



VEGETATIVE BUFFERS AND TREE CANOPY

Promoting the Use of Trees to Improve
Local Air Quality with Local Policy

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M | DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN





CONTENTS

03	Executive Summary
07	Introduction
11	Community Engagement
12	Event Description & Agenda
14	Key Findings
16	Scientific Support: Urban Trees and Vegetative Buffers
21	Ordinances
22	Review of Detroit City Code and Master Plan
24	Best Practices from Other Cities
29	Case Studies
30	Los Angeles, California Clean Up, Green Up Districts
32	Newark, New Jersey Environmental Justice and Impact Ordinance
34	Raleigh, North Carolina Heavy Industrial Ordinances
36	Modeling: Implementation in Detroit
37	Key Findings & Overview
40	GIS Analysis
44	iTree Design
51	Cost Benefit Analysis
55	Appendices
65	Acknowledgments



EXECUTIVE SUMMARY

This report builds upon the foundational efforts of Community Action to Promote Healthy Environments (CAPHE) to improve the air quality for all communities throughout Detroit. This study identifies three land-use based approaches for deploying green infrastructure to mitigate air pollution through the use of urban trees and vegetative buffers. Taking a comprehensive approach, the study integrates case studies from leading cities, insights from a community engagement workshop in Detroit, and extensive modeling of potential implementation at three Detroit sites, representing each of the land-use based approaches proposed.

Contained within the report are Key Findings and Key Recommendations drawn from these technical analyses: Ordinance Case Studies; Community Engagement; Modeling Implementation.



During this study, five University of Michigan Dow Sustainability Fellows and staff at the Great Lakes Environmental Law Center conducted an extensive analysis on avenues for the City of Detroit to improve human health through the use of urban trees.

The team reviewed city ordinances nationwide that utilized urban trees and vegetative buffers to improve air quality; conducted a community engagement event to integrate the voices of Detroit residents; and conducted comprehensive analyses, modeling the implementation of mitigation following three land-use based approaches at sites located in the City's District 6.

Several of the Key Finding contained within this report include:

- Benefits provided by a single urban tree can reach up to \$2,200 over a 40-year span, but species selection is critical with some species producing less than \$300 in benefits per tree.
- Residential yard trees provide significant direct energy savings benefits, and additional co-benefits of avoided carbon and pollutant emissions, while vegetative buffers are focused efforts towards mitigating air pollutants.
- Buffers must be designed and sited effectively to maximize air quality mitigation results. Residential areas that interface with industrial zones and highways present opportunities for project implementation.
- Based on cost-benefit analyses supported by the research of E.G. McPherson and broadly adapted for Detroit, tree planting projects prove to be an overwhelmingly positive investment by both municipalities as well as private homeowners. Specifically, large trees planted by private homeowners provide the best return on investment.
- Cities with the strongest buffer and canopy regulations proposed and framed the advocacy for their ordinances with unambiguous references to environmental justice, historical and present-day industrial air pollution, and the race and class-based disparities present in both.



Benefits provided by a single
urban tree can reach up to

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over a **40-year span**

Based upon Best Practices identified through case studies, we explored three land-use based approaches:

In efforts to improve the air quality in vulnerable areas of Detroit, and maximize the co-benefits provided by green infrastructure, it is recommended that the City of Detroit develop a vegetative buffer and urban canopy ordinance. We offer three complementary land-use based ordinance approaches that can be implemented in key areas, located throughout Detroit. Recommended interventions of yard trees and vegetative buffers are best suited dependent upon the following land-use based approaches:

1. RESIDENTIAL PROPERTY:

A voluntary yard tree program can provide a cost-effective means to reducing energy demand, avoiding emission of pollutants and mitigating the demand for expanding stormwater infrastructure capacity. Examples include programs in which the city provides the tree sapling, while residents maintain the trees, sharing the lifetime costs.

2. HIGH-TRAFFIC ROADWAY INTERFACES:

Vegetative buffers deployed on public-land between transportation corridors and residential, school, park, or other sensitive areas, can effectively mitigate human exposure to traffic related air pollution.

3. INDUSTRIAL LAND USE INTERFACES:

Vegetative buffers along the perimeter of an industrial land use that abuts a vulnerable land use, such as single and multi-family homes, schools, and hospitals, can mitigate human exposure to air pollution.

Key Recommendations

Based upon the analysis conducted in this study, the following 15 key recommendations have been provided as guidance in mitigating air quality issues in vulnerable communities of Detroit, and in developing an ordinance for the use of urban trees and vegetative buffers as green infrastructure air pollution mitigation assets:

► Community Engagement

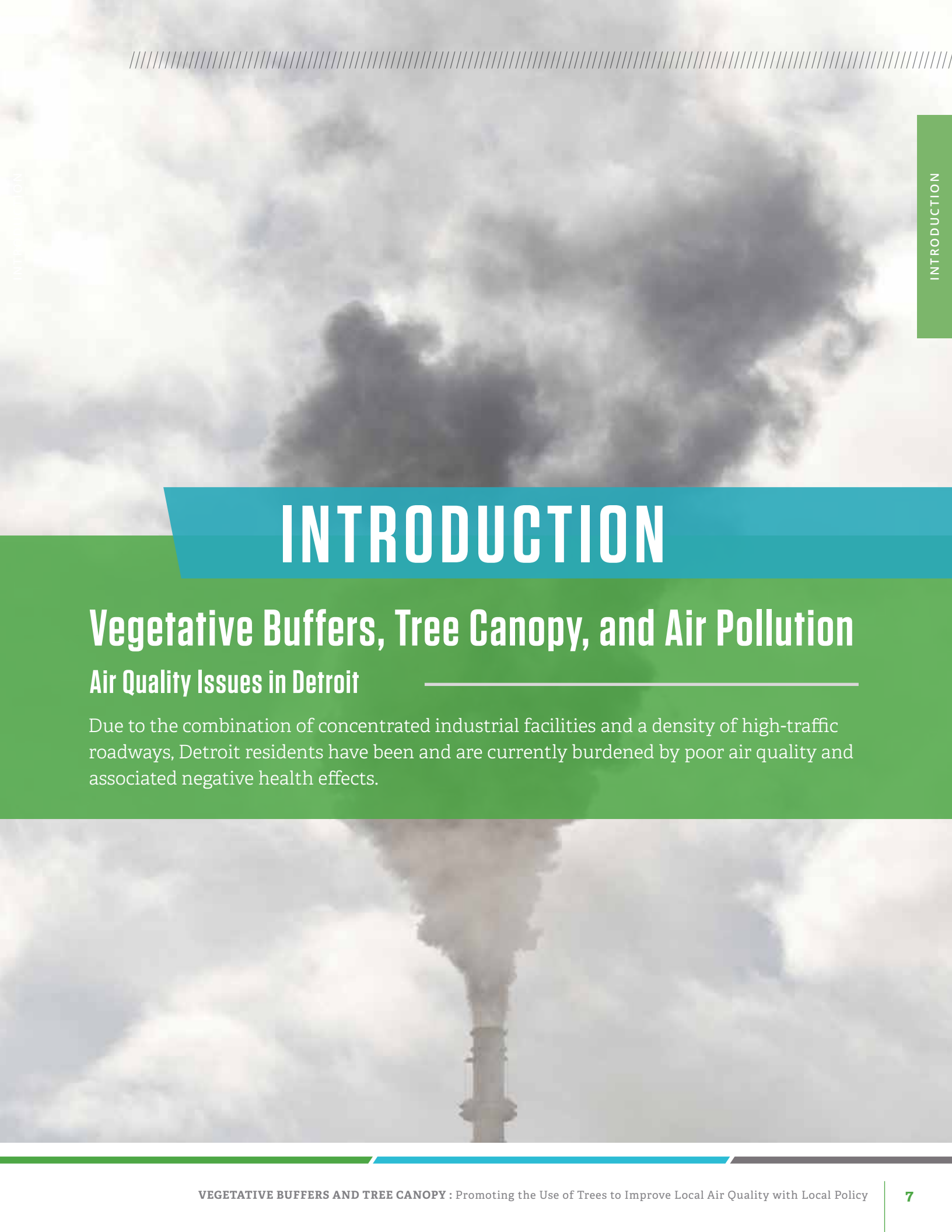
1. Enforce existing regulations that impact local air quality
2. Pass new ordinances that require proposed commercial/industrial developments to mitigate air quality (on-site/off-site) with vegetative buffers
3. Monitor resident identified “hot spots” and report back
4. Facilitate community engagement events regarding air quality to determine air quality issues and to identify solutions
5. Provide residents with incentive to install yard trees on their property

► Vegetative Buffer Ordinance Case Studies

6. Require vegetative buffer for all new polluting developments; existing facilities undergoing: expansion, significant retrofits/renovations, changing use types
7. Include triggers for the requirement of vegetative buffer installation based upon either zones and abutting zones or land use and abutting land use type — *Ex. Industrial zone abutting residential zone vs. intermodal freight abutting residential, park, school, hospital*
8. Use zoning overlay districts to target implementation of vegetative buffers and yard trees
9. Specify vegetative buffer design requirements — *Ex. Width, rows, species (temperate/deciduous), size, density, etc.*
10. Specify maintenance requirements

► Modeling Implementation

11. Develop multiple land use approaches reflecting desired outcomes:
 - Yard trees: dispersed infrastructure for multitude of benefits
 - Buffers: focused infrastructure for air quality mitigation
12. Target land use approach to match district characteristics. —*Ex. District 6 Industrial/Residential buffers & Yard Trees*
13. Select tree species based upon purpose and cost-benefit analysis
14. Pilot and monitor performance of vegetative buffers (air quality mitigation)
15. Seek financing opportunities for a Yard Trees program through co-benefits —*Ex. utility energy efficiency programs, stormwater credits*



INTRODUCTION

Vegetative Buffers, Tree Canopy, and Air Pollution Air Quality Issues in Detroit

Due to the combination of concentrated industrial facilities and a density of high-traffic roadways, Detroit residents have been and are currently burdened by poor air quality and associated negative health effects.

The Federal Clean Air Act establishes national ambient air quality standards (NAAQS) for six air pollutants, commonly referred to as “criteria pollutants,” which are sulfur dioxide, particulate and fine particulate matter, carbon monoxide, ground-level ozone, nitrogen dioxide, and lead. Today, areas of south Detroit are not in compliance with the health-based air quality standards for two of the six criteria pollutants: sulfur dioxide and ozone. Southwest Detroit makes up a large portion of the sulfur dioxide non-attainment area, which is still not in compliance with the air quality standard. Most recently, in 2018, Detroit and all of Wayne County was designated as a “non-attainment area” for ozone.¹

Even in locations where Detroit is in compliance with national health-based standards, pollution levels are high when compared to other areas in the state. For example, an air quality monitor at Southwestern High School regularly detects levels of fine particulate matter that is 2.5 micrometers in

diameter or less (commonly referred to as PM_{2.5}) that are the highest in the state.² Sulfur dioxide, ozone, and particulate matter are all pollutants that have been found to cause and aggravate asthma. Detroit has been labeled **“the epicenter of asthma burden”** by the Michigan Department of Community Health because the rates of asthma hospitalizations in Detroit are three times higher than the state average.³ Numerous community groups are also concerned about the negative impacts of the new Gordie Howe International Bridge, which is expected to significantly increase industry and vehicle traffic in Southwest Detroit.⁴

Many local governments across the country are taking legislative action to address these issues of poor air quality. While the specific approaches vary from city to city, an emerging method has been the promotion of tree canopy cover and vegetative buffers as direct means to mitigate human exposure to air pollution.

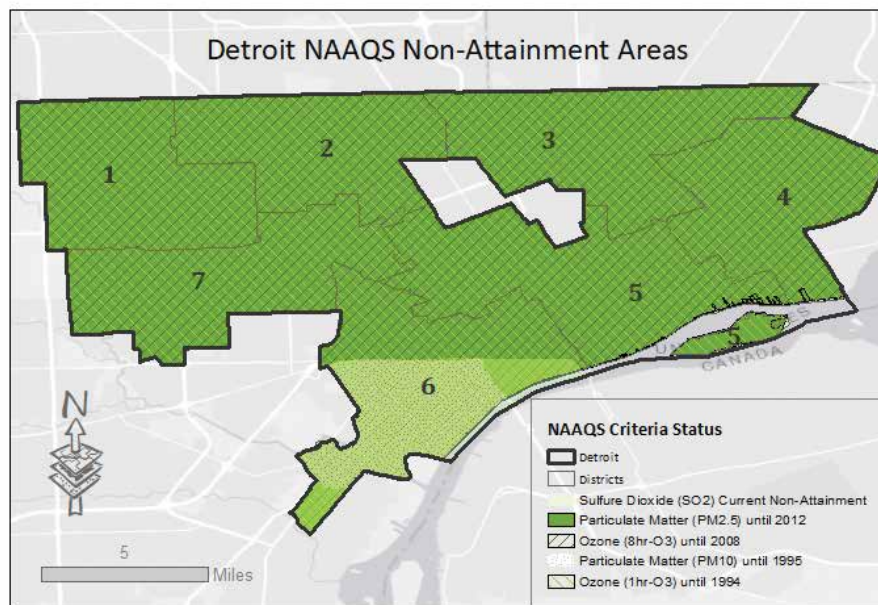


FIGURE 1. Map of non-attainment area for sulfur dioxide and 8-hour ozone.
(Source: U.S. Environmental Protection Agency, EJ Screen, Version 2018)

- 1 83 FR 25,776 (Jun. 4, 2018)
- 2 Michigan Department of Environmental Quality, PM_{2.5} 24-hour Data Summary, available at: https://www.michigan.gov/documents/deq/deq-aqd-amu-monitoring-pm25-24hr-summary_403178_7.pdf; Michigan Department of Environmental Quality, PM_{2.5} Annual Data Summary, available at https://www.michigan.gov/documents/deq/DEQ-AQD-PM25_summary_291638_7.pdf
- 3 Wasilevich EA, Lyon-Callo S, Rafferty A, Dombkowski K. “Detroit - The Epicenter of Asthma Burden” Epidemiology of Asthma in Michigan. Bureau of Epidemiology, Michigan Department of Community Health, 2008, available at https://www.michigan.gov/documents/mdch/14_Ch12_Detroit_Epicenter_of_Asthma_276687_7.pdf
- 4 Community Action to Promote Health Environments (CAPHE), Public Health Action Planning Resource Manual, Buffers and Barriers, 2016, available at <http://caphedetroit.sph.umich.edu/wp-content/uploads/2016/10/Resource-Manual-Executive-Summary-FINAL-10-18-16.pdf>



Trees remove pollution in two ways: intercepting particulate matter on plant surfaces and absorbing gaseous pollutants through the leaf stomata.⁶

Urban Tree Canopy

Re-establishing urban tree canopy is a leading strategy for cities combating air pollution. Urban trees remove air pollutants, sequester carbon, cool air temperatures and beautify the urban landscape. Trees remove pollution in two ways: intercepting particulate matter on plant surfaces and absorbing gaseous pollutants through the leaf stomata.⁵ A 2016 report from the Nature Conservancy found significant positive impacts of increasing tree canopy. In their study of over two hundred cities, particulate matter near trees was reduced by an average of 4%-24%. They estimate that if each city in their study planted the maximum number of trees (total cost \$3.2 billion), the cities could save between 11,000 and 36,000 lives each year.⁶

However, dense canopy in precarious locations can also limit the flow of air, trapping particulate matter at levels where humans breathe the pollutants. In light of this concern, cities must strategically place trees in a manner that allows sufficient air flow between trees. In the vast majority of residential areas this is of little concern due to sparse traffic, although this is a pertinent consideration in residential neighborhoods abutting heavy industrial sites.

From 1950 to 2010, Detroit tree canopy cover remained stable, however, the spatial distribution of tree canopy varied greatly over the course of that period.⁷

5 Nowack, David J. et al, 2018. "Air pollution removal by urban forests in Canada and its effect on air quality and human health." *Urban Forestry and Urban Greening* 29. Accessed at https://www.fs.fed.us/nrs/pubs/jrnl/2018/nrs_2018_nowak_001.pdf.

6 The Nature Conservancy, 2016. "Planting Healthy Air: A Global Analysis of the Role of Urban Trees in Addressing Particulate Matter Pollution and Extreme Heat." Accessed at https://thought-leadership-production.s3.amazonaws.com/2016/10/28/17/17/50/0615788b-8eaf-4b4f-a02a-8819c68278ef/20160825_PHA_Report_FINAL.pdf.

7 Merry, K. et al. (2014). "Urban tree cover change in Detroit and Atlanta, USA, 1951–2010." *Cities* 41. Accessed at https://www.srs.fs.usda.gov/pubs/ja/2014/ja_2014_bowker_004.pdf.

Vegetative Buffers

Vegetative buffers are strips of dense trees and shrubs that are used to filter or block air pollution. They are commonly placed between a polluting source and vulnerable land-use areas where people spend a significant amount of time, such as single and multi-family residences, day care facilities, public parks, senior centers, and schools.

Vegetative buffers are most commonly used to mitigate human exposure to air pollutants from two types of polluting sources: roadways and industrial facilities.⁸ Traffic-related air pollution from cars and trucks presents a significant public health risk for individuals living nearby a high-traffic roadway.⁹ A vegetative buffer along the side of a roadway may limit the pollutant exposure of those individuals living nearby.¹⁰ Additionally, many industrial facilities create air pollution that may be controlled by a vegetative buffer along the fenceline of the facility.¹¹

However, at the outset it's important to note that vegetative buffers are not effective in every situation. For instance, a vegetative buffer along an industrial facility fenceline is unlikely to effectively control air pollution from a 75 foot smokestack designed to disperse air pollutants at higher elevations.¹² Similarly, studies have found that vegetative buffers in "road canyons," which are bounded by tall buildings on either side, may cause air pollution to *increase* rather than decrease.¹³ In addition to site placement, the design specifications of a vegetative buffer are very important.

If improperly designed, a vegetative buffer may increase air pollution concentration, rather than decrease it.

8 Community Action to Promote Health Environments (CAPHE), Public Health Action Planning Resource Manual, Buffers and Barriers, 2016, available at <http://caphedetroit.sph.umich.edu/wp-content/uploads/2016/10/Resource-Manual-7.3-Buffers-and-Barriers-10-4-16-Website-Version.pdf>

9 Community Action to Promote Health Environments (CAPHE), Public Health Action Planning Resource Manual, Executive Summary, 2016, available at <http://caphedetroit.sph.umich.edu/wp-content/uploads/2016/10/Resource-Manual-Executive-Summary-FINAL-10-18-16.pdf>

10 Community Action to Promote Health Environments (CAPHE), Public Health Action Planning Resource Manual, Buffers and Barriers, 2016, available at <http://caphedetroit.sph.umich.edu/wp-content/uploads/2016/10/Resource-Manual-7.3-Buffers-and-Barriers-10-4-16-Website-Version.pdf>

11 Id.

12 Id.

13 Abhijith, K.V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broaderick, B., Di Sabatino, S., Pulvirenti, B., 2017. Air Pollution Abatement Performances of Green Infrastructure in Open Road and Built-Up Street Canyon Environments - A Review. *Atmospheric Environment*.



COMMUNITY ENGAGEMENT

Through a multidisciplinary approach and community-based participatory research, Community Action to Promote Healthy Environments (CAPHE) has identified vegetative buffers as an optimal way to reduce air pollution in Detroit.



Event Description

The Great Lakes Environmental Law Center, with the support of Council Member Raquel Castañeda-López, and the University of Michigan Dow Sustainability Fellows, held a vegetative buffer workshop on October 27, 2018 at El Nacimiento Taqueria in Southwest Detroit. The workshop was free and open to the public.

The purpose of the workshop was to share how vegetative buffers can be used to mitigate human exposure to air pollution, and to discuss where vegetative buffers may be useful as a tool to improve air quality, as well as any concerns residents had.

Community Engagement Goals:

1. Convey the opportunity vegetative buffers provide by mitigating air pollution (related to both roadways and land uses)
2. Obtain valuable information on the concerns of land uses (e.g., business, industry) that are seen as problematic with the objective of identifying which land uses or around which facilities would be good candidates for vegetative buffers

Strategies:



GOAL 1: SHARE BEFORE AND AFTER vegetative buffer visualizations of multiple sites within the neighborhood



GOAL 2: PROVIDE EXAMPLES OF CASE STUDIES in which communities have benefited from vegetative buffers either on roadways or specific land uses that pertain to the community



GOAL 3: PROVIDE AERIAL IMAGES of sites within the neighborhood that could benefit from vegetative buffers in order to identify hot spots through facilitated small-group discussions

Event Agenda

► Introductions

► Presentation

- Air pollution in Southwest Detroit
- Basic introduction to vegetative buffers
- Provide information about vegetative buffer projects in Detroit
- Details regarding how vegetative buffers work
- Display visualizations of potential vegetative buffers in District 6
- Review of city ordinances and vegetative buffers
- Questions and answers

► Break

► Breakout Sessions

Community leaders facilitated each session, during which attendees were presented with maps and asked the following questions:

Q1: Where on the map, have you noticed the most amount of air pollution/dirty air?

This air might have a bad odor or might trigger asthma attacks or might give you a headache after being exposed to it for a long time.

Q2: Where are low elevation areas that you think could benefit from vegetative buffers?

These areas are low to the ground that people come in contact with more frequently, such as diesel exhaust from truck traffic. Are there particular sources (industry, rail, road, etc.) that might benefit from air mitigation processes such as vegetative buffers? Can you point these areas out on the map?

Q3: Do you see any potential issues or concerns with vegetative buffers?

If there was a rule for all the sources that you've identified to have to set up a vegetative buffer, would you support it? Would you be interested in having a tree in your property? Are there any types of vegetative buffers that you have concerns with? For example, are you concerned about who is going to pick up the leaves in the fall if trees are placed along the sources you've identified?

► Additional Questions

- Are there other air or environmental-related issues that you've noticed in your neighborhood?
- Are there ways that these vegetative buffers can help relieve some of those issues?
- Is there anything else you think we should think about or discuss during future workshops?
- What's one thing you took away from this event?
- How can we make these workshops better?

► Share-out

► Conclusion



According to event participants, massive amounts of air pollution are coming from construction of the Gordie Howe International Bridge near 4th Street and more pollution is anticipated as the bridge is completed.

Key Findings

Air Pollution and Hotspots

Many event participants were concerned about the amount of air pollution from the construction activities associated with the Gordie Howe International Bridge, as well as the increase in air pollution from trucks and cars that will result once the bridge is finished. Residents anticipate that the new bridge will attract more traffic flow and shift 90% of truck traffic to their vicinity. Heavy industry surrounding densely populated areas and exposed freshwater sources are also a point of concern among residents. Over 30 schools are located in these hotspots and are susceptible to air pollution from surrounding manufacturing processes. Such industries include: the Edward C. Levy Company, Ferrous Processing and Trading, GLE Scrap Metal, DTE, the Detroit Renewable Power incinerator, the Detroit waste water treatment plant, CSX

intermodal, and the Marathon Petroleum oil refinery. Auto shops, freight terminals, and areas along the railroad were also identified as sources of air pollution and optimal locations for vegetative buffers.

Furthermore, roadways have also been identified as a major hotspot, including neighborhood streets that are the source of preferred transit for diesel trucks. Specific streets or roadways identified by participants include: I-75, Dearborn Street, Fort Street, Jefferson Avenue, Michigan Avenue, Wyoming Avenue, Dix Street, Livernois Avenue, Vernor Highway, Waterman Street, Marion Avenue, Springwells Street, Amazon Street, and Majestic Street. In addition, concerns also surround smoke stacks and emissions from River Rouge and Zug Island.

Potential Issues and Concerns

Residents voiced issues around safety, maintenance, and costs. Safety concerns were oriented around the lack of visibility vegetative buffers, such as tall grasses, could present if not maintained appropriately. Other maintenance-related issues pertained to questions on who would be responsible for clean up when branches fall or leaf litter accumulates. Some residents mentioned that falling branches from potential increased tree canopy coverage could be hazardous for resident safety and could potentially damage property, such as vehicles. Furthermore, a potential increase of rodents that are attracted by the installation of new trees or vegetative buffers was also brought up in small group discussions.

In addition to costs oriented around maintenance, residents were concerned with who exactly would pay for the installation and upkeep of vegetative buffers. A couple of residents brought up the fact that moving mature trees is expensive and planting new trees would take too long for benefits to be felt. Residents voiced that something needs to be done now to reduce pollution and exposure.

One participant stated,
“Too often in Detroit we’re taking baby steps, when bigger steps need to be kept in mind.”

Other Issues of Concern

Overall, there was a large consensus that one of the major issues pertains to trucks driving through neighborhoods and not only emitting air pollution by idling, but also destroying roads and posing safety hazards. Some residents shared pictures and stories about how the residue can be found accumulated on plants and houses from pollutants. In addition to overall exposure, there were concerns regarding soil pollution and tracking emissions into homes through foot traffic. Participants were also well aware about the issues that could stem from pollution exposure, which includes outcomes such as increased violence,

learning disabilities for developing minds, infertility, etc.

Moreover, increased spikes of residents having leukemia and other types of cancer was also voiced as a source of concern among residents. Cumulative impacts, which include the dumping of coal along highways and exposure were identified as the main source. Furthermore, overall monitoring and accountability from both environmental regulators and police were also voiced as lacking in ensuring the health and safety of residents.

Potential Solutions

In addition to voicing concerns and identifying hotspots, participants were also quick to provide potential solutions to problems presented.

Amendments to Detroit's zoning ordinance was broadly identified as a solution to address air pollution issues. Specifically, there was broad agreement that amending the zoning ordinance to require industrial facilities to install vegetative buffers around the property would improve air quality for people living nearby those facilities. Additionally, numerous solutions were presented to address traffic-related pollution, including more street cleaning, thorough washing of trucks, and instituting no truck zones in residential neighborhoods. Event participants also stated that more air quality monitors are necessary to determine whether any potential solutions are working effectively. Lastly, all event participants viewed ongoing and meaningful engagement

between residents and policymakers as necessary to ensure that any potential solution meets the needs of the community.

Furthermore, Patton Park was identified as an optimal location for a vegetative buffer due to where it's strategically located. In addition, residents brought up the fact that the park has trees sparingly, but the park has the potential to serve as a vegetative buffer for surrounding communities. One resident in particular compared the potential of Patton Park to Flushing Meadows Corona Park in New York City. He raved about being one of the best parks he had ever visited. Although the park would be a good location, some residents also voiced that ATVs have been driving through the park and that measures should be taken to ensure that any buffers that are installed are protected from misuse. Another potential park identified by residents that can be retrofitted to serve as a useful vegetative buffer is Clark Park.

Conclusion

In conclusion, as one participant stated in the event, "The community residents are the experts." The community engagement event was well-received among residents and a lot of information was able to be collected through the small

group discussions. Residents are eager about introducing vegetative buffers and ensuring that the potential issues or concerns that were voiced will be addressed.

SCIENTIFIC SUPPORT:

Urban Trees and Vegetative Buffers

The benefits of urban tree canopy are widespread and well-documented. A report recently published by Community Action for Promoting Healthy Environments (CAPHE) indicates that the benefits to human health from an increase in urban tree canopy include reduced lung disease, respiratory illnesses, and cancer.¹⁴

¹⁴ Community Action to Promote Healthy Environments, (February 2018). Vegetative Buffer Toolkit: Using Trees to Improve Air Quality in Detroit.

Additional benefits for human health include improved psychological well-being due to reduced noise pollution and increased exposure to nature.¹⁵ As indicated by the cost-benefit analysis in this report and the research of E.G. McPherson, urban forestry programs. Urban forestry programs improve energy efficiency of buildings, reduce atmospheric CO₂ and other atmospheric particulate matter, absorb gaseous pollutants, reduce rainwater runoff, and improve neighborhood aesthetic (including property values).¹⁶



Human Health Benefits:

- Reduced lung disease, respiratory illnesses, and cancer
- Improved psychological health



Environmental Benefits:

- Reduced stormwater runoff
- Reduced CO₂ and atmospheric particulate matter (e.g., smoke and dust)
- Absorb gaseous pollutants (e.g., nitrogen oxides and sulfur dioxide)
- Reduced city temperatures (via transpiration)
- Increased oxygen
- Increased biodiversity and wildlife habitats



Economic Benefits:

- Reduced energy costs (heating and cooling of buildings)
- Increased property values and aesthetic appeal
- Profitable post-mortality byproducts (e.g. mulch and lumber)

¹⁵ E.G. McPherson et. al. (2006). Midwest Community Tree Guide: Costs, Benefits, and Strategic Planting, USDA.

¹⁶ Ibid.

Vegetative buffers serve as a barrier between sources of pollution and people. More specifically, buffers can reduce concentrations of several common air pollutants, such as ozone (O₃), particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and carbon monoxide (CO).¹⁷ Vegetative buffers can retain particulate matter pollution, as bark and leaves intercept the travel of airborne particles.¹⁸ Trees can also remove gaseous pollutants such as sulfur dioxide, nitrogen oxides, carbon monoxide, and ozone from the atmosphere by absorbing them through the stomata.¹⁹ However, the effectiveness of a vegetative buffer depends on a number of factors, including the types of vegetation used, the density of the buffer, and the polluting source.²⁰

More than 159 million people reside in regions where ozone (O₃) concentrations exceed federal air quality standards. Additionally, more than 100 million people reside in areas that are vulnerable

to dust and particulate matter (PM₁₀) exposure that impact the quality of air.²¹ Exposure to air pollutants causes coughing, headaches, and can lead to serious respiratory and heart disease issues.²² In addition, high exposures to particulate matter have been correlated with cancer.

Vegetative buffers are commonly used to mitigate human exposure to air pollution from industrial facilities and high-traffic roadways. However, the effectiveness of a vegetative buffer will vary based on the built environment. In addition to mitigating the exposure of pollutants, tree and other types of vegetation also have the capability of lowering temperatures in a specific site. A nine degree Fahrenheit temperature difference has been observed between city centers and vegetated suburban areas.²³ The elevated temperatures found among pervious surfaces located in urban cities are called “hot spots” and provoke urban heat island effects.

Vegetative Buffers and Industrial Facilities

Industrial facilities such as steel plants, power plants, and others, emit a large amount of air pollution. As a result, the design of these industrial facilities may make a vegetative buffer ineffectual. For example, many large industrial facilities have high smokestacks. The purpose of these smokestacks is to emit and disperse pollutants so that they are not overly concentrated in the nearby area. For such facilities, a vegetative buffer may be of limited assistance in controlling air pollution since most pollutants emitted from the smokestack are likely to pass over a vegetative buffer installed at the fenceline.²⁴

However, industrial facilities that involve low emission points are likely to be good candidates for an effective vegetative buffer.²⁵ One common source of local air pollution in urban areas is dust. Facilities such as bulk solid material yards, which store large quantities of petroleum coke, limestone, coal, and other industrial materials, trucking terminals, and scrap yards are just a few examples of facilities that tend to create large amounts of dust and other pollutants at or near ground level.²⁶ This dust may be blown past the fenceline of the facility, and create localized hot spots of particulate matter pollution that may impact people's health.²⁷

17 Gallagher J, Baldauf R, Fuller CH, Kumar P, Gill LW, and McNabola A, 2015, Passive methods for improving air quality in the built environment: a review of porous and solid barriers. *Atmospheric Environment*, 120, pp. 61-70.

18 Id.

19 Id.

20 Richard Baldauf, Roadside Vegetation Design to Improve Local, Near-Road Air Quality, *Transp. Res. D. Transp. Environ.*, May 4, 2017; 52(11): 354-361, available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6060415/>

21 McPherson (2006)

22 CAPHE

23 Akbari et. al. (1992)

24 Community Action to Promote Health Environments (CAPHE), Public Health Action Planning Resource Manual, Buffers and Barriers, 2016, available at <http://caphedetroit.sph.umich.edu/wp-content/uploads/2016/10/Resource-Manual-7.3-Buffers-and-Barriers-10-4-16-Website-Version.pdf>

25 Id.

26 Id.

27 J. Watson & J. Chow, Reconciling Urban Fugitive Dust Emissions Inventory and Ambient Source Contribution Estimates: Summary of Current Knowledge and Needed Research, DRI Document No. 6110.4F (May, 2000)

Studies have suggested that vegetative barriers must be



at least
13 ft
TALL

and
16 - 32 ft
THICK

to effectively limit pollution.

Vegetative Buffers and Roadways

Another major source of urban air pollution are emissions from cars and trucks. Similar to industrial facilities, the variations in roadway design can significantly impact the effectiveness of a vegetative buffer.

For example, a vegetative buffer in a downtown roadway that has tall buildings on either sides (commonly referred to as a “street canyon”) will have a different effect than a similarly designed buffer along an open freeway.

Regarding “street canyons,” numerous studies have found that the presence of trees tends to increase air pollution concentration.²⁸ This is due to trees causing a reduction in air exchange between the air above the roof and the air within the canyon,

which leads to an accumulation of pollutants inside the street canyon.²⁹ However, hedges planted along the side of a street in a street canyon may reduce pollutant concentrations in footpath areas.³⁰

Comparatively, vegetative buffers may reduce air pollution concentrations nearby open roadways.³¹ In general, the design characteristics of an effective vegetative buffer in the context of an open roadway and an industrial facility with a low emission point are similar. As detailed below, a vegetative buffer in these contexts must be tall, thick, dense, and continuous to achieve the greatest reductions in downwind pollutant concentrations.³²

Height

Studies have suggested that vegetative barriers must be at least 13 feet tall to effectively limit downwind concentrations of auto related air pollution.³³ A vegetative buffer with a height lower than 13 feet risks allowing pollutants to pass over

the buffer unimpeded.³⁴ Particularly for industrial facilities, it’s important to note that an increase in height may be necessary to effectively control pollution with an emissions point that is above ground-level.

28 Abhijith, K.V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broaderick, B., Di Sabatino, S., Pulvirenti, B., 2017. Air Pollution Abatement Performances of Green Infrastructure in Open Road and Built-Up Street Canyon Environments - A Review. *Atmospheric Environment*.

29 Id.

30 Id.

31 Richard Baldauf, *Roadside Vegetation Design to Improve Local, Near-Road Air Quality*, Transp. Res. D. Transp. Environ., May 4, 2017; 52(11): 354-361, available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6060415/>

32 Id.

33 Steffens JT, Wang YJ, Zhang KM. 2012. Exploration of effects of a vegetation barrier on particle size distributions in a near-road environment. *Atmospheric Environment*. Vol 50: pp. 120-128; Al-Dabbous AN and Kumar P, 2014. The influence of roadside vegetation barriers on airborne nanoparticles and pedestrians exposure under varying wind conditions, *Atmospheric Environment*, 90, pp. 113-124; Brantley HL, Hagler GSW, Deshmukh PJ, Baldauf RW. 2014. Field assessment of the effects of roadside vegetation on near-road black carbon and particulate matter. *Science of the Total Environment*. Vol 468-469: pp. 120-129.

34 Richard Baldauf, *Roadside Vegetation Design to Improve Local, Near-Road Air Quality*, Transp. Res. D. Transp. Environ., May 4, 2017; 52(11): 354-361, available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6060415/>

Thickness

A vegetative buffer must be sufficiently thick to reduce turbulence and wind speed, and to effectively intercept particulate matter pollution. Studies have found vegetation must be at least 16.4 to 32 feet thick to act as an effective vegetative buffer.³⁵ Additionally, the vegetation must have sufficient density. Denser vegetation generally leads to increased pollution reductions.³⁶ The type and species of vegetation may also impact the thickness of a vegetative buffer. For example, a deciduous tree that loses its leaves in the winter will not serve as an effective vegetative buffer in

the winter months due to its lack of foliage.³⁷ In general, coniferous plants are more effective since they are not subject to significant seasonal changes.³⁸ Additionally, some trees and shrubs are more effective at pollution removal than others.³⁹ Trees and shrubs with waxy and/or hairy surfaces have been shown to more effectively remove particulates compared to smooth leaf surfaces.⁴⁰ Lastly, incorporating a solid built barrier, such as a wall, with a vegetative buffer has been shown to result in lower ultrafine particle concentrations.⁴¹

Continuity

Gaps in vegetation, whether due to porosity of vegetation or missing trees, may cause pollutant emissions to funnel through the gaps and stagnate.⁴² Therefore, gaps in a vegetative buffer can cause air pollution concentrations to increase rather than decrease.⁴³ It's important for a vegetative buffer to maintain both horizontal and vertical continuity. Regarding vertical continuity, an effective vegetative buffer should maintain full, dense coverage from the ground to the top of the buffer. To achieve this vertical continuity, multiple rows of different types of vegetation, including trees and shrubs of a variety of heights, may be

necessary. Regarding horizontal continuity, an effective vegetative buffer must extend beyond the area of concern. Otherwise, it is possible for emissions to migrate around the buffer and cause elevated concentrations of air pollution. Studies have found that a vegetative buffer should extend at least 164 feet beyond the area of concern in order to maximize air pollution reductions.⁴⁴ However, if this is not feasible, increasing the height of the vegetative buffer and wrapping it completely around the vulnerable land use may be an effective alternative.⁴⁵

35 Neft I, Scungio M, Culver N, and Singh S. 2016. Simulations of Aerosol Filtration by Vegetation: Validation of Existing Models with Available Lab data and Application to Near-Roadway Scenario. *Aerosol Science and Technology*, Vol. 50, Issue 9; pp. 937-946.

36 Richard Baldauf, Roadside Vegetation Design to Improve Local, Near-Road Air Quality, *Transp. Res. D. Transp. Environ.*, May 4, 2017; 52(11): 354-361, available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6060415/>

37 Id.

38 Id.

39 Id.

40 Id.

41 Baldauf RW, Thoma E, Khlystov A, Isakov V, Bowker G, Long T. 2008. Impacts of noise barriers on near-road air quality. *Atmospheric Environment*. Vol 42: pp. 7502-7507.

42 Richard Baldauf, Roadside Vegetation Design to Improve Local, Near-Road Air Quality, *Transp. Res. D. Transp. Environ.*, May 4, 2017; 52(11): 354-361, available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6060415/>

43 Id.

44 Baldauf RW, Isakov V, Deshmukh PJ, Venkatram A, Yang B., Zhang KM. 2016. Influence of solid noise barriers on near-road and on-road air quality. *Atmospheric Environment*. Vol 129: pp. 265-276.

45 Brantley HL, Hagler GSW, Deshmukh PG, Baldauf RW. 2014. Field assessment of the effects of roadside vegetation on near-road black carbon and particulate matter. *Science of the Total Environment*. Vol. 468-469: pp. 120-129.

ORDINANCES



Detroit's Master Plan of Policies sets specific land use policy goals for Detroit's neighborhoods.

Review of Detroit City Code and Master Plan

Vegetative buffers have the potential to mitigate human exposure to air pollutants that come from roadways and industrial facilities. Detroit's Master Plan expressly includes a goal of planting trees and creating vegetative buffers between residential areas and areas with heavy traffic, agricultural, commercial, or industrial uses to improve air quality. However, Detroit's current city code does not effectively promote or require the development of vegetative buffers in any of these contexts.

Detroit Master Plan

Detroit's Master Plan of Policies sets specific land use policy goals for Detroit's neighborhoods.⁵⁶ One of the goals of the existing Master Plan is to "improve air quality, particularly in areas of the city which are non-compliant with government air quality standards."⁵⁷ One of the specific policies provided for in the Master Plan to achieve this goal is to "plant trees and/or create buffers where residential areas abut industrial areas and/or areas of high truck and other traffic."⁵⁸ Specifically in regards to zoning, the Master Plan suggests

amending the zoning code to require buffering between residential areas and commercial, large scale agricultural, and industrial land uses.⁵⁹ The plan specifically lists the need for buffering between industrial use and the abutting residential area east of St. Cyril and west of Mt. Elliot, as well as between industrial use and residential use in north and northeast Detroit in general.⁶⁰ The need for buffering is mentioned many times throughout the plan.

⁵⁶ City of Detroit Master Plan of Policies <http://www.detroitmi.gov/Portals/0/docs/Planning/Master%20Plan%20Text.pdf>.

⁵⁷ Detroit Master Plan of Policies, 28.

⁵⁸ Id.

⁵⁹ Id. at 58.

⁶⁰ Id. at 69, 74.



Detroit City Code

Regarding roadway vegetative buffers Chapter 57 of Detroit's Code of Ordinances,⁶¹ titled "Vegetation," does not contain any substantive requirements for vegetative buffering along roadways. It does give the Parks and Recreation Department a general grant of authority to plant, maintain, and remove trees within the city of Detroit.⁶²

For the planting or removal of any trees or shrubs upon any public highway, there are additional procedural requirements. In such situations, the Parks and Recreation Department does not have the general authority to plant or remove trees. Instead, if the department finds it is necessary to plant or remove trees upon any public highway, it must report such fact to the City Council, which may, by resolution, declare that a necessity exists for the planting or removal of such trees.⁶³ Alternatively, the parties owning a majority of the lineal footage of the property fronting a street may petition the City Council for the planting of street trees.⁶⁴

Regarding industrial facility buffers, the Detroit zoning ordinance does call on the Industrial Review Committee to review and investigate "...separation/ buffering from sensitive, conforming land uses... such as residences, schools, churches, hospitals, convalescent homes, child care facilities, hotels

or motels, public parks, and similar community facilities..."⁶⁵ The Industrial Review Committee serves in an advisory capacity to the Buildings Safety Engineering and Environmental Department and the Board of Zoning Appeals in their review of permitting of specified, industrial conditional land uses.⁶⁶ While the Industrial Review Committee has the power to review and investigate a proposal, or lack thereof, for a vegetative buffer at an industrial facility and make recommendations to city departments, it plainly does not require any industrial facilities to develop any vegetative buffer. A similar advisory committee exists for the siting and operation of hazardous waste facilities.⁶⁷

Vegetative buffers are required in other contexts, but appear to be for aesthetic purposes rather than to control air pollution. For example, the Detroit zoning ordinance requires a vegetative buffer between a gas station and an adjacent sidewalk along traditional main streets such as Michigan Avenue.⁶⁸ Additionally, a vegetative buffer is required between a taxicab storage lot and a public street,⁶⁹ between parking areas and a public street,⁷⁰ and between parking areas and residential property.⁷¹ However, all of these buffer requirements appear to be for an aesthetic purpose.

61 Detroit City Code § 57.

62 See, Detroit City Code § 57-2-2.

63 Detroit City Code § 57-2-13

64 Detroit City Code § 57-2-12

65 Detroit City Code § 61-2-84(b)(5)

66 Detroit City Code § 61-2-84

67 Detroit City Code § 61-2-104

68 Detroit City Code § 61-12-200(b)

69 Detroit City Code § 61-14-237

70 Detroit City Code § 61-14-221(1)

71 Detroit City Code § 61-14-222

Many cities have enacted ordinances that require the owner of an industrial facility that is nearby a vulnerable land use to develop a vegetative buffer around their facility.

Best Practices from Other Cities

Similar to Detroit, many urban areas struggle with poor air quality. To address these issue, many cities have passed local ordinances that require the development of vegetative buffers as a means to reduce human exposure to air pollution from roadways and industrial facilities.

A. Industrial Vegetative Buffers

Many cities have enacted ordinances that require the owner of an industrial facility that is nearby a vulnerable land use to develop a vegetative buffer around their facility. These ordinances have common characteristics, which are addressed below.

► Identify When an Industrial Facility Must Install a Vegetative Buffer

None of the cities reviewed for this report required every industrial facility to install a vegetative buffer regardless of additional factors. Instead, every ordinance contained some trigger that would activate the requirement that the facility install a vegetative buffer to mitigate human exposure to air pollution. While the specifics of the regulatory trigger vary, all involve assessing what land uses or zoning district abuts the industrial facility.

One common and simple trigger employed by some ordinances is to require a vegetative buffer whenever a portion of a parcel zoned for industrial use abuts a parcel zoned for a vulnerable land use. For example, Ann Arbor requires any parcel zoned for industrial use that abuts a public park or

a parcel principally used or zoned for residential purposes to develop a vegetative buffer.⁷² Similarly, Raleigh requires any property in a heavy industry district that abuts any other type of district to develop a vegetative buffer.⁷³ Notably, these triggers are mostly dependent on the zoning classification of the two abutting land uses.

A similar but slightly different approach is to rely in whole or in part on land use categories as opposed to zoning classifications. For example, Philadelphia requires a vegetative buffer when a building with a principal use in the wholesale, distribution, and storage, or industrial use categories abuts any lot in a residential district.⁷⁴ Similarly, Los Angeles requires vegetative buffers for a long list of specific

⁷² Ann Arbor City Code § 5:603(c)

⁷³ Raleigh City Code § 7.4.4(f)

⁷⁴ Philadelphia City Code § 14-705(d)

types of land uses that abut any use that contains one or more dwelling unit or guest room, school, park, recreation center, day care, hospital, medical building, or nursing home.⁷⁵ This trigger does not solely rely on the zoning classification of the two abutting land uses, but instead relies on the specific use of the property.

Lastly, the number of instances in which a city requires a vegetative buffer varies widely. Some cities will only require a vegetative buffer in limited contexts, such as when an industrial use abuts a residential use. Others, such as Lexington, require a vegetative buffer between land uses in 10 different contexts.⁷⁶

► Specify whether the vegetative buffer requirement applies to existing facilities

In general, vegetative buffer ordinances require new facilities to develop a vegetative buffer, but will only require an existing facility to install a vegetative buffer if it changes its operations or facility in some manner. Some ordinances only require existing facilities to comply with the requirement to install a vegetative buffer if they physically expand the footprint of the facility.⁷⁷

On the other hand, Los Angeles' vegetative buffer ordinance requires existing facilities to satisfy its vegetative buffer requirements not only if the facility physically expands its operations, but also if it undertakes a major improvement of or addition to the facility, or formally changes the use of its facility.⁷⁸

New Construction: The new construction of a stand-alone building

Major Improvement: Alteration of any building(s) or structure(s) on a project site which does not expand the building(s) or structure(s), and for which the aggregate value of the alterations within any 24-month period exceeds 50 percent of the replacement cost of the building(s) and structure(s) on the project site.

Addition: Expansion of any existing building(s) or structure(s) on a project site in which the total aggregate value of work in any 24-month period exceeds 50 percent of the replacement cost of all buildings and structures on the entire project site.

Change of Use: The expansion of or change to a use of a facility.

⁷⁵ Los Angeles City Code § 13.18(E)(2)

⁷⁶ Lexington City Code § 18-3(a)(1)

⁷⁷ Dublin, OH City Code § 153.132(B)

⁷⁸ Los Angeles, CA City Code § 13.18.E

► Specify design requirements for vegetative buffers to ensure that they effectively limit air pollution

As discussed above, the effectiveness of a vegetative buffer regarding the control of air pollution is dependent on the design of the vegetative buffer, and the types of vegetation used. To address this, every city ordinance that requires vegetative buffers also contains specific design requirements to ensure that the buffer effectively serves its purpose.

First, many vegetative buffer ordinances contain a common requirement regarding the width of the buffer area that must be provided. Numerous

vegetative buffer ordinances require a buffer width of 15 feet.⁷⁹ Most ordinances will not require a vegetative buffer to be placed around the entire facility. Instead, the vegetative buffer is generally only required for the portion of the polluting parcel that abuts the polluted parcel.⁸⁰

One common design requirement in vegetative buffer ordinances is to describe the general types of vegetation that must be planted and to specify the spacing between the vegetation.

Different cities have enacted different design requirements, as specified by the table below:

City	Vegetation and Spacing Requirements
Lexington, KY	Install one tree every 40 feet and install either a double row of 6 foot high hedges, or a 6 foot high fence, wall, or earth mound. ⁸¹
Ann Arbor, MI	One tree every 15 feet and a hedge, landform berm, wall, fence, or some combination of these options that is at least 4 feet tall and forms a continuous screen ⁸²
Philadelphia, PA	One tree and four shrubs every 25 feet ⁸³
Los Angeles, CA	One tree every 10 feet ⁸⁴

Additionally, some vegetative ordinances also contain more detailed requirements regarding the specific types of vegetation that must be planted, and the required density of the vegetative buffer. Lexington's vegetative buffer ordinance requires trees to be selected from a specified list, and requires any deciduous trees, evergreen trees, or shrubs and hedges that are included in a vegetative buffer to meet specific height and caliper requirements.⁸⁵

Lexington also requires vegetative buffers to maintain a minimum opacity of 50% in the winter and 70% in the summer.⁸⁶ Los Angeles' ordinance requires trees to be selected from the Department of Public Works Bureau of Street Services, Street Tree Selection Guide.⁸⁷ Additionally, trees or hedges selected for a vegetative buffer to be between 6 and 8 feet high, low in water use, low in biogenic emissions, high in carbon and particulate

79 Lexington, KY City Code § 18-3(a)(1); Ann Arbor, MI City Code § 5:603(1); Los Angeles, CA City Code § 13.18(2)(h); Philadelphia, PA City Code, Table 14-705-1

80 See, Los Angeles, CA City Code § 13.18(2)(i); Ann Arbor, MI City Code § 5:603; Lexington, KY City Code § 18-3(a)(1); Philadelphia, PA City Code § 14-705(1)(d)(2)(a)

81 Id.

82 Ann Arbor, MI City Code § 5:603

83 Philadelphia, PA City Code, Table 14-705-1

84 Los Angeles, CA City Code, § 13.18(2)(i)

85 Lexington, KY City Code §§ 18-3(E)(a)(1); 18-4(c)

86 Lexington, KY City Code §§ 18-3(E)(a)

87 Los Angeles, CA City Code § 13.18(E)(2)(i)



matter filtration qualities, and retain foliage for most months of the year.⁸⁸ Given that the effectiveness of vegetative buffers is often dependent on the specific context in which it is

► Specify maintenance requirements

In general, vegetative buffer ordinances did not include detailed maintenance requirements. Some ordinances did contain a requirement that

being used, many cities will also require a person that is required to install a vegetative buffer to submit a plan to the local government for approval.⁸⁹

adequate irrigation systems be designed, installed, and operated to service the vegetative buffer.⁹⁰

► Target Hot Spots

In general, most vegetative buffer ordinances apply throughout the city. However, Los Angeles' ordinance only applies to specific "Clean Up Green Up" districts.⁹¹ A "Clean Up Green Up" district is a zoning overlay district established "...to reduce cumulative health impacts resulting from land uses, including but not limited to, concentrated industrial use, on-road vehicle travel, and heavily freight-dominated transportation corridors, which are incompatible with the sensitive uses to which

they are in close proximity, such as homes, schools, and other sensitive uses."⁹²

Los Angeles has established three "Clean Up Green Up" districts.⁹³ In Los Angeles, vegetative buffers are only required in the three "Clean Up Green Up" districts. Residents may establish additional "Clean Up Green Up" districts by submitting signatures of at least 75% of the owners or tenants of property within the proposed district.⁹⁴

⁸⁸ Id.

⁸⁹ Lexington, KY City Code § 18-5; Los Angeles, CA City Code § 13.18(2)(i)(2); Philadelphia, PA City Code § 14-705(1)

⁹⁰ Philadelphia, PA City Code § 14-705(1)(c); Los Angeles, CA City Code § 13.18(2)(i)(3)

⁹¹ Los Angeles, CA City Code § 13.18(C)

⁹² Los Angeles, CA City Code § 13.18(A)

⁹³ Los Angeles, CA Ordinance No. 184246 (Effective Jun. 4, 2016)

⁹⁴ Los Angeles, CA City Code § 12.32(3)(b)

B. Roadside Vegetative Buffers

Requiring the development of roadside vegetative buffers via a city ordinance is complicated given two factors: the jurisdictional patchwork regarding roadways and the need for a vegetative buffer to maintain horizontal continuity in order to be effective.

Governmental jurisdiction over roadways in Michigan is generally divided up among the city, county, and state government. The McNitt Act establishes that the state highway commissioner has jurisdiction regarding the construction, maintenance, supervision, control, and improvement of all state trunk line highways.⁹⁵ In Detroit, Fort Street, Gratiot Avenue, Michigan Avenue, Grand River Avenue, Gunston Avenue/ Hoover Street, 8 Mile Road, Interstate 94, Interstate 75, Interstate 96, Interstate 375, the Lodge Freeway (M-10), the Davison Freeway (Between the Lodge and Conant Street; M-8) and the Southfield Freeway (M-39) are all part of the state trunk line system.

Detroit does not have the legislative power to require the development of vegetative buffers on roadways that are under state jurisdiction. Since state law grants the state government jurisdiction over the state trunkline highway system, and since that system includes many of the high-traffic roadways in Wayne county, this presents a major obstacle. While the city of Detroit can encourage the development of vegetative buffers along roadways in the state trunkline highway system, it cannot require it. Additionally, the nature of roadways as pollution sources that continuously run throughout the city presents another challenge. Since horizontal continuity is essential for the effectiveness of a vegetative buffer, a break

in the buffer at any point may make it ineffective at controlling air pollution. This means that gaps in the buffer for cross-streets or other interruptions may reduce the effectiveness of a roadside vegetative buffer.

Many other cities face these same obstacles. In 2018, the City Planning Commission for the city of Los Angeles assessed a number of measures that the local government could pursue to mitigate the impacts of freeway air pollution for nearby residents.⁹⁶ This assessment included the installation and regular maintenance of high efficiency filters, limiting the siting of sensitive uses nearby freeways, and vegetative buffers.⁹⁷ The report concluded that further study on the use of vegetative buffers to control pollution from roadways is necessary to ensure that such buffers are effective.⁹⁸

While local legislative action to require roadside vegetative buffers has been rare, some cities are attempting to promote roadside vegetative buffers through other policy mechanisms. For example, Boston's Complete Streets policy provides detailed guidance regarding tree selection, tree siting and spacing, and steps for creating an appropriate root environment for roadside trees, and expressly notes that roadside trees can improve air quality by capturing gaseous pollutants and particulates in the buffer.⁹⁹

Wayne County, Michigan Road Jurisdiction Map, available at <https://www.waynecounty.com/departments/publicservices/roads/maps-resources.aspx>

⁹⁵ MCL § 247.651a

⁹⁶ Department of City Planning, Report on Freeway Adjacency and Air Quality Concerns in Response to Council Motion No. 17-0309 (Apr. 12, 2018), available at http://clkrep.lacity.org/online/docs/2017/17-0309_rpt_PLAN_04-12-2018.pdf

⁹⁷ Id.

⁹⁸ Id.

⁹⁹ Boston Complete Streets Design Guidelines, 2013, available at http://bostoncompletestreets.org/pdf/2013/BCS_Guidelines_LowRes.pdf



CASE STUDIES

Los Angeles — Clean Up, Green Up Districts

In 2016, the Los Angeles City Council passed the “Clean Up, Green Up” (CUGU) ordinance, which works to improve health and advance environmental justice in three low-income, predominantly Latinx communities within the City of Los Angeles: Boyle Heights, Pacima-Sun Valley, and Wilmington. The CUGU ordinance reduces pollution in “hotspot” neighborhoods, attempts to prevent additional pollution, and advances “revitalization” initiatives by increasing economic development and improving public spaces. In regard to vegetative buffers, the CUGU ordinance requires setback trees and hedges for any new building project or renovation.

Ordinance Specifics

“The purpose of the CUGU District is to reduce cumulative health impacts resulting from land uses including, but not limited to, concentrated industrial land use, on-road vehicle travel, and heavily freight-dominated transportation corridors, which are incompatible with the sensitive uses to which they are in close proximity, such as homes, schools and other sensitive uses.”¹⁰⁰

The CUGU ordinance applies to any building specified as “subject use”¹⁰¹ that is located in the three neighborhoods of Boyle Heights, Pacima-Sun Valley, and Wilmington, that is newly constructed or undergoes major renovations must comply with the specifications of the CUGU ordinance—regardless of whether it is adjacent or abuts a residential or publicly habitable space.

Language Regarding Vegetative Buffers

“All required side and back yard setbacks in Section 13.18.F.2(h) abutting a Publicly Habitable Space shall be landscaped to provide a buffer.”¹⁰²

“A Landscape Practitioner shall select trees or hedges that are between 6 and 8 feet high, low in water use, low in biogenic emissions, high in carbon and particulate

matter filtration qualities, and retain foliage for most months of the year. Trees shall be limited to selections from the Department of Public Works Bureau of Street Services, Street Tree Selection Guide, except non-drought tolerant trees and Palms shall be prohibited. A minimum of one tree shall be planted and maintained every 10 linear feet within the setback.”¹⁰³

Types of Trees

All of the trees recommended by the City of Los Angeles are drought resistant — a vital consideration in Southern California. While all trees must meet the specifications detailed above, the city recommends the following species:¹⁰⁴

White Bottle Brush	Catalina Ironwood	Aleppo Pine	Brazilian Pepper
Smooth Arizona Cypress	Flaxleaf Paperbark	Italian Stone Pine	Elm
Camphor Tree	Cajeput	Torry Pine	California Laurel
Weeping Bottle Brush	Olive	Valley Oak	Chinese Pistache
Australian Willow	Chinese Photinia	African Sumac	
Kaffir Plum	Canary Island Pine	California Pepper	

¹⁰⁰ Los Angeles Municipal Code, Ordinance 184246, Section 13.18

¹⁰¹ The city has identified hundreds of “subject use” industrial structures that are required to comply with this ordinance. The full list can be found in the CUGU ordinance.

¹⁰² Los Angeles Municipal Code, Ordinance 184246, Section 13.18

¹⁰³ Los Angeles Municipal Code, Ordinance 184246, Section 13.18

¹⁰⁴ Common names of trees have been used for readability and familiarity. Full specifications on the CUGU recommended trees can be found in the CUGU ordinance.

Ownership of Roadside Buffers

Property owners are responsible for submitting and obtaining the appropriate building permits to begin any project in a CUGU district. They are also responsible for the funding, creation, and maintenance of vegetative buffers.

The City of Los Angeles also secured funds to appoint an ombudsperson who assists property owners and local businesses in complying with these requirements.

Political Context

In December 2010, six years before Los Angeles City Council passed the CUGU ordinance, a collaborative of environmental justice organizations published *Hidden Hazards: A Call to Action for Healthy, Livable Communities*.¹⁰⁵ Authored by a group of community organizers and academic researchers, the report established an imperative for reducing air pollution and health hazards in several historically underserved neighborhoods (including the eventual CUGU zones of Boyle Heights, Pacima-Sun Valley, and Wilmington).

Leveraging the data in this report, the collaborative petitioned the city to incorporate preventative, mitigating, and revitalizing measures to combat air pollution. The report included several policy recommendations directly for the City of Los Angeles. One recommendation advised that the city create zoning designation to protect heavily

polluted areas from industrial or hazardous land uses—A recommendation that would eventually make it into the CUGU ordinance.

The authors of the report, in collaboration with the City of Los Angeles Planning Department, began community organizing to educate and involve residents in the development of the policies. The collaborative (with the support of philanthropic funders) hired lawyers to draft ordinance language, held several public hearings with residents and business owners, and funded a city employee who researched the impacts of their proposed regulations and policies. In July 2016, the city council passed the CUGU ordinance, and the city hired a former city council neighborhood liaison to serve as an ombudsperson to help businesses navigate the new CUGU regulations.¹⁰⁶

Lessons for Detroit

Detroit should continue to explore opportunities to develop roadside vegetative buffers and study their effectiveness.

Detroit should continue to frame the imperative for zoning changes and new ordinances in a public health context: Stakeholders in Los Angeles gained significant traction by grounding their work in the human elements and detrimental health effects of air pollution.

There may be opportunities to target specific neighborhoods in Detroit, rather than a citywide approach.

¹⁰⁵ Los Angeles Collaborative for Environmental Health and Justice. (2010). "Hidden Hazards A Call to Action for Healthy, Livable Communities." Accessed at, <https://www.libertyhill.org/sites/libertyhillfoundation/files/hidden-hazards-low-res-version.pdf>

¹⁰⁶ Kimbrough, Carla. (2017). "Los Angeles' "Clean Up, Green Up" Ordinance: A Victory in the Environmental Justice Fight." National Civic League. Accessed at, <http://www.nationalcivicleague.org/wp-content/uploads/2017/07/Kim.4.2017.Cleanup.pdf>

Newark, New Jersey — Environmental Justice and Impact Ordinance

In 2016, Newark, New Jersey passed its environmental justice ordinance. The “Environmental Justice and Impacts Ordinance” (EJIO) complements pre existing land-use and vegetative buffer ordinances to explicitly pinpoint industrial pollution as a source of the historical and present-day health and welfare inequities in Newark.

Ordinance Specifics

Newark has adopted ordinances that incorporate the planning and creation of vegetative buffers at all stages of the building construction process. The EJIO ordinance requires that applicants for an industrial building permits prepare an “Environmental Review Checklist” (ERC) that detail efforts to **“avoid, minimize, and mitigate any pollution emissions or environmental impacts both during construction and during operation.”**¹⁰⁷ The ordinance identifies tree canopies and vegetative buffers as methods to meet this stipulation. Once completed, the ERC is forwarded to the Environmental Commission for review and assessment—The Environmental Commission

then makes a recommendation to the City Planning Department or Zoning Board, which the city must take into consideration when deciding whether to grant each permit.

In their broader “Zoning and Land Use Regulations,” the City of Newark requires that **“buffer areas shall be provided along the entire linear footage of lot lines where a non-residential use or district line abuts a residential use, except that where a new residential use is proposed on a lot adjoining an existing non-residential use or district line, the proposed residential use shall provide the buffer.”**¹⁰⁸

Language Regarding Vegetative Buffers

“Buffer areas shall be planted with a combination of evergreens, deciduous trees and shrubs of such species and sizes which will produce within two (2) growing seasons a living screen at least six (6) feet in height. Buffers shall be of a density so as to obscure throughout the full course of the year the glare of automobile headlights or other bright sources of illumination emanating from the premises.”¹⁰⁹

“Buffer areas shall not be less than five (5) feet in width. Where such width is not practical in the side or rear yard,

decorative fencing subject to the requirements of Section 40:16-5 of this Chapter, shall be provided in lieu of a landscaped buffer. However, chain link fencing shall not be used for buffer purposes.”¹¹⁰

“Buffer areas shall be placed so that at maturity they will not protrude across any street or property line and so that a clear sight triangle shall be maintained at off-street intersections and at all points where private accessways intersect a public street.”¹¹¹

Types of Trees and Shrubs

Beyond the specification that trees must be evergreens or deciduous, Newark does not specify or recommend specific tree species. However, the ordinance does *prohibit* invasive plants and the following tree species:

Bradford Pear
Empress Tree
Tree of Heaven

White Poplar
Lombardy Poplar
Populus Nigra

Russian Olive
Siberian Elm
Amur Maple

Silver Maple
Norway Maple
Gingko Biloba – female

¹⁰⁷ City of Newark, Ordinance 16-083, 4(F).

¹⁰⁸⁻¹⁰³ City of Newark, Zoning and Land Use Regulations. Accessed at <https://www.newarknj.gov/viewer/redevelopment-plans>

Ownership of Vegetative Buffers

All buffer zones and other areas subject to the landscaping requirements of this article, including all trees, shrubbery, grass and fences located therein, shall be properly maintained for a period of 12 months. The applicant or developer shall post with the City a maintenance bond in an amount equal to 1/2 of the total cost of the installation of all landscaping required by this article. Said maintenance bond shall be in addition to any performance bond required. All plantings which shall fail to survive for a period of 24 consecutive months shall be replaced by the applicant or developer at their expense.”¹¹²

“The property owner shall be required to maintain all landscaping, site lighting, fences, signs, and other site improvements to keep the features attractive; in good functioning condition; and free of weeds or overgrowth. Property shall be kept free of debris, trash, or rubbish. Regular weeding, pruning, and mowing of plant materials, and replacement of all dead plant material is also required.”¹¹³

Political Context

The Environmental Justice and Impact Ordinance gained traction during a wave of urban revitalization in Newark. The ordinance aims to combat the health hazards of pollution without inhibiting urban development. Advocates for the ordinance also proposed a clause that would enable residents to reject development that contributes towards additional pollution in their neighborhoods, but this did not pass in the final ordinance. In this case, timing was critical: the election of Ras Baraka as Mayor of Newark

opened the opportunity for advocates to successfully push the passage of their bill. In late 2017, a year after Newark passed the EJIO, Corey Booker (D-NJ), introduced a bill titled, “The Environmental Justice Act of 2017,”¹¹⁴ which would require the federal government to create stronger and more comprehensive regulations to protect low-income, communities of color from the detrimental health impacts of pollution.

Lessons for Detroit

Newark’s ordinances for vegetative buffers address the root issue, pollution, at stages throughout the process, from permit proposal, to application review, to implementation. In addition to zoning ordinances that specify requirements for industrial zone use permits, Detroit could pursue additional ordinances that would require the city to consider environmental impact and justice while evaluating broader permit applications.

Within their zoning and land use regulations, Newark highlights vegetative buffers as a way to reduce light pollution and glare from vehicle headlights — another issue that Detroit would benefit by incorporating into an ordinance.¹¹⁵

¹¹² City of Newark, Zoning and Land Use Regulations. Accessed at <https://www.newarknj.gov/viewer/redevelopment-plans>

¹¹³ City of Newark, Zoning and Land Use Regulations. Accessed at <https://www.newarknj.gov/viewer/redevelopment-plans>

¹¹⁴ <https://www.google.com/search?q=cory+booker+environmental+justice+act+of+2017&oq=corey+booker+environmental+justice+act+of+&aqs=chrome.1.69i57j33l2.5952j0j4&sourceid=chrome&ie=UTF-8>

¹¹⁵ Hislip, P. (2017). “The backdrop of Newark’s Environmental Justice and Cumulative Impacts Ordinance.” Accessed at <https://bloustein.rutgers.edu/the-backdrop-of-newarks-environmental-justice-and-cumulative-impacts-ordinance/>

Raleigh, North Carolina

Raleigh's citywide ordinance requires vegetative buffers and tree canopies in high industrial zones abutting any other type of zone. This ordinance requires buffers and canopies not only for reducing pollutants and carbon, but also for environmental and wildlife conservation.

Ordinance Specifics

The City of Raleigh requires any "Heavy Industrial" (HI) district that abuts any type of district other than another HI district to create a protective yard with shade trees, understory trees, and shrubs. Heights, widths, and other

specifications for these protective yards differ dependent on whether the adjacent property is a public right-of-way or another district (residential, mixed-use, etc).¹¹⁶

Language Regarding Vegetative Buffers and Tree Canopy

"The City acknowledges that trees provide environmental, aesthetic, social and economic benefits. Specifically, trees increase property values, provide aesthetic value, provide shade and cooling, reduce energy costs, decrease wind velocities, provide erosion control, conserve energy, reduce stormwater runoff, act as filters for airborne

*pollutants, reduce noise, provide privacy, provide wildlife habitat and food value, sequester carbon and release oxygen. By enacting these regulations, it is the intent of the City to prudently protect and manage the urban forest to secure these benefits"*¹¹⁷

Types of Trees and Shrubs

The City of Raleigh suggests the following species of trees:

Large Maturing Trees

American Elm
Bald Cypress
Black Gum
Ginkgo
Magnolia
Oaks
Red Maple
River Birch
Sugar Maple
Tulip Poplar

Medium Maturing Trees

American Holly
Chinese Elm
European Hornbeam
Hackberry
Musclewood
Trident Maple
Zelkova

Small Maturing Trees

Carolina Silverbell
Chinese Pistache
Crepe Myrtle
Dogwood
Eastern Redbud
Flowering Cherry
Fringetree
Japanese Snowbell
Magnolia
Oklahoma Redbud
Purple Blow Maple
Serviceberry

¹¹⁶ City of Raleigh. (2018). "Unified Development Ordinance," page 96. Accessed at <https://www.raleighnc.gov/content/extra/Books/PlanDev/UnifiedDevelopmentOrdinance/96/#zoom=z>

¹¹⁷ Raleigh City Code, Chapter 8, Section 9-8001

The City of Raleigh specifies requirements for the height, spacing, and placement of trees, which can be found in greater detail in the “City Tree Manual” (Appendix D). Broadly, the city requires that any new plants comply with the American Nursery Standard for Nursery stock Z60.1, with “healthy root systems developed by transplanting

or root pruning and a visible root flare.” “Building owners and their landscapers must provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.”¹¹⁸

Ownership of Vegetative Buffers and Tree Canopy

The City of Raleigh uses their “Unified Development Ordinance” to regulate the placement, maintenance, and removal of trees on private property. However, this has been intensely debated over the past several years

(see “Political Context” below). The city’s urban forestry department manages all trees on public property, which includes trees on street right-of-ways.¹¹⁹

Political Context

Throughout the past several years, North Carolina lawmakers have pursued state-level legislation that would prevent cities from regulating trees and vegetation on private property.¹²⁰ Proponents of the state legislation believe that restrictive zoning regulations inhibit the growth of businesses and economies, while opponents argue that allowing private property owners to remove trees will have detrimental effects on quality of life, runoff

and irrigation, and “cooling zones.”

The “Neighborwoods”¹²¹ program is a partnership between Raleigh residents and the city planning department. Through this program, residents can receive free street trees in Raleigh neighborhoods in exchange for agreeing to provide maintenance (watering and mulching) for the first two years.

Lessons for Detroit

Green ordinance proponents in Detroit should expect pushback from opponents who believe that tree canopy and vegetative buffer ordinances place undue regulatory and financial burdens on the private business sector.

Detroit may benefit from exploring the feasibility of a voluntary tree program that incentivizes resident-owned maintenance of city trees and vegetative buffers.

118 City of Raleigh. (2014). “City Tree Manual.” Accessed at <https://www.raleighnc.gov/content/ParksRec/Documents/.../UFCityTreeManual.pdf>

119 <https://www.raleighnc.gov/home/content/ParksRec/Articles/Programs/UrbanForestry/UFDivision.html>

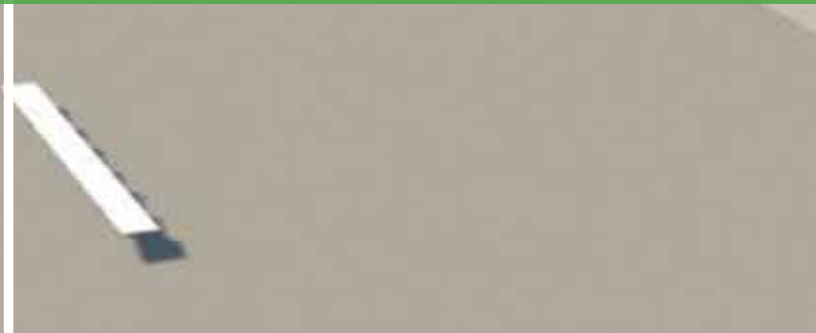
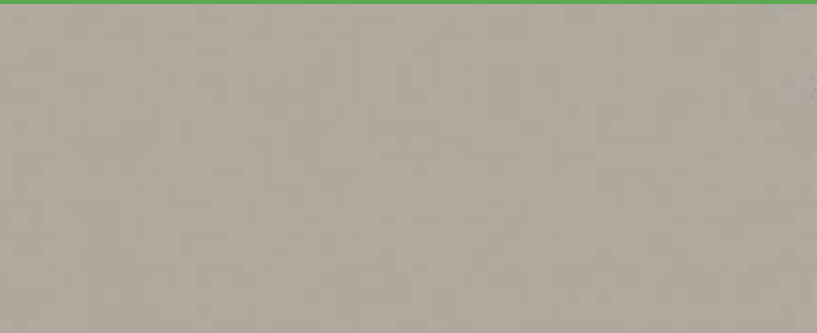
120 Campbel, C. (2015). “Raleigh to fight legislation limiting tree regulations.” *The News & Observer*. Accessed at <https://www.newsobserver.com/news/local/community/midtown-raleigh-news/article10326983.html>

121 City of Raleigh. (2014). “City Tree Manual.” Accessed at <https://www.raleighnc.gov/content/ParksRec/Documents/.../UFCityTreeManual.pdf>



MODELING

Urban Trees and Vegetative Screen in Detroit Neighborhoods



Key Findings:

Modeling Urban Trees and Vegetative Screen in Detroit Neighborhoods

- ▶ **Three land-use based approaches were identified as opportunities across Detroit for mitigating air quality issues and providing highly valued co-benefits. The three land-use approaches were modeled at sites located in Southwest Detroit:**
 - Industrial / Residential interfaces - vegetative buffers
 - High traffic / Residential interfaces - vegetative buffers
 - Residential yard trees - individual trees
- ▶ **Yard Trees v. Vegetative Buffers: These two interventions vary in the relative benefits provided:**
 - Residential yard trees provide homes with shade and wind protection, saving energy and in turn, avoided carbon and pollutant emissions. They also serve to mitigate stormwater impacts.
 - Vegetative buffers are interventions focused on air quality mitigation. Co-benefits include stormwater mitigation and carbon sequestration, however, energy savings are not associated.
- ▶ **District 6 is a priority area for vegetative buffer and yard tree interventions. Currently, District 6:**
 - Is in “non-attainment status” for two criteria pollutants: Sulfur Dioxide & Ozone.
 - Contains 35% of Detroit’s industrial zoned land area.
 - Has the lowest tree canopy cover at 14.5%, almost half when compared to other districts.
- ▶ **Tree species selection is critical. Both within and among size classes (small, medium, large), substantial differences in lifetime benefits are observed:**
 - Large trees produce the greatest lifetime services: valued up to \$2,231.
 - The lowest performer provides only \$239.
- ▶ **Cost-benefits analysis reveals that:**
 - The 40-year net benefit for a large public tree is \$2,738.40, \$755.20 for a medium tree, and \$188.80 for a small tree.
 - The break-even point for a small public tree is about 36 years, for a medium public tree 22 years, and for a large public tree 10 years.

Overview

Modeling Urban Tree and Vegetative Buffers in Detroit Neighborhoods

This study integrates three analyses to provide a robust understanding of the potential impacts of an ordinance supporting vegetative buffers and general urban canopy cover growth. i-Tree model, developed by the US Forest Service, has been widely used for strategically planning urban canopy cover throughout the United States and around the world. Combined with spatial analyses using geographic information systems (GIS) and a

cost-benefit analysis (CBA), this section is intended to provide stakeholders and decision-makers with critical information regarding benefit projections and financial indicators for projects based on real sites located in Detroit. Three land use type approaches are modeled including: Industrial/Residential Interfaces, Interstate/Residential Interfaces, and Residential 'Yards.'

Three sites modeled in Detroit City Council District 6

These analyses focus on neighborhoods located within District 6, a priority area identified in previous analysis conducted by Community Action to Promote Healthy Environments (CAPHE). The three sites chosen in District 6 reflect the three land-use approaches identified. It is important to note that while this model focuses on District 6, all Districts contain these land-use types and would benefit from the strategic implementation of vegetative buffers and the increase of tree canopy in general.



FIGURE 2. Map of modeled sites for urban tree and vegetative buffer project implementation.



Industrial / Residential interface: Dix Road Vegetative Buffer

The CSX Intermodal Detroit facility, located along Dix Road, borders a residential community and is one of several trucking facilities in the area, along with the nearby Detroit Intermodal Freight Terminal (DIFT). Thousands of trucks move through these facilities per day, and they are a significant source of particulate matter pollution and fugitive dust.⁴⁶ A vegetative buffer positioned between the facility and the adjacent neighborhood was modeled in i-Tree as well as the cost-benefit analysis.



Interstate / Residential Interface: I-75 Vegetative Buffer

Interstate 75 (I-75) transverses east-west through District 6 communities and north-south through Districts 3, 5 and 6. A vegetative buffer was modeled between I-75 and an adjacent neighborhood near Junction Avenue and W Fischer Service Road. A vegetative buffer positioned between the interstate and the adjacent neighborhood was modeled in i-Tree as well as the cost-benefit analysis.



Residential: “Yard” Trees: SW Detroit’s Eco-District

A residential area of Southwest Detroit between the borders of Michigan Avenue, Fort Street, Livernois Avenue and Scotten Avenue is situated amidst industrial properties, high traffic areas (ie. I-75), and freight shipping and exchange corridors. A yard tree program was modeled, where trees were scattered throughout residential properties to increase overall tree canopy cover in a given area.

⁴⁶ Dust Busters

GIS Analysis

Pre-existing GIS analyses: Substantial efforts in spatial analysis of pollutants in southwest Detroit have been completed over the past decade. These analyses have primarily focused on identifying pollution hot spots and areas for mitigation across a variety of criteria pollutants. Included in this section are several existing analyses conducted in our focal area.

CAPHE conducted spatial analysis that integrated air quality, population density and canopy cover to identify priority areas for air quality mitigation by District.⁴⁷ Specifically, this study weighted vehicular pollution (NO_x and PM) (0.4), population density (0.3) and lack of tree canopy cover (0.3) to prioritize

and target mitigation areas. The results suggest that District 5 and District 6 are the most impacted areas by vehicular air pollution, and would receive the greatest benefits by use of urban trees and vegetative buffers as shown below.

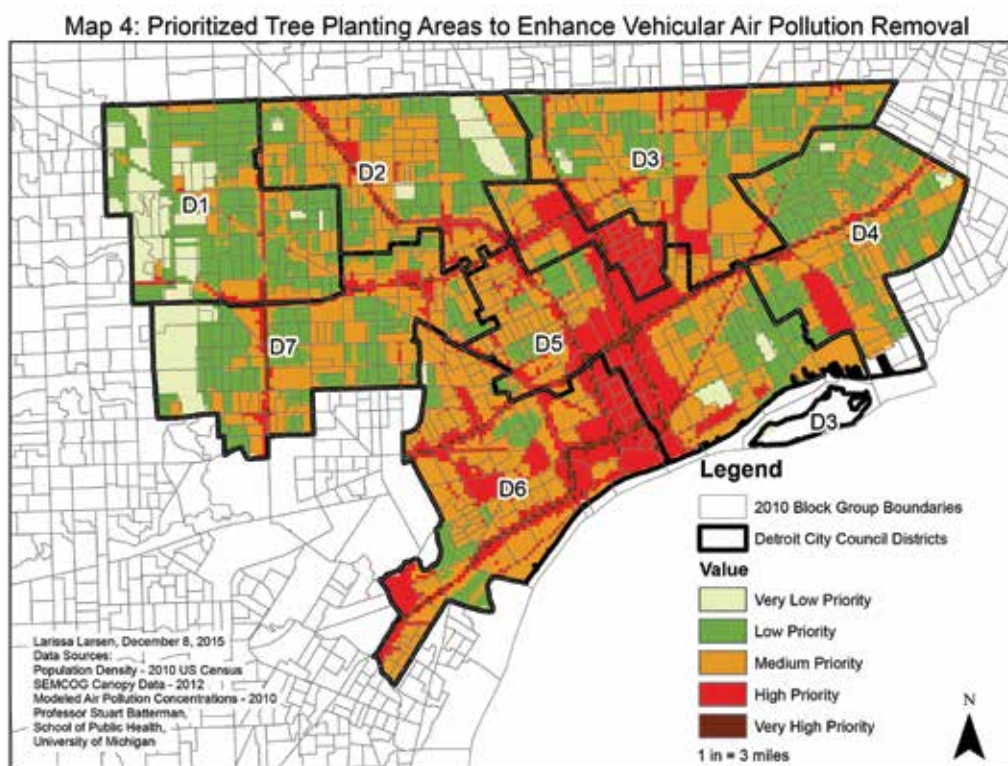


FIGURE 3. Prioritization of tree planting areas by District, for removal of vehicular air pollution⁴⁸

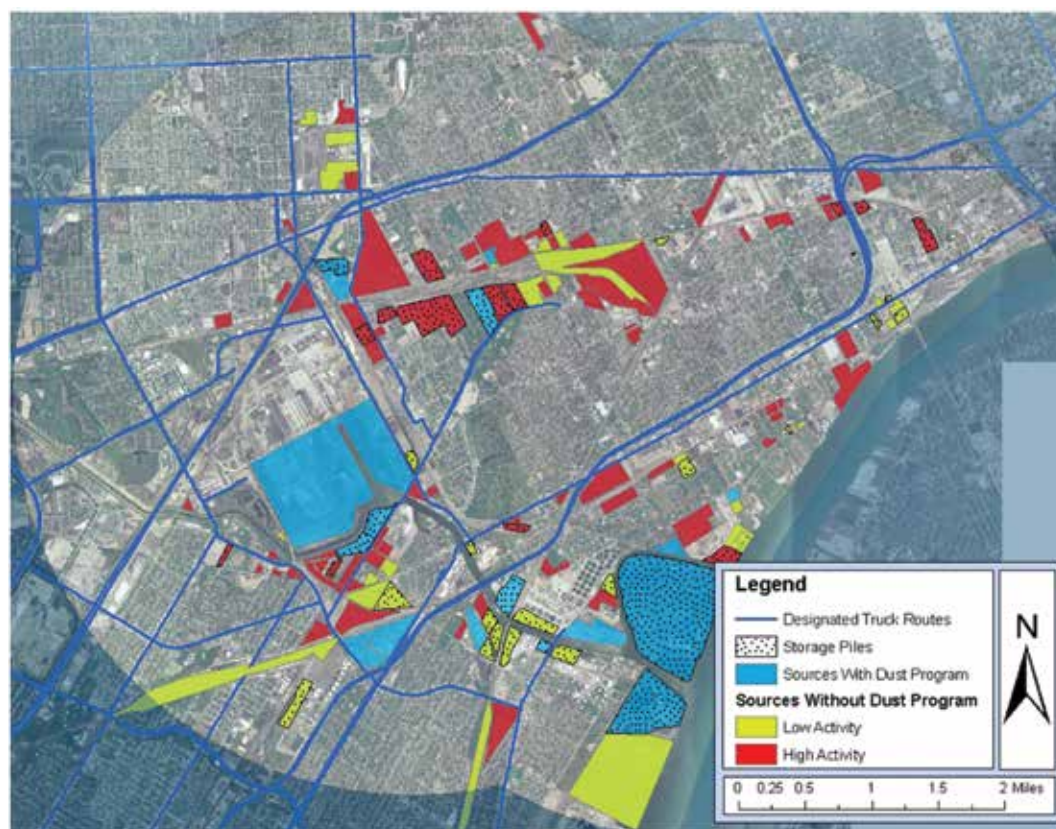
⁴⁷ CAPHE Design Guidelines, 2005 pg. 55

⁴⁸ CAPHE Design Guidelines



Previous GIS analyses have focused on particulate matter (PM) and fugitive dust. One study identified 43 stationary sources for particulate matter in the surrounding area to our focal site, including the 300-acre Livernois- Junction Yard, also known as the Detroit Intermodal Freight Terminal (DIFT) – a major source of particulate matter and fugitive dust.⁴⁹ CSX Intermodal Detroit, was the site selected for this study's example of an Industrial/ Residential interface.

FIGURE 4. Stationary sources for pollution including particulate matter (top) and fugitive dust (bottom).⁵⁰ Key included in Appendix A.



49 (Dust Busters, 2008)

50 Duweke & Larsen, 2008

Approaches: Land-Use Based

The GIS analysis in this study focused on identifying land-use based opportunities for implementing urban trees and vegetative buffers. Land-use type selection considered where people live (residential), and sources of high levels of air pollution (industrial and high traffic roads). Information on layers used in our analysis are located in [Appendix B](#). **Three land use areas were identified as prime opportunities:**

1. **Industrial/Residential Interfaces: implementation - vegetative screens (private land)**
2. **Interstate/Residential Interfaces: implementation - vegetative screens (public land)**
3. **Residential: implementation - “yard” trees (private land)**

1. Industrial/Residential Interfaces

To assess the overall potential for vegetative screen interventions on land zoned for industrial use, it was important to locate and complete an inventory of the interfaces between residential and industrial parcels. Industrial zones were given a 1,000 foot buffer. Residential parcels which fell within this buffer were identified and total area was calculated for each district (Table 1).

The map on the right (Figure 5) illustrates these interfaces (dark purple), and can be seen to located throughout the city, with highest concentration in District 6 which contains 35% of Detroit's Industrial zoned land. Further, 19.2% of the District's residential parcels are located within 1,000 feet of an industrial zone.

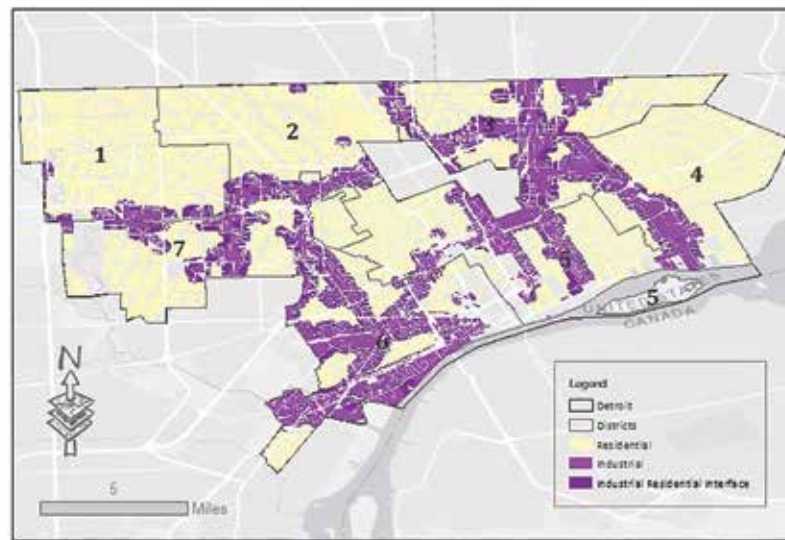


FIGURE 5. Industrial/Residential in Detroit: Residential (yellow), industrial (purple), interfaces with a 500 foot buffer (dark purple).

2. Interstate/Residential Interfaces

To assess the overall potential for vegetative buffer interventions on mobile pollution sources, the interfaces between residential and high traffic roadways were identified. High-traffic roadways were defined as the top quartile of average annual daily traffic. Similar to industrial zones, roadways were given a 1,000 foot buffer. Residential parcels which fell within this buffer were identified and total area was calculated for each district (Table 1).

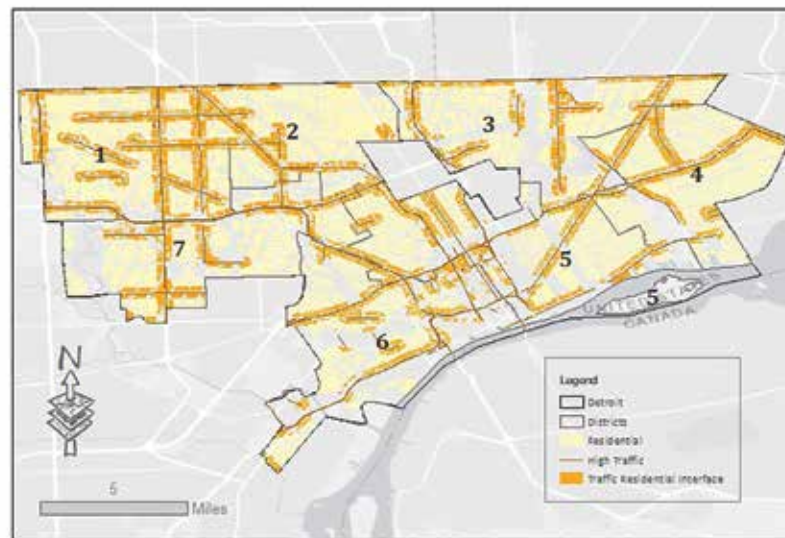


FIGURE 6. High traffic/Residential zoning interfaces in Detroit: Residential (yellow), interfaces with a 1,000 foot buffer (orange) of high annual average daily traffic roadways (dark orange).

3. Residential ‘Yard Trees’

Another approach found in other cities like Orlando, Florida’s “One Person, One Tree” program⁵¹, have focused on increasing overall canopy cover through the use of residential yard trees. This approach varies from the other two, as an opportunity for residents to choose a tree and identify the most beneficial location in their yard on a user-friendly platform. The result is that trees are dispersed through private residential property on a voluntary basis, providing the same type of benefits, with additional benefits in energy savings depending on the location and proximity to the structure.

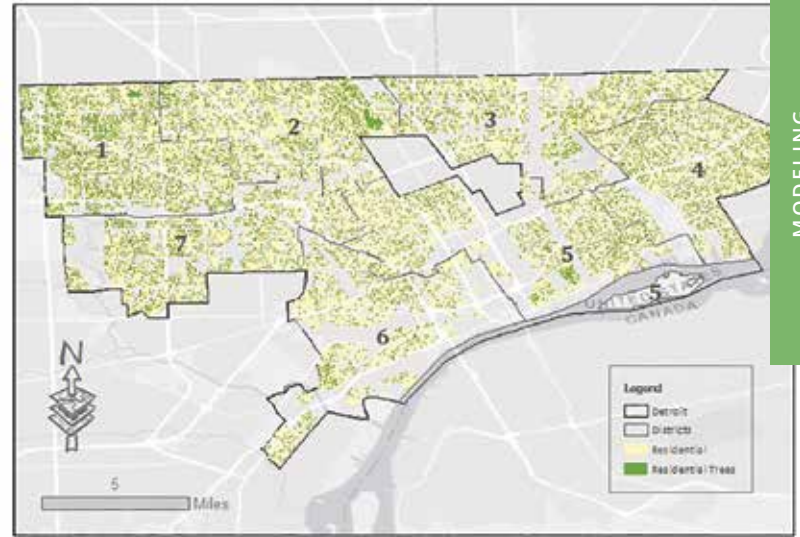


FIGURE 7. Residential tree cover in Detroit: Residential (yellow), trees located within residentially zoned parcels (green), summarized in Table 1, column “% Residential Tree Cover.”

Area	Population* Land area	% Tree Cover (residential) Residential land area	Industrial land (% Detroit) Ind./Res. interface land area (% District)	High Traffic/ Res. Interface land area (% Detroit, % District)
Detroit	648,698 139 sq. mi ²	21.2% 68.2 mi ²	15.6 mi² 100% 13.90 mi ² 10%	22.5 mi ² 100%, 16.2%
District 1	105,185 19 mi ²	30.6% 11.6 mi ²	0.49 mi² 3.1% 0.79 mi ² 4.2%	4.7 mi ² 20.7%, 24.7%
District 2	105,931 17 mi ²	22.0% 10.9 mi ²	0.46 mi² 2.9% 0.95 mi ² 5.6%	3.5 mi ² 15.5%, 20.6%
District 3	97,082 24 mi ²	20.5% 9.9 mi ²	3.57 mi² 22.9% 3.26 mi ² 13.6%	11.5 mi ² 14.6%, 47.8%
District 4	98,666 17 mi ²	21.8% 9.7 mi ²	1.11 mi² 7.1% 0.90 mi ² 5.3%	2.6 mi ² 11.5%, 15.3%
District 5	98,100 23 mi ²	18.0% 9.1 mi ²	2.89 mi² 18.5% 1.85 mi ² 8.0%	3.1 mi ² 13.8%, 13.5%
District 6	41,328 20 mi ²	14.5% 7.6 mi ²	5.39 mi² 34.5% 3.83 mi ² 19.2%	2.7 mi ² 12.2%, 13.5%
District 7	102,406 19 mi ²	22.8% 9.3 mi ²	1.71 mi² 11.0% 2.32 mi ² 12.2%	2.6 mi ² 11.2%, 13.7%

TABLE 1. Results from GIS analysis of interfaces between residential land use and interstate or industrial zoned land. Note: “% Detroit” represents the relative amount of the land type in Detroit, while “% District” represents the relative amount of land type compared to the total land area of the district.⁵²

51 Orlando’s One Person One Tree program: <http://www.cityoforlando.net/trees/>

52 2010 Data *Driven Detroit*, 2010 SEMCOG land coverage, Detroit Open Data Portal

i-Tree Design

Modeling tree planting, growth and benefits

i-Tree is a software suite from the USDA Forest Service that provides urban and rural forestry analysis of how tree selection, size, and placement in a specific area can generate multiple benefits, including the control of stormwater, energy efficiency for nearby homes, and improved air quality.

Tree species selection:

The tree species used for i-Tree modeling were derived from two sources: Detroit General Services [Appendix C](#) and species on i-Tree Design. Sixteen (16) tree species contained on both lists were identified, including small, medium and large types (Table 2). Species selection was critical for modeling for two reasons: substantial variation in upfront purchase cost and benefits accumulated

over time. To account for this variability, species were strategically selected for i-Tree modeling and cost-benefit analysis as described in the corresponding sections below. Plantings simulated in i-Tree were performed at 2-inch B&B (ball and burlap) stock in reflection of current practices of Detroit’s Office of General Services.

Small	Medium	Large
Dogwood	Red Maple	Kentucky Coffeetree
Flowering Dogwood	Sugar Maple	Dawn Redwood
Kwanzan Cherry	European Hornbeam	White Oak
	Eastern Redbud	Swamp White Oak
	American Yellowwood	Bur Oak
		Greenspire Littleleaf Linden
		Silver Linden
		American Elm

TABLE 2. Tree species found on both Detroit General Services Tree list and i-Tree Design.



Flowering Dogwood



Red Maple



American Elm

MODELING

Optimizing Tree Species Selection with i-Tree Design:

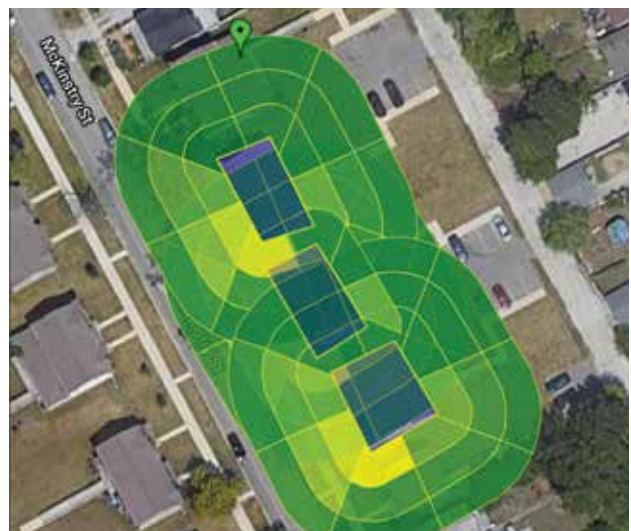
i-Tree analysis was conducted to evaluate the benefits of various tree species under different land-use approach conditions. Due to the proximity to housing structures, an i-Tree analysis was performed for residential yard trees because they provide substantial energy savings benefits. Modeling was also done for trees located in a vegetative buffer. Two design approaches, dispersed yard trees and vegetative buffers were therefore modeled in i-Tree design to differentiate between tree species. All species contained on both the Detroit Tree List and i-Tree were modeled, separated by size class (small, medium, large). Trees were planted at a 2-inch diameter with lifespans of 40 years.

Results indicate that tree species selection will have substantial impact on the type and magnitude of benefits received. Yard trees, provide opportunities for substantial energy savings benefits, which can vary widely between size classes, and within size classes. Benefits captured with i-Tree also varied substantially between Residential Yard trees and vegetative buffers. Because of the lack of energy savings (which are not located close enough to buildings), the compound effects of vegetative buffers producing air quality saving benefits would need to be between 7-55 times per tree, to produce equivalent overall resulting benefits.

1. Residential “Yard trees”

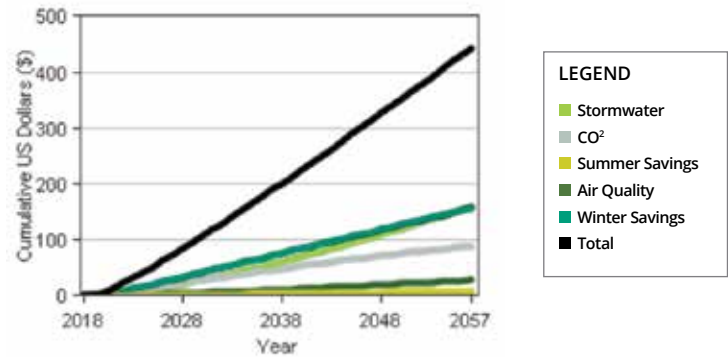
Tree Placement: Significant energy benefits can be captured when buildings are manually identified by i-Tree users. With underlying satellite imagery, a site located within the Eco-District of Southwest Detroit was modeled (Figure 8). All surrounding building structures were traced allowing for the model to capture energy impacts. Depending on the proximity and relative location to these buildings, energy savings or losses were estimated. I-Tree identifies optimal on-site placement, which was used for all simulated tree placements.

FIGURE 8. i-Tree Design sample optimizing placement of yard trees in residential parcels of Southwest Detroit.



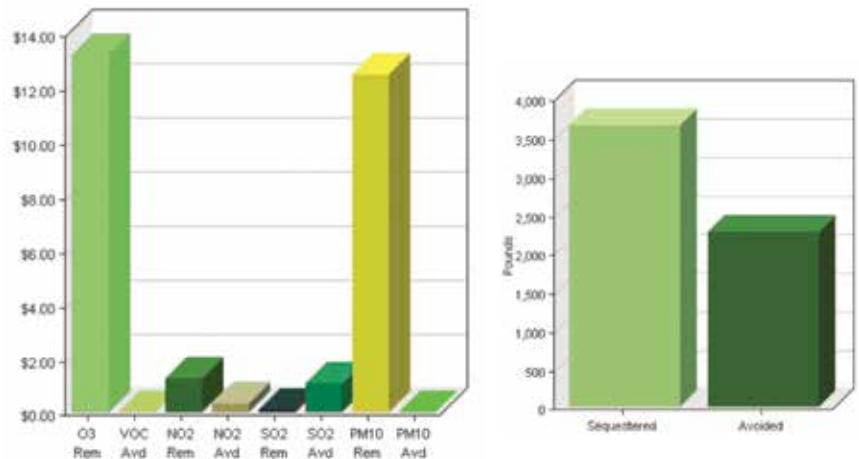
2. Small trees

Small trees, on average, produced the least amount of overall benefits, ranging from \$306-\$459 over the course of 40 years (excludes aesthetic value). Each tree species resulted in varying levels across benefit types as shown in their respective benefit curves below. The majority of benefits for small trees are derived from winter energy savings and stormwater mitigation.

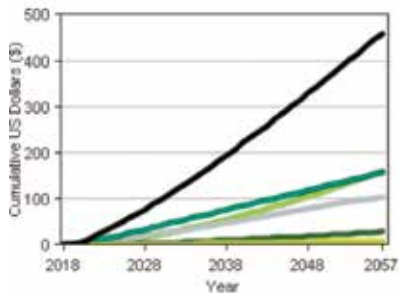


Flowering Dogwood: *lifetime benefits: \$459*

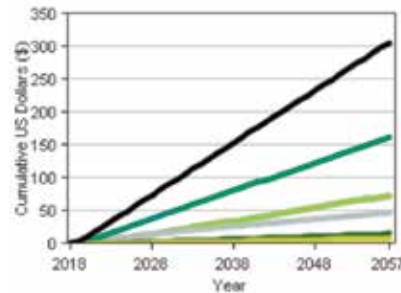
The Flowering Dogwood had the greatest cumulative lifetime benefits of small trees, with a total of \$459. This was achieved mainly through winter energy savings (111 therms of natural gas avoided) and 20,082 gallons of stormwater intercepted. Additionally, 5,933 pounds of carbon were sequestered or avoided.



The remaining two small size class trees had the following benefit curves:



Dogwood, lifetime benefits: \$443



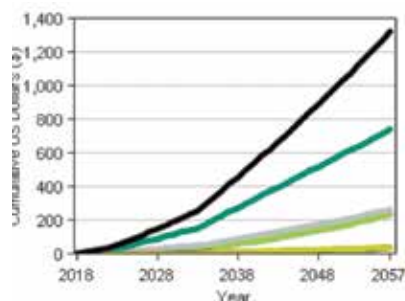
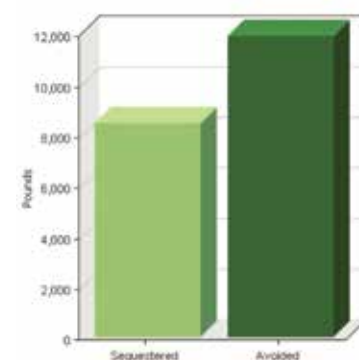
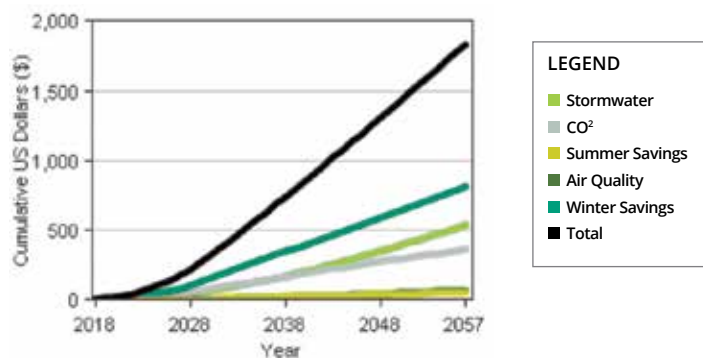
Kwanzan Cherry: lifetime benefits: \$306

3. Medium trees

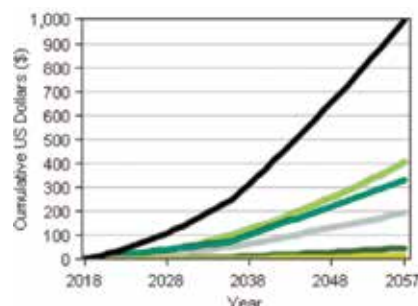
Medium trees produced very low to moderately high amount of overall benefits, which ranged from \$239-\$1,836 over the course of 40 years (excluding aesthetic value). Each tree species resulted in varying levels across benefit types as shown in their respective benefit curves below. The majority of benefits for medium trees is derived from winter energy savings and stormwater mitigation.

Red Maple: lifetime benefits: \$1,836

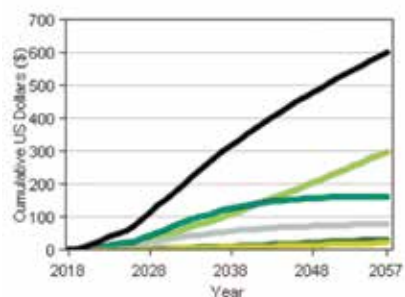
Red maple have the greatest estimated lifetime savings of medium sized trees, providing substantial winter energy savings (560 therms of natural gas), and intercepting 67,204 gallons of water. Red maples also produce carbon mitigation benefits, both from avoided emissions (mainly avoided combustion of natural gas), and carbon sequestration, in the tree itself equivalent to offsetting an average individuals travel by car for two years.



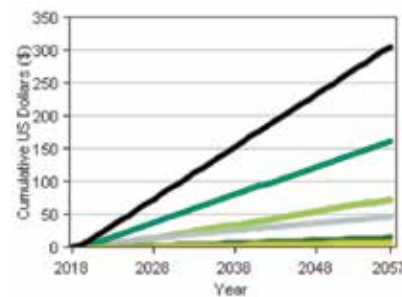
Sugar Maple: lifetime benefits: \$1,322



European hornbeam: lifetime benefits: \$998



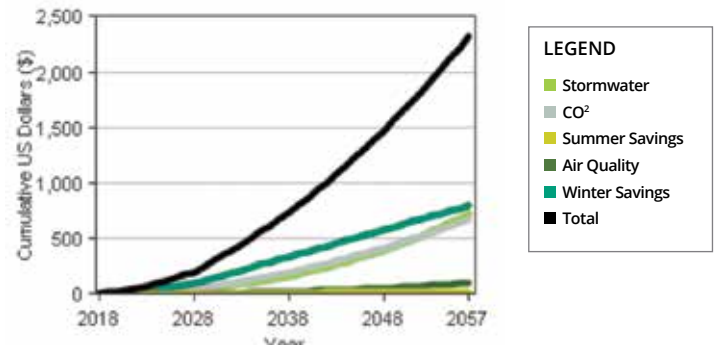
Yellowwood: lifetime benefits: \$601



Eastern Redbud: lifetime benefits: \$239

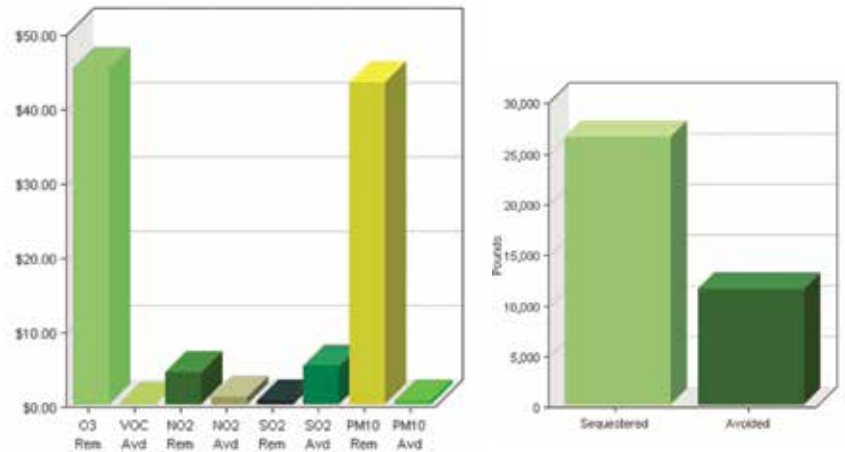
4. Large trees

Large trees benefits ranged from low (\$755) to high (\$2,321) over the course of 40 years (excluding aesthetic value). Each tree species resulted in varying levels of benefits by type, as reflected in their respective benefit curves located below. The majority of benefits for large trees is derived from winter energy savings, stormwater mitigation, and carbon mitigation.

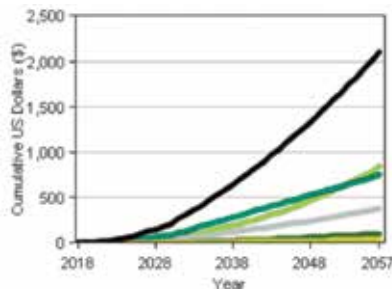


Swamp White Oak: lifetime benefits: \$2,321

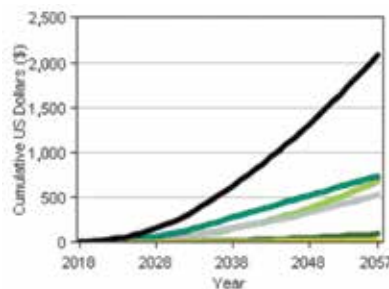
Swamp White Oaks had the greatest lifetime benefits achieved at \$2,321. Three types of benefits had relatively equivalent value at year 40, included winter energy savings (563 therms of avoided natural gas), stormwater mitigation (90,006 gallons of intercepted and carbon sequestration and avoided emissions (38,000 lbs, equivalent to three years of car travel). Removal of pollutants included ozone (O3) and particulate matter (PM 10).



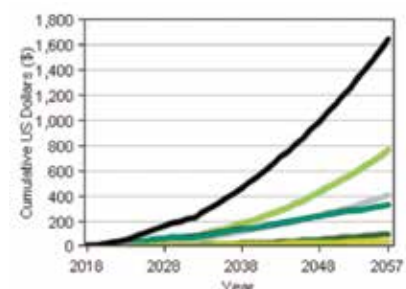
Additional large size class trees included:



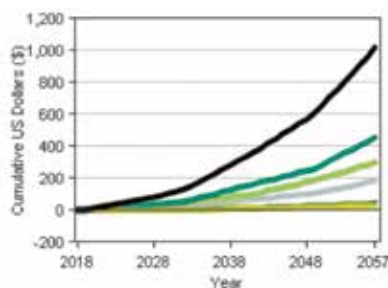
Dawn Redwood: lifetime benefits: \$2,107



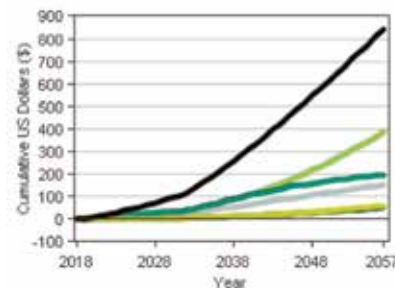
White Oak: lifetime benefits: \$2,088



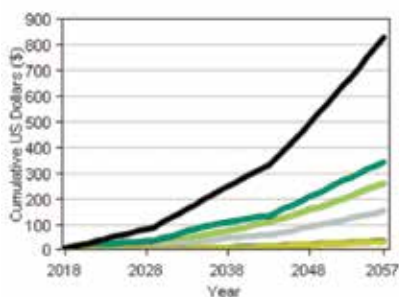
American Elm: lifetime benefits: \$1,647



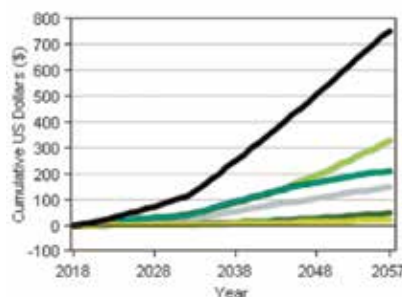
Kentucky Coffeetree: lifetime benefits: \$1,019



Silver Linden: lifetime benefits: \$844



Bur Oak: lifetime benefits: \$828



Greenspire Littleleaf Linden: lifetime benefits: \$755

Vegetative buffers

Design guidelines, including spatial arrangement of tree size classes, spacing between individual trees and rows, were derived from the CAPHE Design Guidelines report.⁵³

While i-Tree is the most advanced open access software available and widely used for urban tree planning, it has limitations in estimating the compound benefits of vegetative buffers. There were two primary reasons for this limitation. First, the i-Tree model lacks high enough resolution to distinguish air quality differences at small spatial scales, such as residential areas in close or further proximity to highways and/or industrial zones. Second, the model does not account for the compound effect of vegetative screen design — it simply sums the impacts of single trees. After accounting for these limitations, i-Tree results provided useful insights.

Some tree species performed substantially better in yards, than their baseline performance in vegetative buffers (i.e. without buffer design effect).

This is largely due to the fact that yard trees produce energy savings benefits, which further avoid emissions of pollutants and carbon. Therefore, to outperform an identical tree modeled as a yard tree in terms of cumulative economic benefits, a vegetative buffer tree must be more effective at removing air pollutants. While this is not captured by i-Tree Design, we have calculated “Vegetative Buffer Air Quality Factors” below as an indicator for how effective vegetative buffer trees would need to be to perform with equivalent total benefits as a yard tree. We found that vegetative trees would have factors ranging from, seven to eighteen, with an outlier of fifty four (Table 3, last column). Whether individual trees within a vegetative buffer are seven to eighteen times as effective as yard trees has yet to be determined, but may be within a reasonably assumable range.

⁵³ CAPHE Design Guidelines

Tree Species	Yard Tree Life Benefits	Est. air quality benefits	Veg. buffer life benefits (non-compounded)	Vegetative Buffer Air Quality Factor
Dogwood	\$443	\$27	\$235	7.7
Flowering Dogwood	\$459	\$26	\$252	8.0
Kwanzan Cherry	\$306	\$14	\$94	15.1
Red Maple	\$1,836	\$62	\$752	17.5
Sugar Maple	\$1,322	\$30	\$348	32.5
European Hornbeam	\$998	\$45	\$562	9.7
Easter Redbud	\$239	\$10	\$58	18.1
American Yellowwood	\$601	\$31	\$368	7.5
Kentucky Coffeetree	\$1,019	\$40	\$408	15.3
Dawn Redwood	\$2,107	\$95	\$1,122	10.4
White Oak	\$2,088	\$32	\$362	53.9
Swamp White Oak	\$2,321	\$90	\$1,283	11.5
Bur Oak	\$828	\$33	\$356	14.3
Greenspire Littlelead Linden	\$755	\$44	\$466	6.6
Silver Linden	\$844	\$46	\$525	6.9
American Elm	\$1,647	\$92	\$1,182	5.1

TABLE 3. Comparison of tree species used as yard trees vs. vegetative buffers. Air quality benefits not fully captured for vegetative buffers. Vegetative buffer air quality factor is the multiplier which air quality impacts would need to be multiplied by to reach equal lifetime benefits as a yard tree (ie. effect of vegetative design). ($VBAQF = \text{column1} - \text{column3} / \text{column2}$).

Urban Tree Canopy Cost-Benefit Analysis

Introduction

Based on the research of E.G. McPherson and the recommendations of his team in the *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planting*, the following figures highlight the costs and benefits for planting trees in Detroit.⁵⁴ Three representative trees have been selected for calculating average costs and benefits: crabapple (small), red oak (medium), and hackberry (large). Both yard trees (located on private property) and public trees (maintained by municipalities) have been listed to highlight differences in costs and,

therefore, net benefits. Monetizable benefits from trees in this analysis include: energy savings (both cooling and heating), carbon dioxide and air pollution sequestration, hydrology, and aesthetics (i.e., property value). Financial costs for public tree canopy projects include: planting, pruning, tree removal and disposal, pest control, infrastructure repair, irrigation, cleanup, legal and liability, and administration. Administration costs are not included in the yard tree analysis.

Assumptions and Limitations

All dollar amounts represented in the figures below and in the appendices have been derived from McPherson's 2006 *Midwest Community Tree Guide* and adjusted for inflation (2018 dollars).⁵⁵ These figures do not take into account the future value of money and do not include the post-mortality benefits of trees (e.g., mulch or the resale of harvested lumber). All figures include a 40% mortality rate over 40 years. Costs listed below

are based on surveys administered by McPherson to municipal and commercial arborists in the U.S. Midwest, an area which includes Detroit. Benefits listed below are based on the research of McPherson and the iTree software. For additional specificity regarding the costs of tree planting and maintenance in Detroit, please contact the Detroit Urban Forestry Office.

Summary of Results

For every dollar spent on a large public tree, \$2.56 of value is created. For every dollar spent on a small and medium public tree, \$1.14 and \$1.48 of value is created, respectively. Due to a large leaf canopy, large trees have a net benefit which grows more rapidly over time (Figure 9). The 40-year net benefit for a large public tree is \$2,738.40, compared to \$188.80 for a small tree and \$755.20 for a medium tree. Average annual benefits for public small, medium, and large trees are \$4.72,

\$18.88, and \$68.46 respectively. The largest cost for trees is pruning and maintenance (Figure 10), especially for public trees, which is why expenses for public trees exceed yard trees. The second largest expense is the cost of planting, which is incurred in the first year. Due to this large upfront cost, the break-even point for a small public tree is about 36 years, for a medium public tree 22 years, and for a large public tree 10 years (Figure 11). With time, the cumulative benefits of large trees

⁵⁴ E.G. McPherson et. al. (2006). *Midwest Community Tree Guide: Costs, Benefits, and Strategic Planting*, USDA.

⁵⁵ Inflation based on U.S. Bureau of Labor Statistics: <http://www.in2013dollars.com/Detroit-Michigan/price-inflation/2006-to-2018?amount=100>

increase exponentially compared to small and medium trees. The largest benefits of trees are due to energy savings and aesthetics (Figure 12). Trees keep buildings cooler during summer months and warmer during winter months. For this reason, the benefits for yard trees are categorized based on location (i.e., which side of a building the tree is located). Trees located on the west-side of buildings have the greatest benefits (Figure 13).

Overall, this cost-benefit analysis indicates that trees are a good investment. For a tree planting project in Detroit which includes 500 small, medium, and large trees (1500 trees total), total net benefits exceed \$1.8 million (Figure 14). These net benefits could increase further with the support of a volunteer workforce and the application of post-mortality uses of trees (i.e., mulch and resale of lumber).

Figures

FIGURE 9: Net benefits for small, medium, and large trees over 40 years.

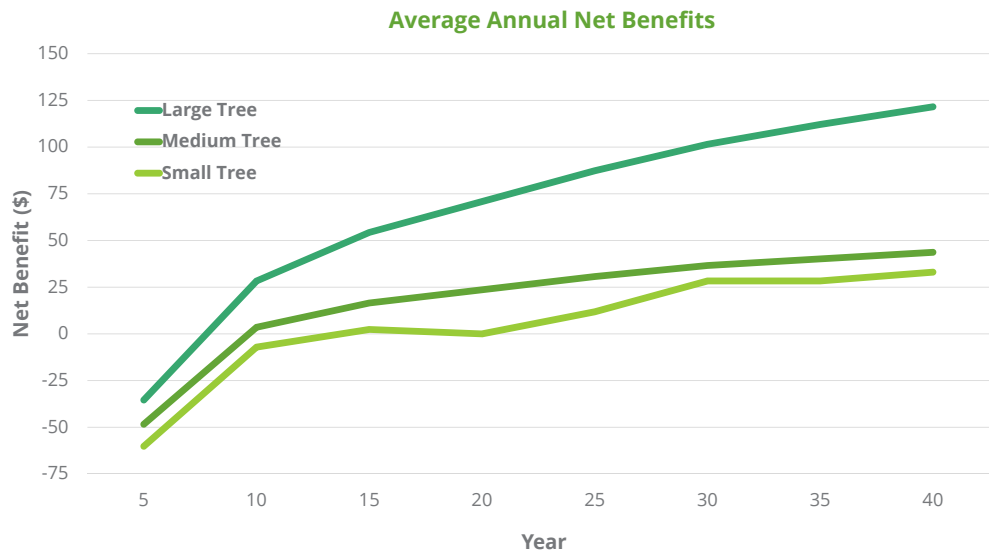


FIGURE 10: Combined average costs for small, medium, and large public trees averaged over 40 years.

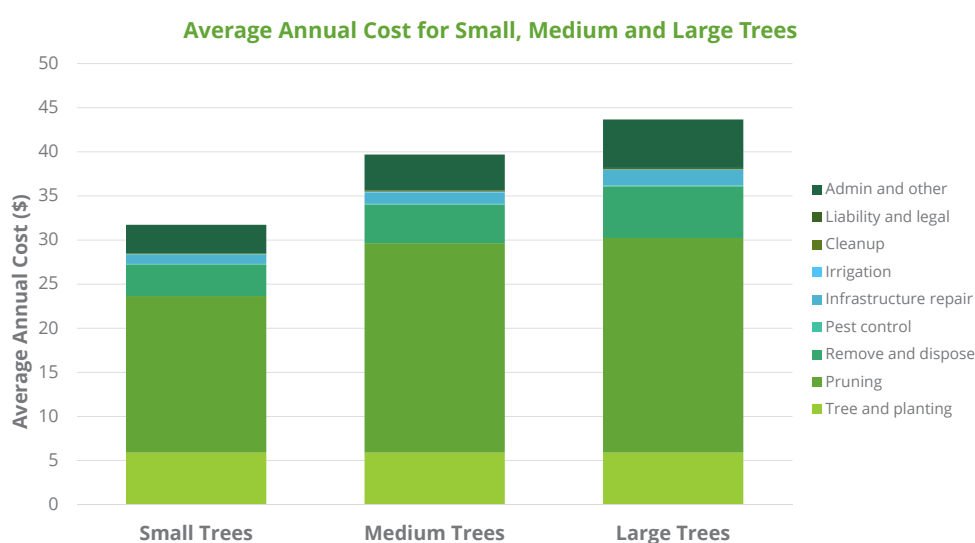




FIGURE 11: Breakeven point for small, medium, and large trees over 40 years.

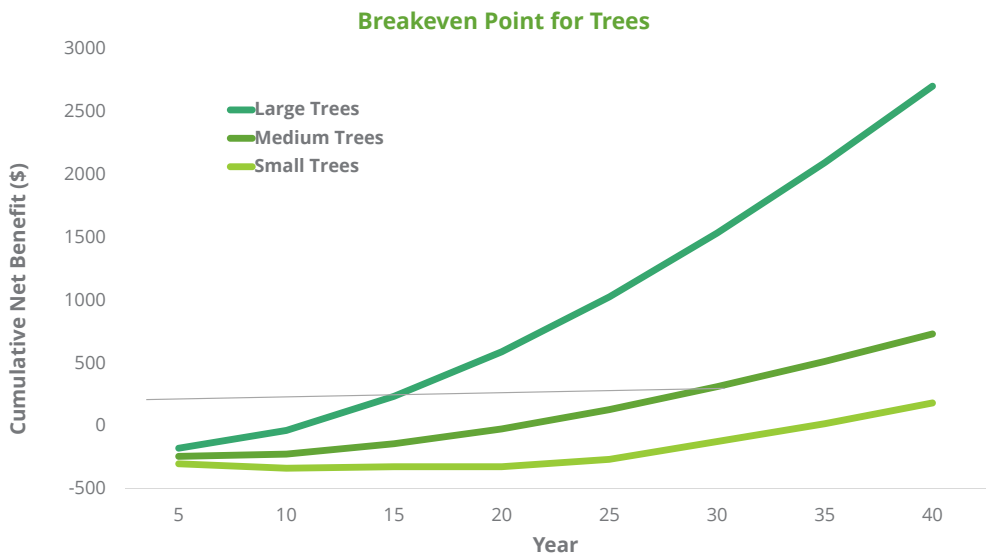


FIGURE 12: Breakdown of average benefits for public trees over 40 years.

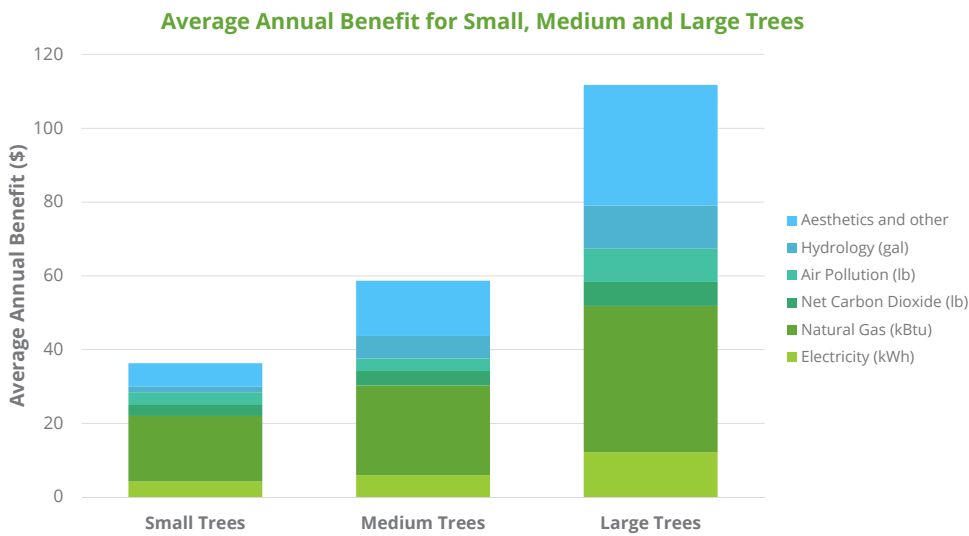


FIGURE 13: Average net benefits of small, medium, and large yard trees based on location.

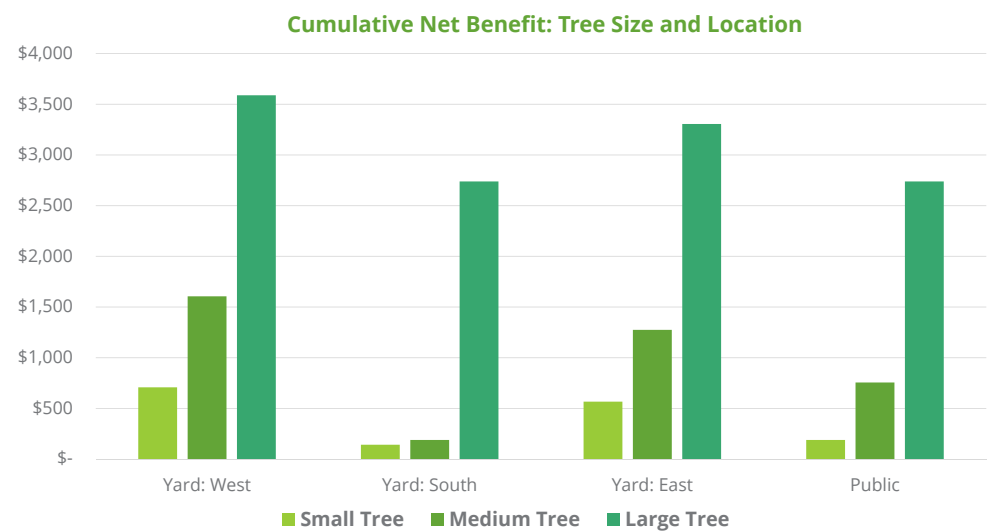


FIGURE 14: 40-year cost benefit analysis for tree planting project with 1500 trees in Detroit.

Spreadsheet calculations of benefits and costs for the Detroit planting project (1,000 public trees) over 40 years										
	500 Small Trees			500 Medium Trees			500 Large Trees			1500 Total Trees
	Average Annual Dollars	Resource Unit RU/tree/year	Total Value Dollars	Average Annual Dollars	Resource Unit RU/tree/year	Total Value Dollars	Average Annual Dollars	Resource Unit RU/tree/year	Total Value Dollars	Total Value Dollars \$/tree/year
Benefits										
Electricity (kWh)	4.26	48	85200	5.96	67	119200	12.17	136	243400	447800 7.46333333
Natural Gas (kBtu)	17.74	1534	354800	24.29	2099	485800	39.67	3430	793400	1634000 27.23333333
Net Carbon Dioxide (lb)	2.97	336	39400	3.91	444	78600	6.49	734	129800	267800 4.46333333
Air Pollution (lb)	3.47	8.99	69400	3.39	1.11	87800	9.01	2.59	180600	317800 5.29666667
Hydrology (gal)	1.58	292	33600	4.13	1129	122600	11.71	2142	234200	388400 6.47333333
Aesthetics and other	6.38	6.28	125600	14.95	14.95	299000	32.68	32.68	653600	1078200 17.87
Total Benefits			726000			1173000			2230400	4134000 68.9
Costs										
Tree and planting		\$/tree/year	Total \$		\$/tree/year	Total \$		\$/tree/year	Total \$	Total \$ \$/tree/year
Pruning		5.90	118030		5.90	118030		5.90	118030	354090 5.9015
Remove and dispose		17.75	355000		23.74	474800		24.33	486600	1356400 21.94
Pest control		3.58	71600		4.38	87600		5.85	117000	276200 4.60333333
Infrastructure repair		0.06	1,200.00		0.08	1,600.00		0.11	2,200.00	3400 0.05666667
Irrigation		1.03	20600		1.30	26000		1.75	35000	81600 1.36
Cleanup		0.06	1200		0.06	1200		0.06	1,200.00	3600 0.06
Liability and legal		0.04	800		0.05	1000		0.06	1200	3000 0.05
Admin and other		0.06	1200		0.11	2200		0.11	2200	5600 0.09333333
Total Costs		3.24	64800		4.07	81400		5.49	109800	256000 4.26666667
Net Benefit			654430			762230			872230	2298800 38.1215
Benefit-Cost Ratio			0.5320			1.80770			1.961770	1634110 30.5685
			1.144334284			1.48063062			2.559463143	

APPENDIX

A. Point Source Pollution Key	56
B. GIS Data Sources	56
C. Detroit General Service's Tree List	57
D. Case Studies	59

APPENDIX A

GIS Layers – Point Source Pollution Key

NAAQS shapefiles: <https://www.epa.gov/green-book/green-book-gis-download>

Key for Point Source Map			
Site #	Source	Site #	Source
1	Comprehensive Environmental Solutions	22	Sunoco Inc
2	Darling International Inc	23	Marathon Ashland Petroleum
3	Dearborn Industrial Generation	24	US Gypsum Company
4	BP Products North America	25	BASF Corporation
5	DTE River Rouge Power Plant	26	Crown Plating Co
6	US Steel Great Lakes Works	27	Honeywell
7	Carmeuse/River Rouge	28	National Steel Corp
8	Detroit WWTP	29	Fritz Products
9	Ford Motor Co	30	Fabricon Products
10	Ford Motor River Rouge Complex	31	EDW C Levy DO Plant 6
11	Ford Elm St Boiler House	32	Detroit Salt
12	Ford Motor Company - R&E and Elm St PP	33	Detroit Electro-Coatings Company
13	Severstal	34	IPMC Aquisition LLC
14	DTE Delray Power Plant	35	EDW C Levy Plant 1
15	St Mary's Cement	36	Reily Plating/Mlok Incorporated
16	Detroit Public Lighting - Mistersky Power	37	Kasle Steel Corp
17	Magni Industries	38	Ferrous Environmental Recycling Corp
18	Spartan Industrial	39	Coca Cola Bottling Co
19	Equilon Enterprises	40	Hispanic MFG/Gonzalez MFG
20	Owens Corning Trumbull Div	41	Carmeuse/Detroit Lime
21	Cadillac Asphalt Products	42	Daimler Chrysler - McGraw

APPENDIX B

GIS Data Sources

GIS data	Source
Detroit Zoning	Detroit Open Data Portal (2018)
Detroit Parcel Map	Detroit Open Data Portal (2018)
Land Cover	Southeast Michigan Council of Governments (SEMCOG, 2009)
Traffic AADT Maps	Michigan Department of Transportation (2018)

APPENDIX C

Detroit General Service's Tree List

SMALL TREES (Flowering ornamentals)

Scientific Name	Common Name
Cornus 'Cherokee Brave'	Dogwood
Cornus 'Cherokee Princess'	Cherokee Princess Flowering Dogwood
Cornus 'Rubra'	Pink Dogwood
Malus 'Cardinal'	Cardinal Crabapple
Malus 'Coralburst'	Coralburst Crabapple
Malus 'Prairifire'	Prairifire Flowering Crabapple
Malus 'Profusion'	Profusion Crabapple
Malus 'Royal Raindrops'	Royal Raindrops Crabapple
Malus 'Sargent Tina'	Sargent Tina Crabapple
Malus 'Golden Treat'	Golden Treat Crabapple
Malus 'Sugar Tyme'	Suger Tyme Crabapple
Malus 'Velvet Pillar'	Velvet Pillar Crabapple
Prunus serrulata 'Kwanzaan'	Kwanzan Cherry

MEDIUM TREES

Scientific Name	Common Name
Acer rubrum 'Autumn Flame'	Autumn Flame Red Maple
Acer rubrum 'Red Sunset'	Red Maple
Acer saccharum 'Green Mountain'	Green Mountain Sugar Maple
Acer x freemanii Autumn Blaze	Freeman Maple
Acer x fr Marmo	Freeman Maple
Aesculus x autumn. Splendor	Horse Chestnut
Aesculus x carnea briotti	Red Horse Chestnut
Carpinus betulus 'Fastigiata'	Fastigiata' European Hornbeam
Cercidiphyllum japonicum	Katsura Tree
Cercis canadensis	Eastern Redbud
Cercis canadensis 'Forest Paney'	Forest Paney Eastern Redbud
Cercis canadensis 'Hearts of Gold'	Hearts of Gold Easturn Redbud
Cladrastis kentucka	American Yellowwood
Pyrus calleryana 'Cleveland'	Cleveland Pear Tree
Quercus robur 'Regal Prince'	Regal Prince Oak

LARGE TREES

Scientific Name	Common Name
Gleditsia 'Skyline'	Skyline Honey Locust
Gymnocladus dioicus	Kentucky Coffeetree
Liriodendron tulipifera	Tulip Tree
Matasequoia glyptostroboides	Dawn Redwood
Platanus x 'Bloodgood'	Bloodgood London Plane Tree
Quercus alba	White Oak
Quercus bicolor	Swamp White Oak
Quercus macrocarpa	Bur Oak
Taxodium distichum	Baldcypress
Tilia Americana 'Redmond'	Redmond American Linden
Tilia cordata 'Greenspire'	Greenspire Littleleaf Linden
Tilia tomentosa 'Sterling'	Sterling Silver Linden
Ulmus 'Princeton'	American Elm
Ulmus 'Valley Forge'	Valley Forge American Elm
Ulmus 'New Harmony'	New Harmony Elm
Ulmus 'Independence'	Independence Elm
Ulmus x Cathedral	Cathedral Elm
Ulmus x Fronteir	Frontier Elm
Ulmus x homestead	Homestead Elm
Ulmus x New Horizon	New Horizon Elm
Ulmus x patroit	Patroit Elm
Ulmus x regal	Regal Elm

APPENDIX D

Vegetative Buffers:

Buffers are strips of land, vegetation or physical barriers located between sources of pollution (e.g., roadways) and homes, schools or other places where people spend time and may be exposed to air pollution. There are three main types of buffers that can be useful for reducing exposure to air pollution:

1. **vegetative buffers (i.e. green buffers)**

2. **sound walls**

3. **spatial buffers**

These buffers can be placed along roadways or around the perimeter of stationary pollution sites. They are often combined with spatial buffers, which are required amounts of distance between two conflicting areas. Vegetative buffers can be implemented through a city ordinance in different ways. A city can develop and employ a conflicting use chart, which matches different land uses or zones and requires a certain buffer, or it can target specific hotspots and require a buffer in those areas. Cities can also employ larger environmental initiatives that include increased canopy, planting manuals, and required street trees.

How do vegetative buffers work?

Vegetative buffers separate people from sources of pollution and filter pollutants from the air before they reach people. Buffers can reduce exposure to harmful air pollutants, such as ozone (O₃), particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and carbon monoxide (CO), by absorbing or trapping some of the pollutants, by displacing pollutants, and by physically separating people from emission sources like roadways. The purpose of this guide is to help you plan and install a vegetative buffer in your community.

Why is this important?

Living next to highly traveled roadways is associated with negative health outcomes. Many schools and childcare centers are located within a few hundred feet of highways, particularly in urban areas including Detroit. Air pollution from cars and trucks may negatively impact those who drive to work. In the City of Detroit an estimated 69,000 (about 10%) residents live within 150 meters about 500 feet) of a major freeway.

Planting additional trees in strategic locations in Detroit can improve air quality and health for city residents, and can also help to reduce adverse health effects associated with extreme heat events that can affect urban areas.

Where should buffers be built in Detroit?

Those who live, work, and spend time near major freeways could benefit from the implementation of buffers. Our report focuses on ordinances that would impact sites in Southwest Detroit, but further buffering work would be beneficial in other Detroit sites including:

- Ambassador Bridge and the future site of the Gordie Howe Bridge
- The new Industrial Park and Logistic Center in Eastside
- Schools near major roadways
- Truck and rail transfer stations, for example the Container Port on West Fort Street
- Along major freeways such as I94 and I75
- Along major traffic routes, such as Fort Street and Michigan Avenue

Designing Your Buffer:

There are many important design considerations and options for types of trees and shrubs. In order to get the complete range of benefits offered by vegetative buffers and ensure their long-term effectiveness, several factors should be accounted for. A variety of conditions such as the slope, soil roughness, plant height, strip width (or available area), soil type and rainfall intensity will change the effectiveness of vegetative buffers. These factors should be considered when selecting the location and type of vegetative buffer system.¹

Each buffer project and design is different, with a unique set of goals, site characteristics, and resources. Designing a successful buffer will depend on developing a clearly defined project goal and ensuring that the available resources (e.g. funding and staffing) and design plans (e.g. site appraisal; plant selection, placement, and maintenance) fit that goal.²

5 Steps to Designing your vegetative buffer:

STEP 1: Clearly identify your goal(s)

STEP 2: Identify location(s) where a buffer would be most beneficial, given the problem/goal and surrounding community

STEP 3: Assess site conditions by performing a site inventory

STEP 4: Identify which type of trees would best address the problem

STEP 5: Create a detailed work plan that links your goals, resources, costs and timeline

Details, such as physical location of the buffer, species selection, and maintenance regimen all influence the buffer's effectiveness in reducing air pollution. Paying careful attention to these details can also minimize potential undesirable characteristics such as impairing sight lines or increasing allergens and biogenic volatile organic compounds³

Key Design Considerations :

Buffers have been found to be most effective in trapping particulate pollutants. Review of a cross section of peer-reviewed studies identifies the following buffer characteristics that are most effective at filtering runoff and treating stormwater.

- Narrow buffers have also been shown to be effective in reducing particulate pollutants. One of the main purposes of buffers is to slow surface water movement, which then reduces the emission of pollutants, particularly particulate pollutants.
- Narrow strips of dense grass can function in this capacity and provide water quality benefits.⁴
- Narrow strips could also be used as vegetative barriers to slow pollutant movement in-field and control concentrated flow erosion. To maximize efficiency, wider buffers or a greater buffer area to source area ratio should be used.⁵
- Research has found a significant range in buffer performance, with reported sediment trapping efficiencies ranging from 41% to 100%.⁶
- Buffers that interact with shallow groundwater moving through the root zone have been found to remove nitrate. Nitrate-removal efficiency has been found to vary between 25% and 100%.⁷

¹ <https://seedinnovation.ca/wp-content/uploads/2017/11/Vegetative-Buffers-Whitepaper.pdf>

² CAPHE Toolkit

³ CAPHE Toolkit

⁴ Dabney, S. M. 2003. Erosion control, Vegetative. In Encyclopedia of Soil Science, 209-213. R. Lal, ed. New York, N.Y.: Marcel Dekker.

⁵ https://www.epa.gov/sites/production/files/2015-07/documents/2006_8_24_msbasin_symposia_ia_session4-2.pdf

⁶ https://lib.dr.iastate.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1580&context=abe_eng_pubs

⁷ Simpkins, W. W., T. R. Wineland, R. J. Andress, D. A. Johnston, G. C. Caron, T. M. Isenhardt, and R. C. Schultz. 2002. Hydrogeological constraints on riparian buffers for reduction of diffuse pollution: Examples from the Bear Creek watershed in Iowa, USA. Water Science and Tech. 45(9): 61-68.

Citation: CAPHE Resource Manual: Buffers and Barriers

Width The determination of buffer widths on individual wetlands could be based on the following minimum guidelines:

1. 50 feet for reduction of human impact
2. 50 to 100 feet for overall water quality protection
3. 50 to 200 feet for habitat protection and species diversity.⁸

Plant Selection:

Different plant species are suited to grow in different climates. In the Detroit area, the plant hardiness zone ranges from 6a to 6b. When selecting your plants compare their hardiness zone to that of Detroit's. In general, plants from hardier zones can survive in our zone. However, plants from zones with numbers higher than 6 are less likely to survive. Climate change is also a consideration and the US Forest Service has an atlas that identifies appropriate species under changing climate conditions, see: US Forest Service Atlas⁹.

Plant selection criteria for air pollutant removal:

- Evergreen trees can remove more pollutants; however, many conifer species are sensitive to common pollutants.
- Select plants with dense branching and twig structure.
- Leaves with hairy, resinous, and coarse surfaces capture more particles than smooth leaves. Smaller leaves are generally more efficient collectors than larger leaves.
- Herbaceous species may adsorb more gaseous pollutants.
- Use multiple species to minimize risks with low diversity.
- Use long-lived species that require minimal maintenance.
- Use trees, shrubs, and grasses for multi-level trapping
- Plant buffers in energy conserving locations.
- Select species with pest and disease resistance.
- Select species suitable for the site (e.g., urban environments often have compacted and droughty soils).

*** Consider porosity and density of the tree, which may be assessed using Leaf Area Index and Leaf Area Density.**

What species can be easily maintained in MI?

Some examples include Dogwood, Pink Dogwood, Cardinal Crabapple, Coralburst Crabapple, Prairifire Flowering Crabapple, Red Maple, and Frontier Elm¹⁰

What species is cost effective?¹¹

⁸ https://stormwater.pca.state.mn.us/index.php?title=MS4_fact_sheet_-_Vegetated_Swales_%26_Buffer_Strips

⁹ CAPHE Toolkit

¹⁰ See Detroit Tree List

¹¹ See Cost Benefit Analysis in report

Maintenance:

In order to leverage the complete range of benefits offered by vegetative buffers and ensure their long-term effectiveness, a number of factors should be taken into account. Several conditions such as the slope, soil roughness, plant height, strip width (or available area), soil type and rainfall intensity will change the effectiveness of vegetative buffers.¹²

Generally, plants will need more water when they are getting established (1-3 years). Little to no growth will occur within one year of planting as the tree acclimates to its new surroundings. Different soil types absorb and hold moisture differently

so watering schedules need to consider the soil type and conditions. Sandy soils quickly absorb moisture but don't retain water for long. Therefore, trees planted in sandy soil would require more frequent watering. Most trees thrive in well-drained, loamy soils. If the soil is largely clay and is poorly drained (too wet) this can kill the tree. Assess the drainage conditions at your planting site, as well as how much water your site receives each week to determine how much watering (if any) will be required. Anticipate a weekly soaking and possibly two if summer conditions are dry.¹³

Questions that you should ask after planting a buffer:

How will you maintain the trees and plants?

Who will water, fertilize, and prune the tree in the first year after planting and then as needed once the tree is established?

Maintenance is essential to ensure that a vegetative buffer functions properly over time.

Some of the maintenance suggestions include:

- Regular mowing of grass
- Removal of garbage, debris, and dead plant material at least once a year
- Regularly inspect for erosion and proper infiltration
- Remove sediment build-up as needed
- Replace any damaged or dead plants as needed

Typical buffer maintenance activities include:

- Removal of accumulated pollutants or trash
- Weed control or other tasks to maintain healthy vegetation
- Aeration or other mitigation to maintain the high pervious quality of the soil¹⁴

¹² <https://seedinnovation.ca/wp-content/uploads/2017/11/Vegetative-Buffers-Whitepaper.pdf>

¹³ CAPHE Toolkit

¹⁴ https://stormwater.pca.state.mn.us/index.php?title=MS4_fact_sheet_-_Vegetated_Swales_%26_Buffer_Strips

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