Vegetative Buffer Toolkit

Using Trees to Improve Air Quality in Detroit

February 2018

Created by: Community Action to Promote Healthy Environments

Community Action to Promote Healthy Environments (CAPHE) is a partnership between academic, community, and governmental organizations working together to identify, and create solutions for, Detroit's air quality challenges. CAPHE builds on 20 years of community-academic research partnerships in Detroit. Members from these long-standing partnerships serve on CAPHE's Core Team, Steering Committee and Public Health Action Team. This structure promotes collaboration and shared decision making at all levels of the CAPHE project, ensuring Detroit residents will have a significant voice in identifying and creating solutions to Detroit's air pollution problems.

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Community Action Against Asthma

Healthy Environments Partnership

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greendoor initiative

CONTRIBUTORS

Kristina Rice
Project Manager
Community Action to Promote Healthy Environments
School of Public Health
University of Michigan

Rebecca Weiland
Research Assistant
School of Public Health
University of Michigan

Dr. Larissa Larsen
Associate Professor
Urban and Regional Planning and Natural Resources
University of Michigan

Eric Krohngold
Research Assistant
Urban and Regional Planning
University of Michigan

Ricardo DeMajo
Database Analyst
School of Public Health
University of Michigan

Dr. Amy Schulz
Professor
Health Behavior & Health Education
School of Public Health
University of Michigan

Dr. Graciela Mentz
Database Analyst
Health Behavior & Health Education
School of Public Health
University of Michigan

CONTRIBUTORS

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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 and,
3) spatial buffers

This manual provides a basic introduction to vegetative buffers, with a particular emphasis on the use of vegetative buffers along roadways. The purpose of this guide is to provide easy to use information that will help you plan and install a vegetative buffer in your community.

There are many important design considerations and options for types of trees and shrubs. The primary purpose of this handbook is to support Detroit-based organizations and community members when implementing buffer projects in their areas. The same general principles may apply in other urban communities in temperate climates.

WHAT IS A VEGETATIVE BUFFER?

Vegetative buffers are trees, shrubs and herbaceous cover that are planted around pollution sources, or between pollution sources and people. Vegetative buffers separate people from sources of pollution and filter pollutants from the air before they reach people. The majority of pollutants collect on bark or leaf surfaces (to either be recirculated later or dropped by leaf-fall and twigs) with a small amount of air pollution being absorbed through the plant's stomata (small openings largely on the underside of the leaf) into the leaf. Vegetative buffers also can reduce temperatures by shading structures, thus reducing energy use. (1)

Buffers can reduce exposure to harmful air pollutants, such as ozone (O_3), particulate matter (PM), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and carbon monoxide (CO), by absorbing or trapping some of the pollutants (2), by displacing pollutants, and by physically separating people from emission sources like roadways. Estimates of the effectiveness of trees and tree canopies in removing pollutants depend on many factors, including the pollutant and density of the canopy: estimates range from under 1% to about 13%. (3,4,5)

Health Benefits of Vegetative Buffers

Vegetative buffers alongside roads have the potential to reduce the concentration of pollutants from vehicle emissions and can reduce the likelihood of:

- respiratory diseases such as asthma
- lung irritation, coughing, and difficulty breathing;
- lung diseases;
- heart attacks, irregular heartbeat, and cases of cardiovascular disease;
- low birth weight infants; and
- cancer (6,7,8)

CAPHE estimates that in 2014-2015 there were approximately 58 public schools, with an estimated 24,490 students, within 200 meters of large highways that have heavy diesel traffic. (9)

Co-Benefits of Vegetative Buffers

In addition to the many physical health benefits of vegetative buffers, they also have important environmental impacts. Vegetation can reduce temperatures by shading structures, reducing overall energy use. (10) They provide a valuable mode of noise pollution reduction, dampening sound in surrounding areas such as nearby native ecosystems, neighborhoods, and schools.

Vegetation provides an important service to society by storing and sequestering large amounts of carbon, removing it from the atmosphere. Roadside vegetation management practices that promote natural vegetation may also be extremely important in conserving native plant species and providing wildlife habitats and migration corridors. Increasing the plant and animal biodiversity of our urban communities is particularly important in highly altered landscapes, such as those within Detroit.

Installing vegetative buffers can also help improve mental health and well-being, reduce the number of heat-related deaths, improve a community's overall aesthetic appeal, and provide enhanced opportunities for people to engage in physical activity and exposure to nature. (11)


The Dequindre Cut

The Dequindre Cut Greenway

The Dequindre Cut Greenway is an urban recreational path that opened to the public in May of 2009, and expanded in 2016. The original two-mile greenway was developed through a partnership between the federal government, the City of Detroit, the Community Foundation for Southeast Michigan, and the Detroit Economic Growth Corporation. The Greenway offers a pedestrian link between the East Riverfront, Eastern Market and several residential neighborhoods. (12)

Greenways are vital corridors for re-establishing green infrastructure, reconnecting open space, and providing outdoor recreation. In 2006, it was estimated that by expanding the Dequindre Cut Greenway's tree canopy from 31% to 40%, the greenway would remove an additional 1,000 pounds of Detroit's' air pollution annually. (13)

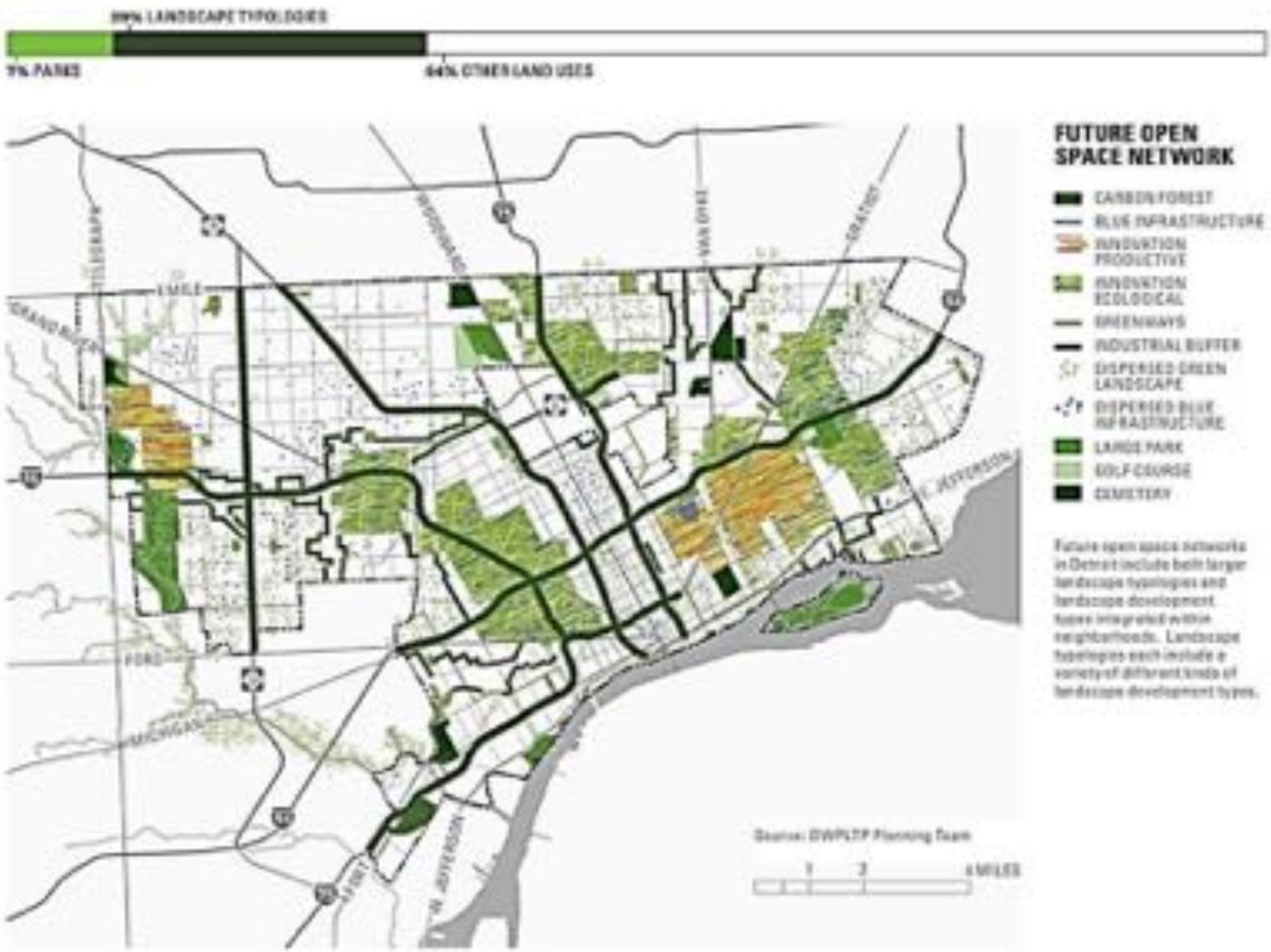
In 2006, a Detroit public workshop sketched out a citywide greenways vision. Assuming a 150 foot vegetative buffer, it was estimated that Detroit's envisioned 3,250 acre network of greenways would increase the tree canopy from 19% to 25% and remove 16,000 pounds of air pollution annually. (14)

Marathon Gardens Park

Marathon Petroleum Company (MCP) completed a property purchase program in Southwest Detroit, with the intent of developing a 100-acre "green space." The area falls between the company's refinery and the Rouge River in the most heavily industrialized area of Detroit, encompassing a residential area known as Oakwood Heights. The urban development firm PEA was engaged by Marathon to assist in developing the green space vision plan.

The project became known as "Marathon Gardens" and was vetted through numerous community venues for public input. Program development includes the following elements: wildlife habitat restoration, urban agriculture, park -like landscape and riverfront greenspace with public amenities. A first phase of implementation initiated habitat restoration on three acres and a community-driven urban farming project. (15)

CASE STUDIES


FUTURE OPEN SPACE NETWORK
CARBON FOREST
BLUE INFRASTRUCTURE
INNOVATION PRODUCTIVE
INNOVATION ECOLOGICAL
GREENWAYS
INDUSTRIAL BUFFER
DISPERSED GREEN LANDSCAPE
DISPERSED BLUE INFRASTRUCTURE
LARGE PARK
GOLF COURSE
CEMETERY

Detroit Future City Open Space Plan

The 2012 Detroit Future City Strategic Framework created a comprehensive, 50-year vision for addressing the city's economic and redevelopment challenges and opportunities. The Framework calls for a significant portion of the city's vacant land to be transformed into open space. These envisioned open spaces would be critical assets for the city, creating an interconnected ecological system that maximizes the value of Detroit's large inventory of vacant land. Detroit Future City prioritizes forests as an effective use of open space and is examining the use of forest buffers along transportation corridors. (16)

Spatial buffers can reduce concentrations of pollutants from local Detroit sources by as much as 80% when sufficient distance is provided between ground level sources of pollution (such as vehicles) and people.(17)

There is no one recipe for planning and planting a vegetative buffer. Each project differs, 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. If the buffer is adjacent to areas where people live, and will impact the neighborhood aesthetics, it should be designed through an informed, collaborative process that engages both community members and technical experts.

5 Steps to Designing a Vegetative Buffer

Step 1: Clearly identify your goal(s) (see *Appendix i for goals and inventory worksheet)*

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 workplan 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 compounds (BVOCs).

DESIGNING YOUR BUFFER

Step 1: Clearly identify your goal(s)

- What functions can the buffer serve?
    - Is the only goal to mitigate air pollution?
    - Do you also want to impact noise?
    - Do you want to create a visual barrier?
    - Do you want your trees to aid in water retention?
- What air pollution sources is the buffer intended to reduce? (e.g. roadway pollution, point sources from an industrial land use, etc?)

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

- Where should buffers be prioritized? Who is most vulnerable in the community? (e.g. schoolchildren, residents, workers, etc.)?
- Who owns the land? Do you plan to plant the trees on private property, city property, along a roadway that is owned by the city/state/etc?

Step 3: Assess site conditions by performing a site inventory

Assess four important site conditions before embarking on a buffer project: **soil conditions, space, exposure and maintenance.**

Soil Conditions

- What are the **soil conditions**?
- Is there enough soil available of sufficient quality to support mature tree growth and does the soil have sufficient organic matter?
- Does the soil have a neutral (or base) ph level?

Soil is composed of sand, silt, and clay. Desirable soils for plant growth contain a mixture of the three (seeking a loamy consistency) and possess some organic matter. Michigan State Extension offers inexpensive soil testing ($25). They can evaluate your site's soil for texture, fertility, salinity, and pH to determine which plants are best suited to your soil or what soil amendments should occur before planting. Evaluate your soil's conditions and the extent to which it is disturbed (e.g. nutrient deficient, shallow, compacted, and/or subject to drought). If you are working with highly disturbed soil, as is common in urban areas, consider more resilient plants and soil amendments (adding organic matter, nutrients or different soil types to alter soil composition)

Space

- Is a small, medium, or large tree best suited for the location and **available space**?
- Do overhead or belowground utilities preclude planting a large tree (or any tree at all)?
- What clearance is needed for sidewalks, patios, or driveways? (Generally, you should keep 8 feet below the tree clear for safe passage for pedestrians and cyclists.)

Select trees that will be appropriate for your space. Consider site constraints such as overhead or underground utilities, pavement, buildings, roads, neighboring trees, and visibility, among others. Oak trees, while a native species, have a dominant tap root and therefore may not be suited for shallow beds. For most trees, the majority of their roots are located within the top 18 inches of the soil. It is important that compaction around the root zone is avoided as air needs to pass through the soil to the roots.

Step 3: Assess site conditions by performing a site inventory

Exposure

- What type of sun exposure does the site have?
- Is the site windy?
- If the site is along a road, will there be exposure to salt due to road maintenance in winter months?

Some tree and plant species grow best in full sun while others prefer shade or partial sun. Wind is also a consideration as excessive wind may dry out soil or damage leaves and branches. Many vegetative buffers along roadsides must tolerate salt and this alters your species selection. See Tables 1-4, pages 34-39 for a list of species we have identified that are best suited for different sun, moisture, and salt conditions.

Maintenance

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

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.

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

Plant Selection

- Which trees are appropriate for your soil conditions, space, exposure and maintenance needs?

Careful and informed plant selection is an important part of the buffer design process. Choosing the correct trees for the job will allow you to grow a healthier, stronger plant and create a more effective buffer. When considering plants, you must again remember to take into account factors such as your project purpose, budget, resources (including availability of personnel to provide site and plant maintenance), and various site characteristics unique to your location. Please see Table(s) 1-4, pgs. 34-39, which combines local standards with scientific research on species specific characteristics to aid you in selecting your trees.

Plant Hardiness

- What is Detroit's climate?

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 (example zone 5) 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 Atlas.

Consider the following plant selection tips for air pollutant removal:

- Evergreen trees can remove pollutants year round, however many conifer species are sensitive to common pollutants.
- Plants with dense branching and twig structure will remove more pollutants.
- Leaves with hairy, resinous, and coarse surfaces capture more particles than smooth leaves.
- Smaller leaves (with more leaf area) are generally more efficient collectors than larger leaves.
- Herbaceous species (native grasses or prairie plants) may absorb more gaseous pollutants.
- Use of multiple species will help protect against invasive pests or diseases.

- Use of long-lived species that require minimal maintenance will help your buffer survive over time.
- Species suitable for the site (e.g., urban environments often have compacted and droughty soils) will help the buffer survive and thrive over time.

Table 1: Small Deciduous Trees* (mature height less than 30 feet) (18)									
Common Name	**Latin Name**	**Native to MI**	**Suitable for sites w/ Overhead Utilities**	**Tolerates Wet Sites**	**Drought Tolerant**	**Prefers Well-Drained Sites**	**Salt Tolerant**	**Pollutant Removal**	**BVOC Emission**
Eastern Redbud	*Cercis canadensis*	X	X	X	X			PM	
Japanese Tree Lilac	*Syringa reticulate 'Ivory Silk'*		X	X	X		X	PM	
Kwanzan Cherry	*Prunus serrulata 'Kwanzan'*		X	X			Moderate	PM	

Table 2: Medium Deciduous TREES* (mature height 25-40 feet) (18)									
Common Name	**Latin Name**	**Native to MI**	**Suitable for sites w/ Overhead Utilities**	**Tolerates Wet Sites**	**Drought Tolerant**	**Prefers Well-Drained Sites**	**Salt Tolerant**	**Pollutant Removal**	**BVOC Emission**
American Hophornbeam	*Ostraya virginiana*	X	X		X			PM	
English Oak	*Quercus robur*		X		X		X	PM	X
European Hornbeam	*Carpinus betulus*				X			PM	

Table 3: Shrubs* (between 3-6 feet tall) (19)									
Common Name	**Latin Name**	**Native to MI**	**Suitable for sites w/ Overhead Utilities**	**Tolerates Wet Sites**	**Drought Tolerant**	**Prefers Well - Drained Sites**	**Salt Tolerant**	**Pollutant Removal**	**BVOC Emissions**
Buttonbush	*Cephalanthus occidentalis*	X	X	X					
New Jersey Tea	*Ceanothus Americanus L.*	X	X		X	X			
Shrubby Cinquefoil	*Dasiphora Fruticose*	X	X		X	X			
Bush Honeysuckle	*Diervilla lonicera*	X	X		X	X			

Table 4: Large Deciduous Trees* (mature height greater than 40 feet) (18)									
Common Name	**Latin Name**	**Native to MI**	**Suitable for sites w/ Overhead Utilities**	**Tolerates Wet Sites**	**Drought Tolerant**	**Prefers Well - Drained Sites**	**Salt Tolerant**	**Pollutant Removal**	**BVOC Emission**
American Elm	*Ulmus americana*	X		X	X		X	PM	
American Beech	*Fagus grandifolia*					X		Ozone, NOx, SO2	
American Linden	*Tilia americana*	X			X	X		PM, Ozone,	
American Sycamore	*Platanus occidentalis*	X		X	X		Moderate	PM, SO2	X
Bald Cypress	*Taxodium distichum*			X	X		X	PM	
Big Leaf Linden	*Tilia platyphyllos*			X		X		Ozone	
Blackgum (Sourgum)	*Nyssa sylvatica*	X		X	X		Moderate	PM	X
Black Walnut	*Juglians nigra*	X			X	X		PM	
Common Beech	*Fagus sylvatica*					X		Ozone	
Dawn Redwood	*Metasequoia glyp-tostroboides*			X	X			PM, Ozone, Sulfur, Nitrogen Dioxide	
European Linden	*Tilia x europaea*					X		PM, Ozone, SO2	
Ginkgo	*Ginkgo biloba*				X		Moderate	PM	
Hackberry	*Celtis occidentalis*	X		X	X		Moderate	PM	
Honeylocust	*Gleditsia triacanthos*	X		X	X		X	PM	

Table 4: Large Deciduous Trees* (mature height greater than 40 feet) (18)

Common Name	Latin Name	Native to MI	Suitable for sites w/ Overhead Utilities	Tolerates Wet Sites	Drought Tolerant	Prefers Well-Drained Sites	Salt Tolerant	Pollutant Removal	BVOC Emission
Japanese Pagodatree	*Sophora japonica*			X	X			PM	
Japanese Zelkova	*Zelkova serrata*			X	X			PM	
Littleleaf Linden	*Tilia cordata*					X		PM	
London Planetree	*Platanus x acerifolia*			X	X		Moderate	PM, SO2,	X
Northern Red Oak	*Quercus rubra*	X			X	X		PM	X
Paper Birch	*Betula papyrifera*			?		X		Ozone	
Red Maple	*Acer rubrum**	X						PM	
Silver Linden	*Tilia tomentosa*				X			PM	
Sugar Maple	*Acer saccharum**	X		X		X		PM	
Sweetgum	*Liquidambar styraciflua*			X	X		X	PM	X
Tuliptree (Yellow Poplar)	*Liriodendron tuli-pifera*	X		X				PM, Ozone, SO2	
Turkish Filbert	*Corylus colurna*				X			PM,	
Yellow Birch	*Betula alleghaniensis*					X		Ozone	

Table 5: Conifers (20)									
Common Name	**Latin Name**	**Native to MI**	**Suitable for sites w/ Overhead Utilities**	**Tolerates Wet Sites**	**Drought Tol-erant**	**Prefers Well-Drained Sites**	**Salt Tolerant**	**Pollutant Removal**	
Blue spruce	*Picea pungens*				X	X	Salt Spray - moderately tolerant - Soil Salt - tolerant	PM	X
Chinese Juniper	*Juniperus chinensis*				X	X	Salt Spray - tol-erant - Soil Salt - intolerant	PM	
Douglas Fir	*Pseudotsuga men-ziesii*				Intolerant	X	Salt Spray - In-tolerant - Soil Salt - Tolerant	PM	
Eastern Red Cedar	*Juniperus virginiana L.*	X			X	X	X	PM	
Eastern White Pine	*Pinus strobus*	X				X	No	PM	
Eastern/Canadian Hemlock	*Tsuga canadensis*	X			Moderately	X	Intolerant	PM	
Northern White Cedar (aka Eastern Arborvitae)	*Thuja occidentalis*	X			Moderately	X	Salt Spray - moderately tolerant - Soil Salt - tolerant	PM	

Table 5: Conifers (20)									
Common Name	**Latin Name**	**Native to MI**	**Suitable for sites w/ Overhead Utilities**	**Tolerates Wet Sites**	**Drought Tolerant**	**Prefers Well-Drained Sites**	**Salt Tolerant**	**Pollutant Removal**	
Norway Spruce	*Picea Abies*				Intolerant		Moderate	PM	X
Scots Pine	*Pinus sylvestris*				Moderately tolerant	X	Salt Spray - tolerant - Soil Salt - intolerant	PM	X
Leland Cypress	*Cupressocyparis x leylandii*					X		PM	
Red Spruce	*Picea rubens*					X		PM	

*BVOCs are biogenic volatile organic compounds emitted by some species of trees, and are ozone percursors. Ideal scenarios favor low-emitting species.

All information in these tables was adapted from the following sources: 1- the City of Ann Arbor Approved Tree Species List, 2) the i-tree catalog, and 3) "Ranking the suitability of common urban tree species for controlling PM 2.5 pollution, and 4) a literature review of trees and their potential to remove air pollutants (i.e. Larissa's draft table)

Step 5: Create a detailed workplan that links your goals, resources, costs, and timeline

- How much time and money will the project the project will require?
- What resources do you have?
    - What is your budget?
    - Do you have staff and/or volunteers?
    - What resources you will need to secure from outside sources?
- Can you identify potential funding sources for both installation and maintenance?

DESIGNING YOUR BUFFER: STEP 5

Potential Funding Sources for Vegetative Buffer Projects

- **CAPHE Mini Grants** are available in Spring 2018 to support community buffer projects and tree planting initiatives aimed at improving local air quality. See: Take Action in Air Quality Mini-grant
- The **Arbor Day Foundation's TD Green Streets Grant program**. Through the TD Green Streets Grant program, municipalities are eligible to receive one of ten $20,000 grants in support of local forestry projects in low- to moderate-income neighborhoods. See: Green Streets Grant
- The **Michigan Department of Natural Resources** and the **DTE Energy Foundation** are awarding grants totaling $159,825 to 41 Michigan communities for local tree-planting projects. See: Grants
- **The Michigan Department of Natural Resources** awards **Community Forestry Grants** to provide information and technical assistance to municipal governments, schools, nonprofit organizations and volunteer groups for urban and community forest activities such as tree inventories, management plans, planting and other maintenance activities. See: Community Forestry Grants

- **American Forests** and **Bank of America Partners** have partnered to provide a $250,000 grant to fund Community ReLeaf, an assessment of urban forests and climate change in five U.S. cities, including Detroit, see: Community ReLeaf Grants

- The **Alliance for Community Trees**, a national nonprofit dedicated to improving the health and livability of cities by planting and caring for trees, awards various grants (e.g. Community Tree Planting Grants and NeighborWoods® Grants) to fund urban forestry projects, see: Community Tree Planting Grants

- The **USDA Forest Service's National Urban and Community Forestry Challenge Grants** are awarded annually to state governments, nonprofits, or educational entities who demonstrate how healthy urban forests can increase public health benefits, improve development and redevelopment efforts, and contribute to urban food production.

- **Urban and Community Forestry Grants** are awarded by many state governments to help assist municipalities and local units of government in developing, managing and sustaining local community forestry programs

Implementing vegetative buffers along roadways in the City of Detroit could benefit public health, safety, and the environment. While there is an abundance of literature on the effectiveness of buffers to mitigate air pollution and act as windbreaks, little guidance exists as to best practices in physical buffer design and plant composition. Currently, there are few design standards adapted specifically to different types of roadways found throughout the City of Detroit, and little information on which design could work best in Michigan's climate. On the following pages we offer tips and guidelines to help guide decisions related to vegetative buffers along roadways.

Properly installed windbreaks (i.e., continuous rows of trees or shrubs planted to provide a wind barrier) can lower concentrations of CO and $PM_{2.5}$ generated by vehicles by 12-40%.(18)

10% (about 69,000) of Detroit residents live within 150 meters (about 500 feet) of a major freeway.(19)

Three primary road types typical in Detroit are appropriate locations for vegetative buffers; freeways, arterial roads, and collector roads. These three road types see the highest volumes of vehicle traffic. Local roads were omitted because they typically see low volumes of daily traffic.

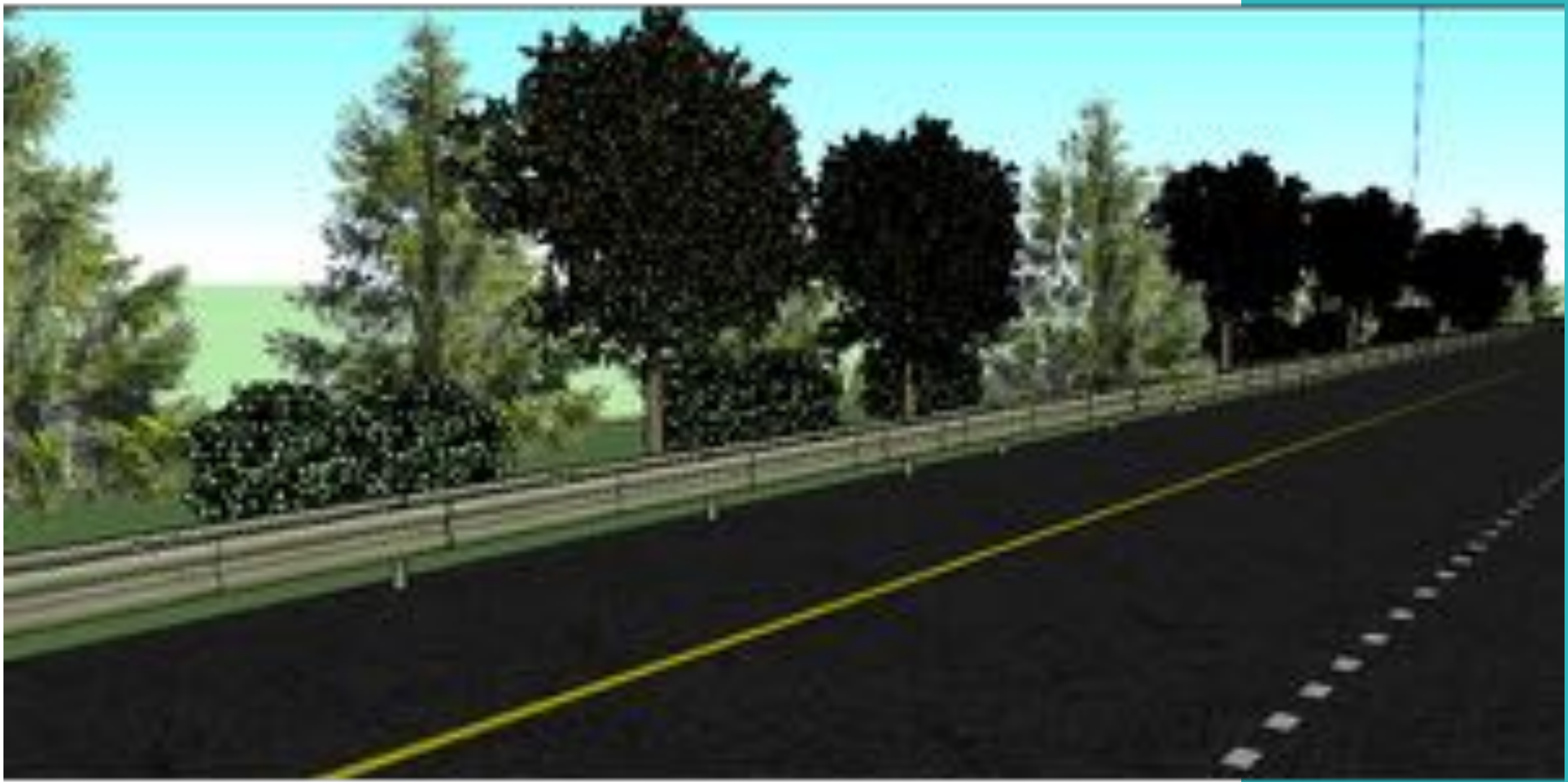
We recommend designs that include both woody shrubs and trees to capture pollution at different levels along the roadway. The following design examples attempt to maximize the density of each buffer and its effectiveness, while also allowing for easy maintenance and upkeep.

Vegetative Buffers along Freeways and Interstates

This roadside buffer design is meant to be compatible with most freeways or highways. The goals of this design are to capture ground level pollutants as well as pollutants that get swept higher in the air. Combining conifer and deciduous trees increases the likelihood that individual plantings will survive. Additionally, mixing tree types increases the effectiveness of the buffer during winter, when many of the deciduous trees will have shed their leaves.

- Width: 25' – 28'
- Rows of Plantings: 3
    - 1st Row: Tree Planting
    - 2nd Row: Shrub Planting
    - 3rd Row: Tree Planting
- Tree Height: 10' or higher
- Offset Each Row: 3'
- Shrub Height: Less Than 4'
- Space Between Each Planting: Roughly 10' – 20'
- Space Between Each Row: 6'-8'

Recommended planting order for Row 1 and 3: 2- 3 Deciduous trees, 2 - 3 Conifer trees, 2 – 3 deciduous trees, 2 - 3 conifer trees, repeated. Trees should be planted in succession with 10-15' between them.



Vegetative Buffers along Arterial Roads

The goal of the design for arterial roadside buffers is to capture ground level pollutants as well as pollutants that get swept higher in the air. Combining conifer and deciduous trees increases the likelihood that individual plantings will survive. Additionally, mixing tree types increases the effectiveness of the buffer during winter when many of the deciduous trees will have shed their leaves. This buffer design also acts as physical barrier, separating pedestrians from vehicle traffic.

Arterial Road Buffer Design

- Width: 15' - 18'
- Rows of Plantings: 2
    - 1st Row: Tree Planting
    - 2nd Row: Shrub Planting
- Tree Height: 10' or higher
- Shrub Height: Less Than 4'
- Space Between Each Planting: Roughly 10' – 20'
- Space Between Each Row: 6'-8'

Recommended planting order for Row 1: 2- 3 Deciduous trees, 1 - 2 Conifer trees, 2 – 3 deciduous trees, 1 - 2 conifer trees, repeated. Trees should be planted in succession with 10-15' between them.

Vegetative Buffers along Collector Roads

This roadside buffer design is compatible with most collector roads. Most collector roads do not have a shoulder, which reduces the distance between the pollutant source and the buffer. Shrubs can be the most effective means of capturing pollutants in these scenarios. Trees can be added in intermittently, though their presence will not significantly alter the effectiveness of the buffer. Similar to the arterial roads buffer, this buffer is meant to act as physical barrier, separating pedestrians from vehicle traffic.

Collector Road Buffer Design A

- Width: 8' – 12'
- Rows of Plantings: 1
- 1st Row: Shrub Planting
- Shrub Height: Less Than 4'
- Space Between Each Planting: Roughly 3-6'

Recommended planting order: Shrubs should be planted in close proximity to one another to minimizing space between them. Plant in a uniform line with minimal breaks or unnecessary offsets.

Collector Road Buffer Design B

- Width: 8’ – 12’
- Rows of Plantings: 1
- 1st Row: Shrub Planting with intermittent tree planting
- Shrub Height: Less Than 4’
- Space Between Each Planting: Roughly 3-6’

Recommended planting order: Shrubs should be planted within close proximity to one another with the goal of minimizing space between them. Every 10’ – 15’ a tree may be planted instead of a shrub. Tree plantings should be a mix of deciduous and conifer trees. They should be planted in a mostly uniform line with minimal breaks or unnecessary offsets.

PRIORITY TREE PLANTING AREAS

Prioritizing specific tree-planting sites within the City of Detroit is important, and site prioritization can enhance air pollution removal. The following section provides several criteria to consider when deciding where to plant trees.

PRIORITY TREE PLANTING AREAS

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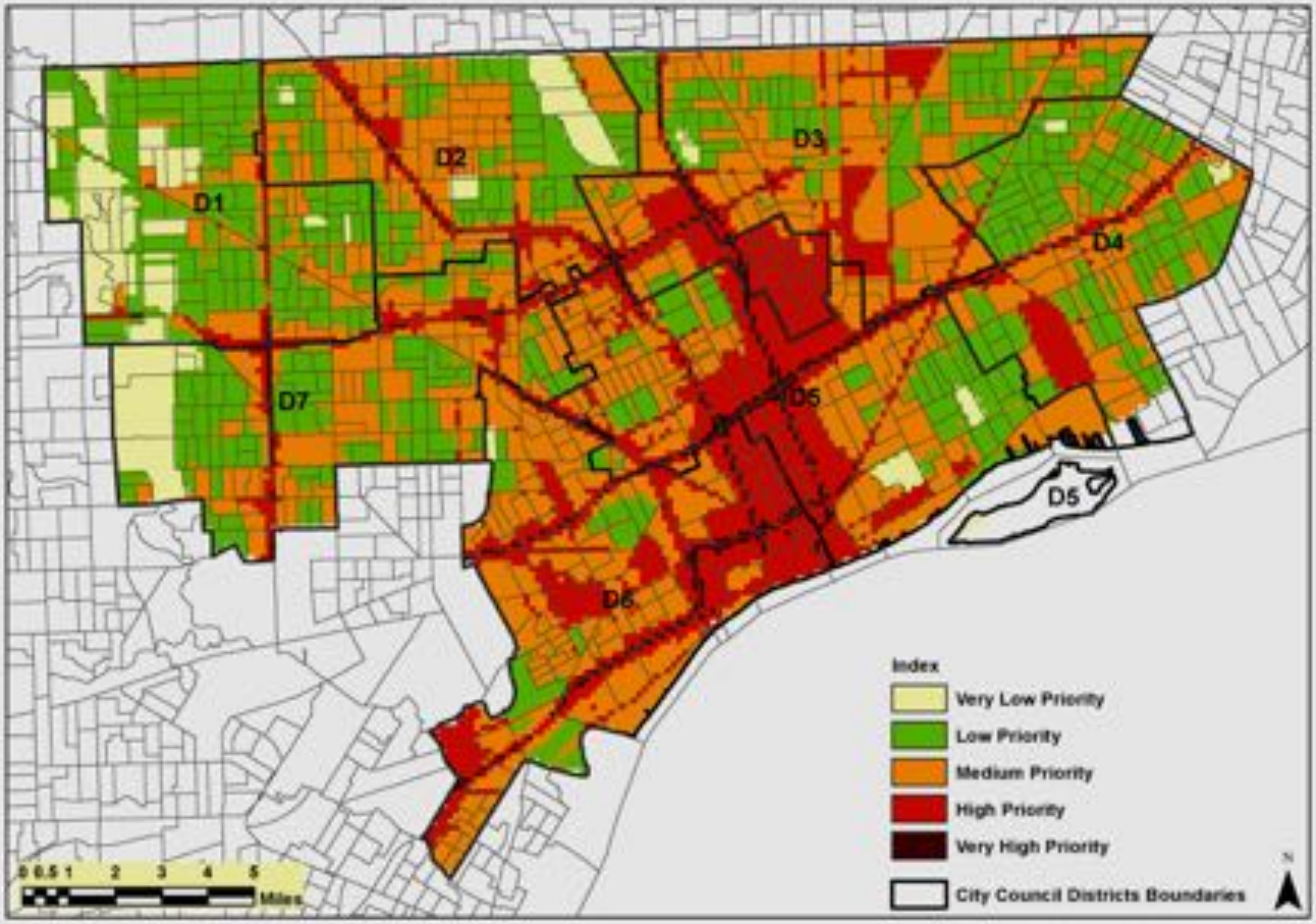
Based on an approach conducted in New York City in 2011, CAPHE created an index that prioritizes tree planting areas in the City of Detroit. The index contains three spatial layers of information including pollution concentration (for $PM_{2.5}$ and NO_2), population density, and lack of tree canopy. Figure 1 provides results from this analysis, ranging from very low priority tree planting areas, to very high priority tree planting areas. The findings from this study help identify specific locations for tree planting, including information on tree species and on where impervious surfaces may limit planting (What number? Quantifying the Protective Effect of the Urban Tree Canopy on Mortality Related to Particulate Matter Air Pollution in Metropolitan Detroit).

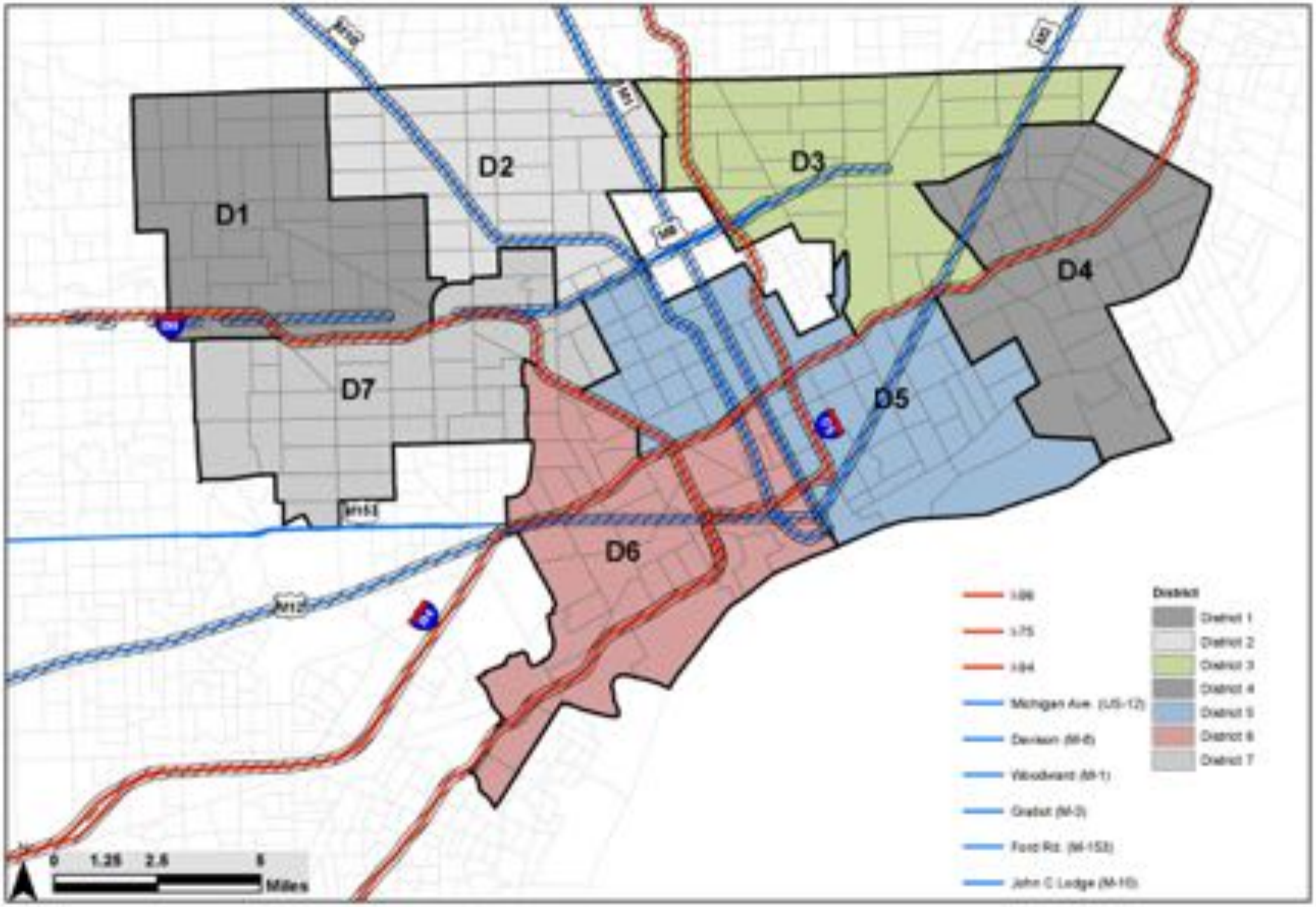
Figure 1 : Prioritized Tree Planting Areas to Enhance Vehicular Air Pollution Removal



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public Health).

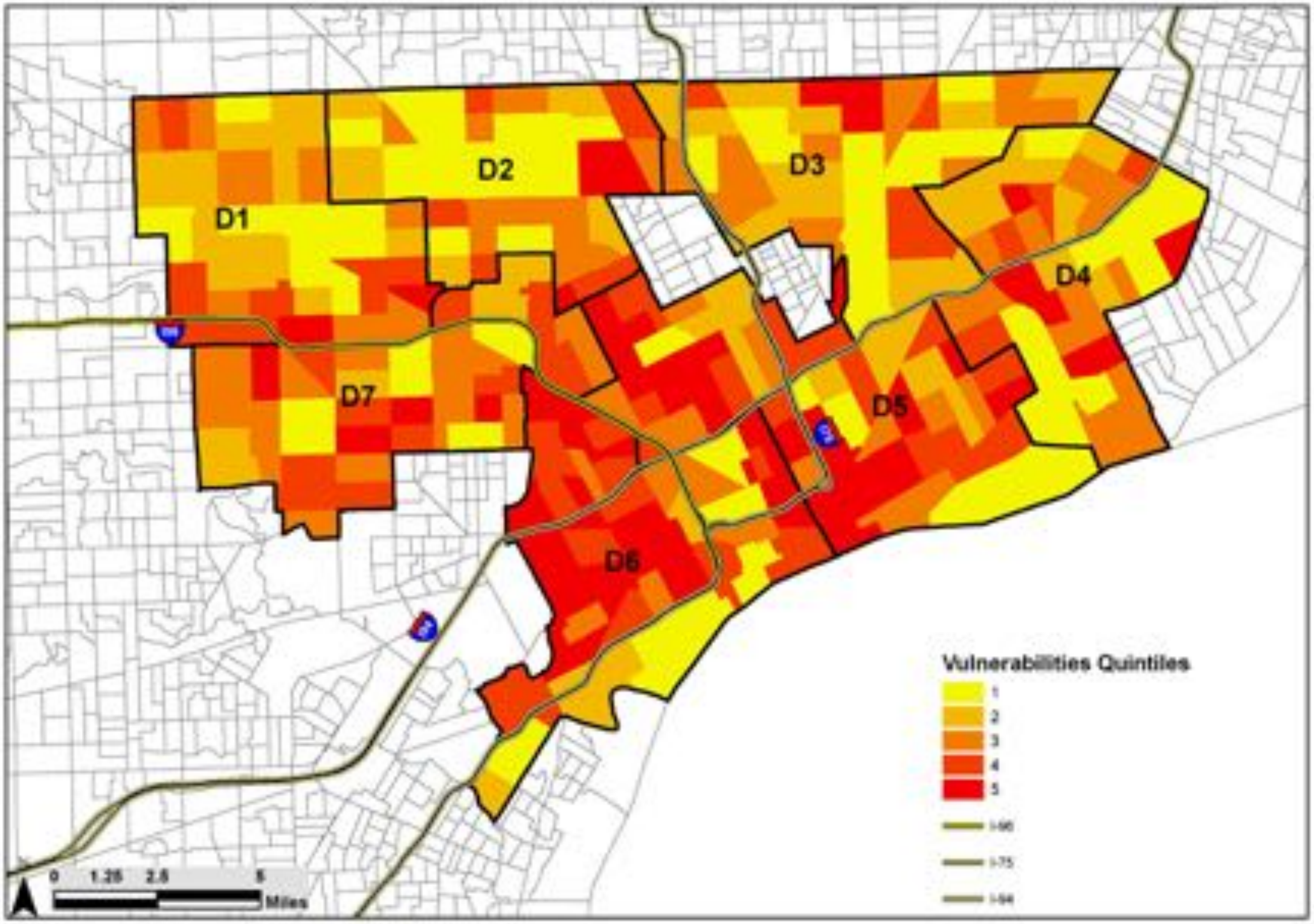
Figure 2: 500 Foot Spatial Buffers Along Major Roadways in Detroit



CAPHE estimates that if all Detroit residents lived beyond 500 feet (150 meters) from a major freeway, there would be 9-10 fewer cardiopulmonary deaths per year due to diesel Particulate Matter ($PM_{2.5}$). (20)

Concentrations of air pollutants from vehicle emissions tend to be highest close to their source, and are lowered as distance from the source increases. Spatial buffers create greater physical separation between the pollution source and places where people are, such as schools, playgrounds, childcare centers, health care facilities, rehabilitation centers, convalescent centers, hospitals, retirement homes, or residences. Spatial buffers around roadways can be supplemented with vegetation and sound barriers, particularly if the buffer is close to the roadway, enhancing the protection of people nearby.

Figure 3: Social Vulnerabilities in the City of Detroit



Dr. Amy Schulz, University of Michigan School of Public Health, 2017.

Vulnerabilities include: % below the national poverty level, % renters, median house value (reverse coded), % > age 24 with < high school completion, children age < 5, adults age >= 60, and linguistic isolation.

Some communities or individuals may be more vulnerable than others to the adverse effects of exposure to air pollutants. The term "susceptibility" or "more strongly affected" describes those who are likely to have a stronger or more negative health effect at any given level of exposure. "Vulnerability" refers to those who are more likely to be exposed to higher levels of a pollutant.

Children, pregnant women, infants, adults 60 and over, those with existing health conditions (i.e. asthma or other lung related diseases) can have increased susceptibility and/or vulnerability to air pollutants. Socioeconomic status, community preparedness, race and ethnicity, and behavioral and genetic factors can also influence exposure to air pollutants. Some groups, such as children, may be both more vulnerable to high levels of exposure and more susceptible to the adverse effects of those exposures.(21)

The following pages contain district level maps that include the prioritized tree planting areas, along with district level statistics and sites where vulnerable and/or more susceptible populations are located. These sites include **home health service sites**, **nursing homes**, **school and child care centers**, which tend to have high concentrations of infants, children, and adults over 60.

PRIORITY TREE PLANTING AREAS

Figure 4: City of Detroit District 1 Prioritized Tree Planting Areas

Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public Health).

District 1 statistics:

Population: 71,160
Children less than 5: 6.2%
Adults equal to or older than 60: 18.2%
People of Color: 92.4 %
Non-Hispanic Black: 98.7%
Hispanic: 1.3%
Residents older than 24 with less than a High School Diploma: 17.1%
Median Household Income: $33,831
Households below (less than?) Poverty: 34.4%
Unemployed: 13.9%
Renters: 39.3%
Households in poverty: 34.4%

District 1 has a high concentration of early childhood care centers. Any sites along roadways should be considered a priority for tree planting. Several areas along the Southfield Freeway (which runs north/south) could also be prioritized, as areas along that route range from very high priority on the southern end, to high and medium priority.

Similarly, the Jeffries Freeway has both very high and high priority areas along its route.

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

District 2 statistics:

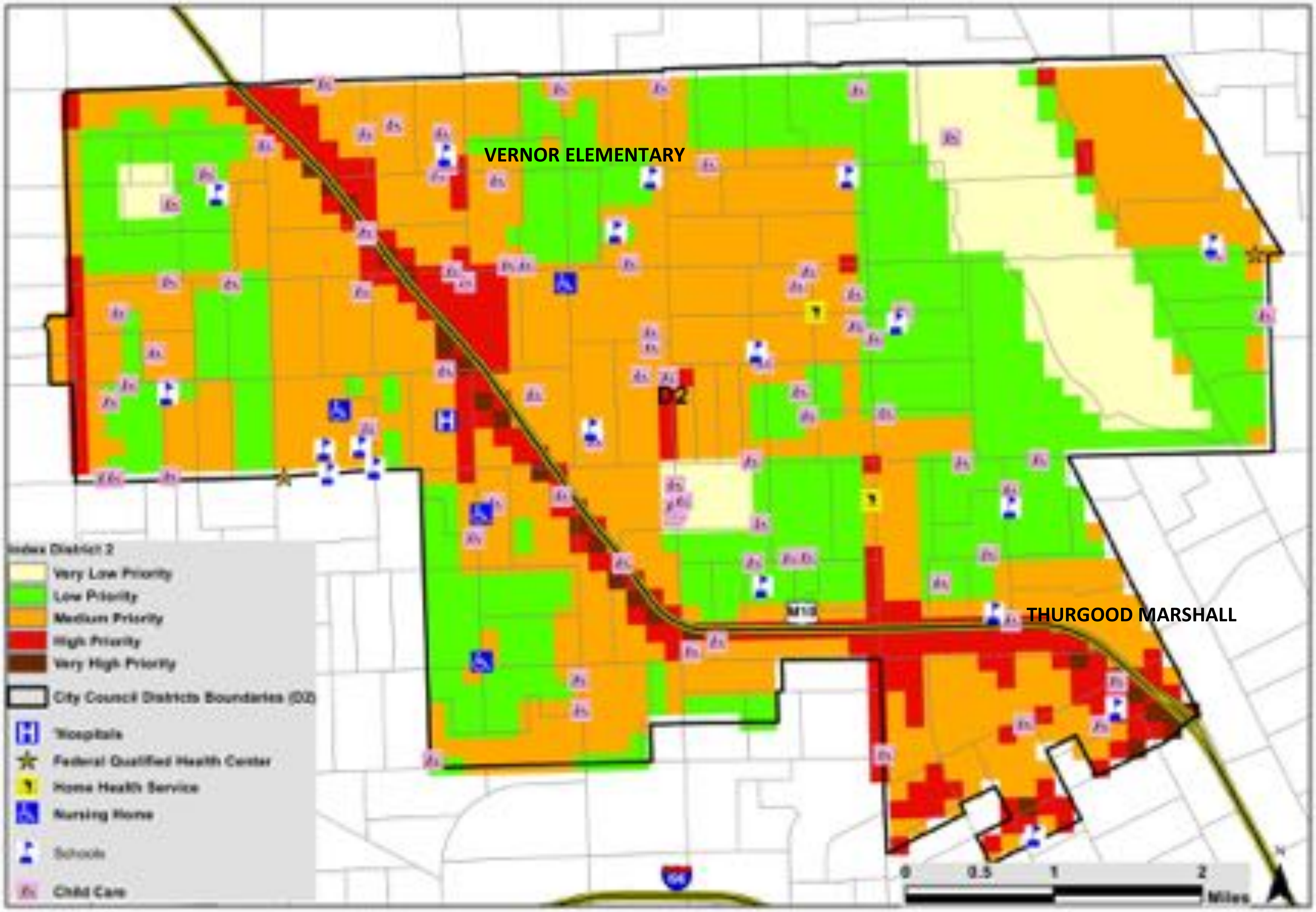
Population: 75,229
Children less than 5: 5.5%
Adults equal to or older than 60: 22.2%
People of Color: 96.6%
Non-Hispanic Black: 99.5%
Hispanic: .5%
Residents older than 24 with less than a High School Diploma: 15.7%
Median Household Income: $33,288
Households below (less than?) Poverty: 33.3%
Unemployed: 14.4%
Renters: 38%
Households in poverty: 33.3%

District 2 has a high concentration of child care centers, and sites along M-10 are high priority for tree planting. Thurgood Marshall Elementary, which is just north of M-10, and Vernor Elementary are also higher priority sites.

Southfield freeway runs along the western border and is another site that could be considered a priority.

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

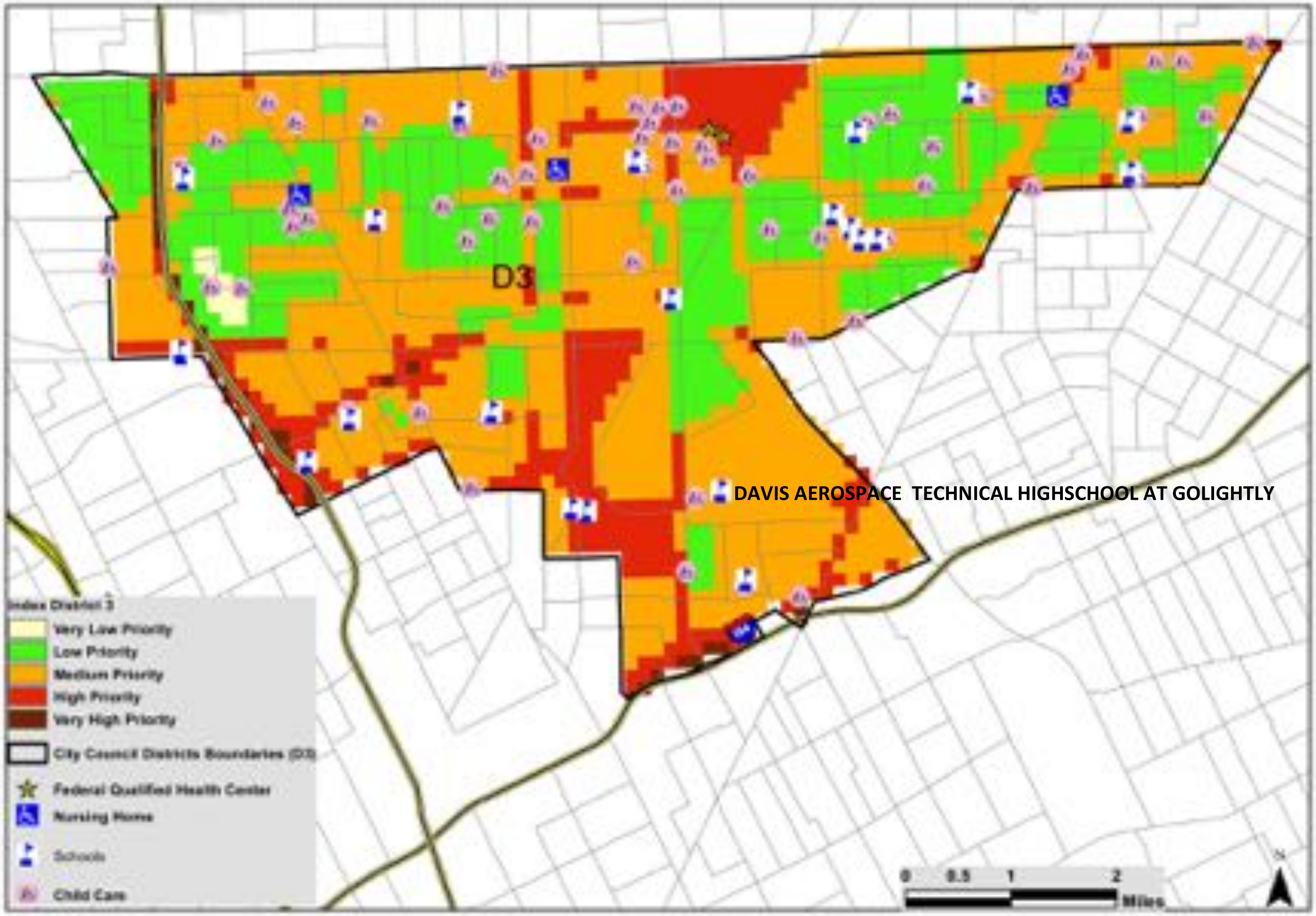
Figure 5: City of Detroit District 2 Prioritized Tree Planting Areas



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public Health).

Figure 6: City of Detroit District 3 Prioritized Tree Planting Areas



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public Health).

District 3 statistics:

Population: 77,224

Children less than 5: 6%
Adults equal to or older than 60: 15.7%
People of Color: 94%
Non-Hispanic Black: 99.3%
Hispanic: .7%
Residents older than 24 with less than a High School Diploma: 25.3%
Median Household Income: $26,563
Households below (less than?) Poverty: 42.9%
Unemployed: 19.7%
Renters: 39.5%

District 3 has several areas along 1-94 and I-75 that are both very high priority and high priority for tree planting. Any schools, childcare facilities, or nursing homes that are near large cites, like the Coleman A. Young International Airport, should also be a priority.

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

PRIORITY TREE PLANTING AREAS

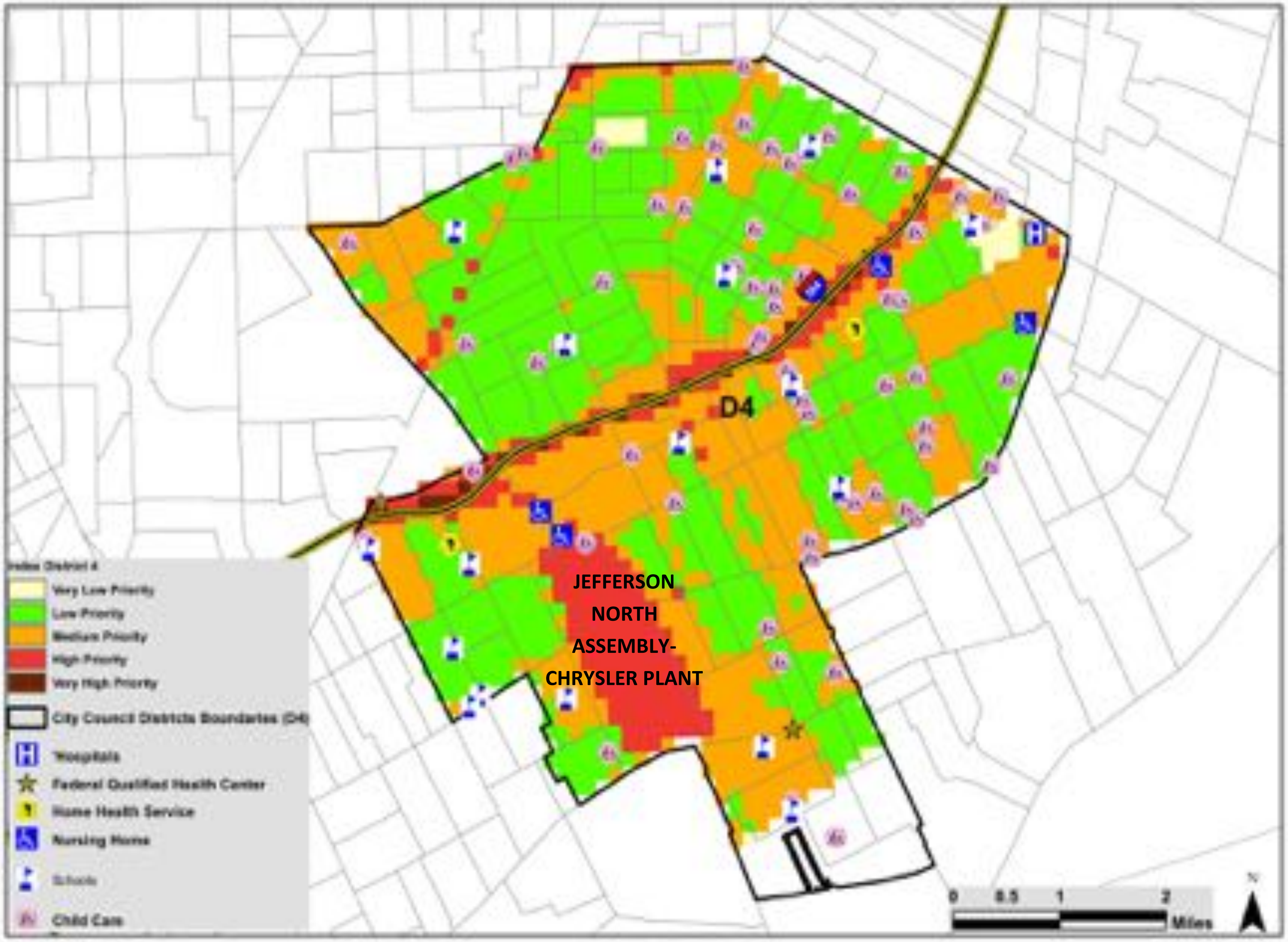
District 4 statistics:

Population: 78,731
Children less than 5: 6.9%
Adults equal to or older than 60: 15.2%
People of Color: 94.2%
Non-Hispanic Black: 99.1%
Hispanic: .9%
Residents older than 24 with less than a High School Diploma: 22.5%
Median Household Income: $26,152
Households Below Poverty: 43.2%
Unemployed: 17.7%
Renters: 45.7%

District 4 has several child care centers and nursing homes that are close to I-94 should be considered very high and high priority. Planting trees around the Jefferson North Assembly Chrysler Plant is also labeled high priority (See pg 12 & 13 of the CAPHE Resource Manual)

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

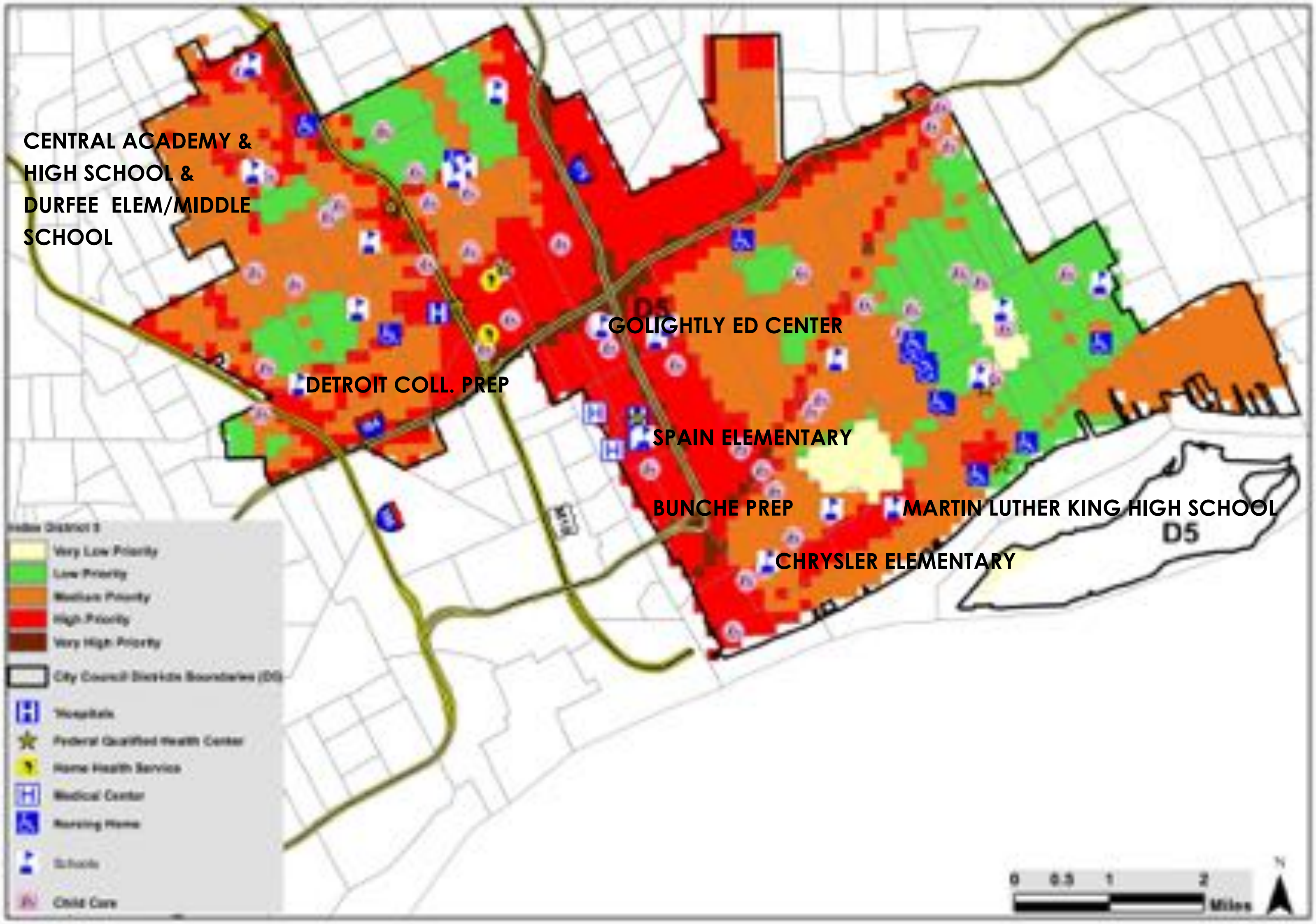
Figure 7: City of Detroit District 4 Prioritized Tree Planting Areas



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public

Figure 8: City of Detroit District 5 Prioritized Tree Planting Areas



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public Health).

District 5 statistics:

Population: 65,355
Children less than 5: 5.7%
Adults equal to or older than 60: 21.5%
People of Color: 92.2%
Non-Hispanic Black: 99%
Hispanic: 1%
Residents older than 24 with less than a High School Diploma: 22.9%
Median Household Income: $24,550
Households below Poverty: 41.7%
Unemployed: 15.2%
Renters: 60.9%

District 5 has several schools that should be high priority and very high priority. These include:

- Central Academy and High School & Durfee Elementary and Middle School
- Detroit Collegiate Prep
- GoLightly Education Center
- Spain Elementary
- Bunche Prep
- Martin Luther King High School, and Chrysler Elementary

Generally, planting trees throughout this district, especially along major routes, like I-94, I-75, I-96, and M-10 could help improve air quality.

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

District 6 statistics:

Population: 67,224
Children less than 5: 8.3%
Adults equal to or older than 60: 15.5%
People of Color: 82.3%
Non-Hispanic Black: 68.7%
Hispanic: 31.3%
Residents older than 24 with less than a High School Diploma: 34%
Median Household Income: $25,249
Households below Poverty: 43.5%
Unemployed: 13.9%
Renters: 57.6%

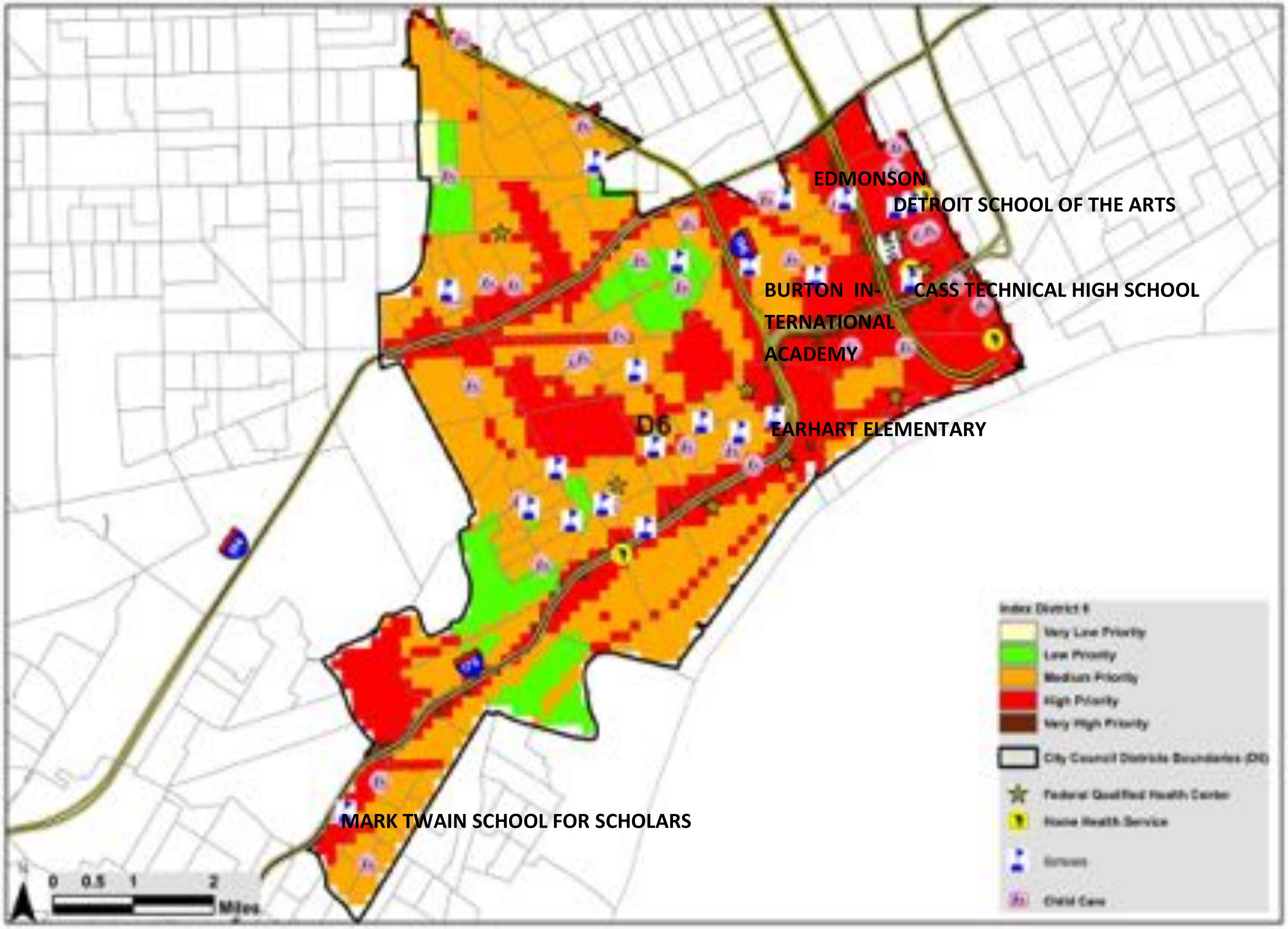
District 6 has several school sites that are very high or high priority. These include:

- Mark Twain School for Scholars
- Burton International Academy
- Cass Technical High School
- *Earhart Elementary—checking this one*
- Detroit School of the Arts, and
- Edmonson

Generally, planting trees throughout this district, especially along major routes, like I-94, I-75, I-96, and M-10 could help improve air quality.

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

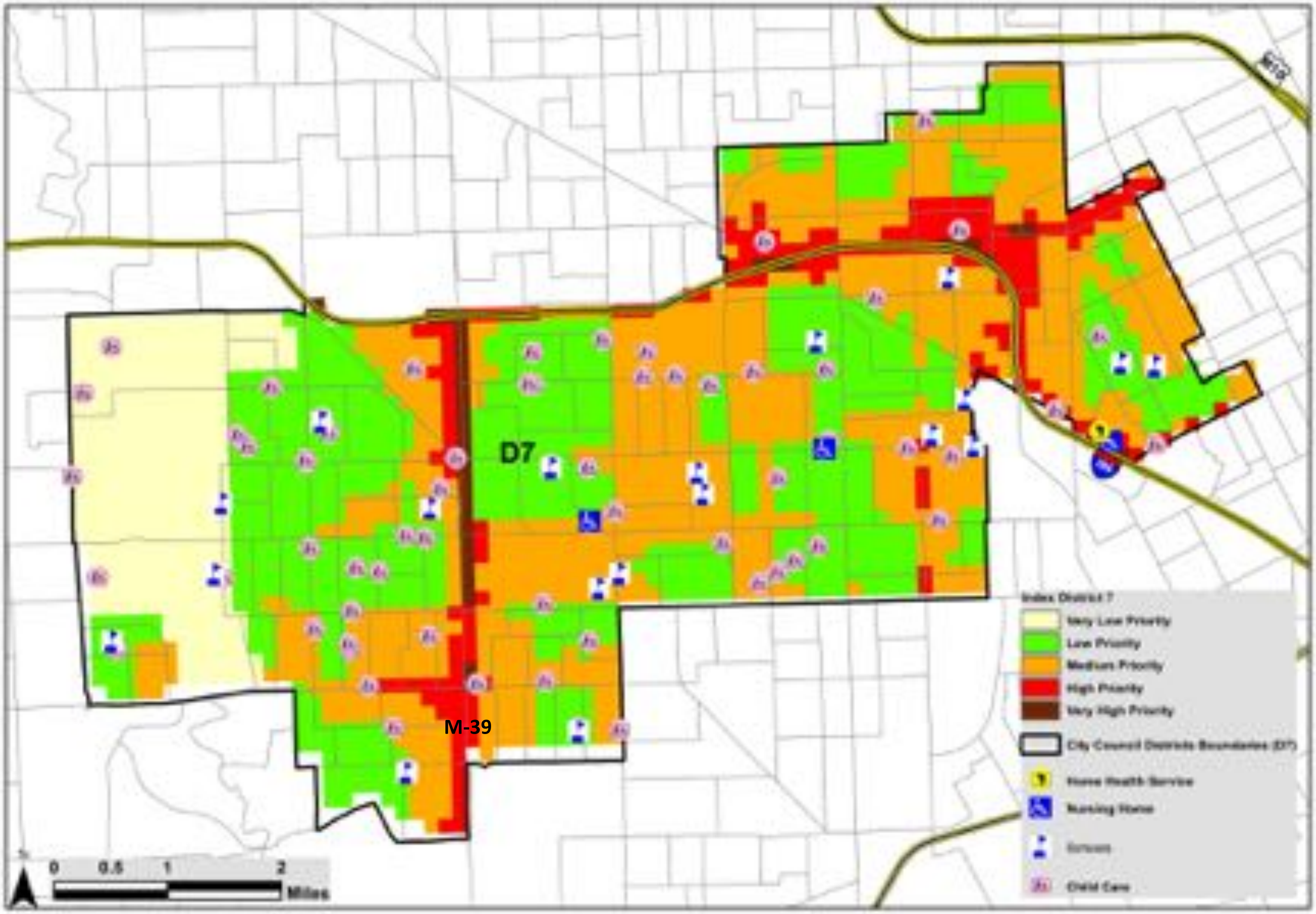
Figure 9: City of Detroit District 6 Prioritized Tree Planting Areas



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution

Figure 10: City of Detroit District 7 Prioritized Tree Planting Areas



Dr. Larissa Larsen, University of Michigan Taubman College of Architecture and Urban Planning, December 8, 2015.

Data Sources: 2010 US Census Population Density, 2012 SEMCOG Tree Canopy Data, 2010 Modeled Air Pollution Concentrations (Air Pollution Concentration Data: Stuart Batterman, University of Michigan School of Public Health).

District 7 statistics:

Population: 78,679
Children less than 5: 7.2%
Adults equal to or older than 60: 16.7%
People of Color: 92.2%
Non-Hispanic Black: 97.8%
Hispanic: 2.2%
Residents older than 24 with less than a High School Diploma: 22.2%
Median Household Income: $26,934
Households Poverty: 40.7%
Unemployed: 15.3%
Renters: 46.1%

District 7 has two main routes that should be prioritized for tree planting, these are I-96, and M-39, which runs north to south.

Statistics: Vulnerability factors that influence health effects of exposure, taken from the American Community Survey 2009-2013.

Goals assessment and site inventory worksheet

(adapted from Green Farmstead Partner Program)

Goals Assessment

Check those items that apply to your need(s):

_____ Air pollution filter

From (circle all that apply):

Road/highways Factories Other: ______________________________

Types of air pollution (circle all that apply):

PM 2.5 CO2 BVOC Ozone SO2/NOx Unsure

_____ Visual screen
_____ Sound protection
_____ Energy efficiency
_____ Windbreak
_____ Shade for cooling
_____ Less mowing/maintenance to reduce fuel costs
_____ Snow management
_____ Aesthetics
_____ Water quality/storm water management

Any other reasons you have to install vegetative buffers:

Site inventory: List information needed to design the site

Operational information

Location of overhead utilities (present or future):

Location of underground utilities (present or future):

Location of wells and water lines:

Electronic cables:

Situation of neighboring buildings (e.g., N-S; NE-SW, etc.):

Equipment needed to maintain site:

Natural resource information

Soil types at site:

Drainage capabilities/characteristics at site:

Direction of prevailing winds in winter and summer:

Sun exposure at site:

Irrigation facilities at/near site:

Surrounding Community information

Location of neighbors most affected:

Are there any neighbors who have voiced concern or disapproval?:

ENDNOTES

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3. Nowak, DJ, Crane, DE, Stevens, JC. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Greening 4:115-123.
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13. Urban Ecosystems Analysis SE Michigan and City of Detroit. 2016 Calculating the Value of nature. Available: https://www.michigan.gov/documents/SE_MI_UrbanEcosystemAnalaysisReport_160216_7.pdf [accessed 21 February 2018]
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ENDNOTES

18. The information on deciduous trees that mitigate air pollution was adapted from the following sources: Yang J, Chang Y, and Yan P. 2015. Ranking the suitability of common urban tree species for controlling PM2.5 pollution. Atmospheric Pollution Research 6: 267-277; Nowak DJ, Crane DE, Stevens JC. 2006. Air Pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Greening 4: 115-123; City of Ann Arbor Approved Tree Species List. 2016; i-Tree: Tools for Assessing and Managing Forests & Community Trees. 2017. Available: http://www.itreetools.org/ [accessed 10 October 2017]; The Arbor Day Foundation. 2017. Tree Guide. Available: https://www.arborday.org/trees/treeGuide/browsetrees.cfm [accessed 10 October 2017]; The Morton Arboretum. 2017. Tree and Plant Selection. Available: http://www.mortonarb.org/trees-plants/tree-and-plant-selection [accessed 10 October 2017]; Missouri Botanical Garden. 2017. Available: http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=a892 [accessed 10 October 2017];
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24. Ibid
25. Ibid
26. Ibid

ENDNOTES