64%	8893	362	204	13779	540	294
110403	Hyde Park	54%	537	21	12	45122	1825	1001
120500	Hyde Park	71%	385	15	10	5023	196	107
130406	Jamaica Plain	50%	4951	202	113	83835	3404	1914
140105	Hyde Park	54%	97416	3968	2232	40892	1649	926
140106	Hyde Park	57%	97280	3963	2229	20086	821	453
140107	Hyde Park	55%	97763	3982	2240	58414	2369	1329
140201	Hyde Park	66%	356	15	8	47887	1950	1099
140202	Hyde Park	58%	575	24	14	86142	3481	1949
140300	Hyde Park	61%	17049	694	391	58180	2356	1311
140400	Hyde Park	58%	617	26	13	106241	4296	2415
981800	Hyde Park	76%	41071	1674	941	7922	323	182