Appendices

Appendix A:

Support Letters

Jenita McGowan, Chief of Sustainability, City of Cleveland

Terry Schwarz, Director, Kent State University Cleveland Urban Design Collaborative

Robert Shibley, Dean, University at Buffalo School of Architecture and Planning

Elizabeth Gibbons, Director, University of Michigan Climate Center

Timothy L. Tramble, Executive Director, Burten, Bell, Carr Development, Inc.

Jeff Ramsey, Executive Director, Detroit Shoreway Community Development Organization

John Anoliefo, Executive Director, Famicos Foundation

Christopher Alvarado, Executive Director, Slavic Village Development

City of Cleveland
Frank G. Jackson, Mayor

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June 25, 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

The City of Cleveland Mayor's Office of Sustainability is pleased to express support for Cleveland's Climate Resiliency and Urban Opportunity Draft Implementation Plan. We are confident that the recommendations outlined in this plan will increase Cleveland's climate resiliency, especially for our most vulnerable residents. We are eager to join Cleveland Neighborhood Progress and the other project partners in implementing this plan.

The Office of Sustainability leverages Cleveland's wealth of assets by collaborating with the community to improve the economic, environmental, and social well-being of its citizens. The Office, in partnership with its 50-member Cleveland Climate Action Advisory Committee, convenes stakeholders across sectors to help build thriving and resilient neighborhoods through climate action. Through the process of working on this grant, we are confident that the draft implementation plan aligns well with the Cleveland Climate Action Plan, as well as the Neighborhood Climate Action Toolkit that was developed in tandem. It has been exciting to see this toolkit used in the planning process as a basis for engaging with residents on adaptation, especially in low-income neighborhoods.

Throughout the six month planning process, the Office of Sustainability ensured appropriate links were made to the citywide Climate Action Plan as well as the larger Sustainable Cleveland 2019 initiative. Moving forward, The Office of Sustainability will help to align City of Cleveland departments with the implementation of the plan. I am particularly interested in leveraging the Cleveland Climate Action Fund as an implementation tool for this plan. Finally, the plan recommendations will go a long way toward further integrating climate resiliency into revisions of City policies, plans, and protocols.

I look forward to partnering with the implementation team to refine and begin implementation of the plan. It's crucial that we work together to make climate action at the neighborhood level reach its full potential in Cleveland.

Sincerely,

Jenita McGowan
Chief of Sustainability
City of Cleveland Mayor's Office of Sustainability

KENT STATE UNIVERSITY
CLEVELAND URBAN DESIGN COLLABORATIVE

1 July 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

On behalf of Kent State University's Cleveland Urban Design Collaborative, I'm writing to my express support for the Cleveland Climate Resilience and Urban Opportunity Initiative.

As the outreach division for the College of Architecture and Environmental Design at Kent State, the CUDC works with neighborhoods and communities throughout northeast Ohio, with a particular emphasis on the city of Cleveland. As you know, we have a well-established and productive relationship with your organization. We see climate resilience as a critically important issue to the future of Cleveland neighborhoods and city residents. We welcome an opportunity to continue this work with Cleveland Neighborhood Progress.

Since January of this year, the CUDC has been working closely with CNP staff, faculty from the University at Buffalo and Kent State, the Cleveland Office of Sustainability, and several local community development corporations to engage residents in lively, neighborhood-specific conversations about how we can anticipate and adapt to the effects of climate change. We have an initial range ideas and strategies that will continue to evolve as we move toward implementation. As the work progresses, the CUDC is committed to helping with on-going community engagement, the development of performance metrics and evaluation tools, and revisions to the initial plan in response to new information and emerging priorities.

Thank you for giving us an opportunity to work with CNP on this exciting and timely project. We look forward to the next phases of the work.

Sincerely,

Terry Schwarz
Director

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University at Buffalo
The State University of New York

Office of the Dean
School of Architecture and Planning

July 1, 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

The University at Buffalo (UB) Department of Architecture is pleased to express support for your proposal to The Kresge Foundation for the "Climate Resilience and Urban Opportunity Initiative."

Our Department of Architecture is committed to the philosophy that architects have a role to play in the aesthetic, social, and cultural betterment of society. The UB curricula prepare students to see the full implications of what architecture does for the built environment. Through pedagogy, creative practice, and faculty research, we engage students in local and global issues to help them understand the human, ecological, material, and technological consequences of design.

One of our faculty members, Dr. Nicholas B. Rajkovich, has been actively engaged with the City of Cleveland, the Cleveland Urban Design Collaborative, and Cleveland Neighborhood Progress on their planning efforts since the beginning of this year. He has attended a number of community meetings in Ohio, defined climate change impacts for the region, mapped vulnerability to climate change, produced educational materials for your climate "ambassadors," and provided training to local community leaders.

Dr. Rajkovich is actively engaged in this work because it is a logical extension of his research on heat wave morbidity and mortality in Cuyahoga County. Over the last five years, his work has quantified the impact of land uses and land cover on local temperatures, how energy efficiency programs might reduce exposure to high temperatures in homes, and how collaborative processes can help to overcome barriers in local adaptation planning. This research has complemented the expertise from the University of Michigan Climate Center and the Kent State University geography and architecture departments.

Should you receive additional funding from The Kresge Foundation, Dr. Rajkovich plans to continue to attend meetings in Cleveland to assist with your planning efforts. He will also work with the academic teams from Kent State and the University of Michigan to attract external support for research around the issue of climate change. He has also expressed interest in reviewing the projects, programs, and policies developed by the Cleveland Neighborhood Progress team as the project moves forward. I am confident that his expertise in environmental planning, building science, and climate change policy will continue to be a tremendous asset to your team.

We wish you the best of luck with your proposal.

Sincerely,

Robert G. Shibley, FAIA, AICP
Professor and Dean

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GLISA
A NOAA RISA TEAM

July 1, 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

The University of Michigan Climate Center and the Great Lakes Integrated Sciences and Assessments Program expresses support for your proposal to The Kresge Foundation for the "Climate Resilience and Urban Opportunity Initiative."

Sponsored by the National Oceanic and Atmospheric Administration (NOAA), the Great Lakes Integrated Sciences and Assessments Program (GLISA) is part of a national network of regional centers focused on adaptation to climate variability and change. GLISA is a collaboration of the University of Michigan and Michigan State University and is housed at the University of Michigan Climate Center at the Graham Sustainability Institute. With a team of leading climatologists, social scientists, and outreach specialists, GLISA addresses a wide range of interconnected regional issues related to the Great Lakes—including agriculture, watershed management, natural resources-based tourism, and urban management.

Since the start of your project, we have been happy to provide you with up to date information like the climatology you have included with this plan to The Kresge Foundation. We have also provided your team with climate projections of temperature and precipitation, access to the Cities Impacts and Adaptation Tool (CIAT), and put you in contact with other adaptation efforts in the Great Lakes Region.

Should you be selected by The Kresge Foundation for the next round of support, we will continue to deliver climate data in a format useful for your decision-making processes. In addition, we are currently planning regional workshops to discuss climate specific impacts, challenges, and opportunities—at these events we will convene research leaders including atmospheric science, civil engineering, informatics, urban planning, public policy, public health, and natural resource management to share critical emerging lessons, resources, and technologies from the Great Lakes region. In addition, we pledge to work with the University at Buffalo and Kent State University to pursue research funding opportunities to support regional adaptation and resilience efforts. We hope that these activities will help your efforts in Northeast Ohio, and that lessons learned from your work will be useful to other cities in our region.

We look forward to continuing to work with you team. Best of luck with your proposal.

Sincerely,

Elizabeth Gibbons

Elizabeth Gibbons
Director, University of Michigan Climate Center
Program Manager, GLISA

CLIMATE CENTER
UNIVERSITY OF MICHIGAN

MICHIGAN STATE
UNIVERSITY

BURTEN, BELL, CARR
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June 26, 2015

Mr. Joel Ratner, President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

Burten, Bell, Carr Development, Inc. (BBC) is pleased to express support for Cleveland's Climate Resiliency and Urban Opportunity Draft Implementation Plan to be submitted July 1st for consideration by The Kresge Foundation. We are confident that the recommendations outlined in this collaboratively-generated plan will increase Cleveland's climate resiliency through vacant land strategies, land use adaptation and community network building. We are eager to join Cleveland Neighborhood Progress in the implementation of this plan..

BBC is committed to working with Cleveland Neighborhood Progress, the City of Cleveland, and numerous other community stakeholders to engage the public in and promote the local Climate Resilience dialogue through focus groups and community outreach events, as well as an information campaign aimed at raising awareness about climate concerns, refining strategies for neighborhood-scale actions with regional impacts, and building social capital to help communities withstand future challenges.

As the community development corporation for Kinsman, we envision climate resilience as an essential part of elevating the physical environment, neighborhood economy, culture, education, and social-fabric of the community. BBC strives to combine climate and economic resilience by collaborating with partners who will invest in the community, create jobs, and act as leaders in environmental stewardship. To date we have successfully chartered a 10 acre land assembly of the Green City Growers Hydroponic Greenhouse, and spearheaded the formation of the 23 acre Urban Agriculture Innovation Zone. Our organization helped design, plan, and develop Heritage View Apartments, a 207 unit redevelopment of an infamous public housing complex. Heritage View Apartments includes permeable driveways, and solar panels eliminating tenants' gas bills. BBC is also involved in the integration of a 5.5 million dollar investment in green infrastructure from the Northeast Ohio Regional Sewer District, which will remove over 1 million gallons of combined sewer overflows from entering Lake Erie.

BBC remains committed to expanding our network of community partnerships to help Kinsman residents thrive, and build effective ways to promote climate action. In 2012, BBC joined Detroit Shoreway Community Development, Enterprise Community Partners, and the Mayor's Office of Sustainability, in a collaborative working group to charter an EcoDistrict framework for Cleveland. Utilizing the framework to explore metrics planning, alignment of resources, and setting neighborhood scale strategies to achieve carbon, waste, energy and water reduction.

As you move from the planning into the implementation phase of this initiative, we will dedicate staff time to the coordination of new and improved community outreach and capacity building programs and will work to bring our neighborhood master plan into alignment with the plan recommendations. We are very interested in the outcomes of this work; particularly, empowering residents to play an active role in Climate Resilience. We look forward to partnering with you as we refine and begin to implement the plan recommendations.

Yours for a better community,

Timothy L. Tramble

Timothy L. Tramble
Executive Director

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June 26, 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

Detroit Shoreway Community Development Organization (DSCDO) is pleased to support Cleveland's Climate Resiliency and Urban Opportunity Draft Implementation Plan to be submitted for consideration to The Kresge Foundation. We are confident that the recommendations outlined in this collaboratively-generated plan will increase Cleveland's climate resiliency through vacant land strategies, land use adaptation and community network building. We are eager to join Cleveland Neighborhood Progress in the implementation of this plan.

Since 1998, DSCDO has been a leader in promoting environmentally focused neighborhoods through creation of the Cleveland EcoVillage, a place-based and transit-oriented approach to an ecological redevelopment, centered on a light rail transit station. Within the EcoVillage, DSCDO has successfully completed initiatives including development of 20 state of the art green built townhomes; rehabilitation of $3.5 million green transit station; development of two (2) green single family homes; and a $3.5 million redevelopment of the 20 acre Michael Zone Recreation Center greenspace, a storm water management demonstration project.

DSCDO remains committed to expanding our network of community partnerships to help EcoVillage residents thrive, and build effective ways to promote climate action. In 2012, DSCDO joined Burten, Bell, Carr Development, Inc., Enterprise Community Partners, and the Mayor's Office of Sustainability in a working group to charter an EcoDistrict framework for Cleveland. DSCDO is utilizing the framework to explore metrics planning, identify opportunities to align resources, and create neighborhood scale strategies to achieve carbon, waste, energy and water reduction.

As Cleveland Neighborhood Progress moves from the planning into the implementation phase of the Climate Resiliency and Urban Opportunity initiative, DSCDO is committed to engaging the public in and promoting the local Climate Resiliency dialogue through focus groups and community outreach events, as well as an information campaign aimed at raising awareness about climate concerns, refining strategies for neighborhood-scale actions with regional impacts, and building social capital to help communities withstand future challenges. We will work to bring our neighborhood master plan into alignment with the plan recommendations, and we are very interested in the outcomes of this work – particularly, empowering residents to play an active role in Climate Resiliency.

We look forward to partnering with you in the refinement and implementation of the plan recommendations.

Sincerely,

Jeff Ramsey
Executive Director

famicos FOUNDATION
Building Homes. Restoring Hope.

NeighborWorks CHARTERED MEMBER

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June 26, 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

Famicos Foundation is pleased to express support for Cleveland's Climate Resiliency and Urban Opportunity Draft Implementation Plan to be submitted July 1st for consideration by The Kresge Foundation. We are confident that the recommendations outlined in this collaboratively-generated plan will increase Cleveland's climate resiliency through vacant land strategies, land use adaptation and community network building. We are eager to join Cleveland Neighborhood Progress in the implementation of this plan.

Famicos is committed to working with Cleveland Neighborhood Progress, the City of Cleveland, and numerous other community stakeholders to engage the public in and promote the local Climate Resilience dialogue through focus groups and community outreach events, as well as an information campaign aimed at raising awareness about climate concerns, refining strategies for neighborhood-scale actions with regional impacts, and building social capital to help communities withstand future challenges.
We believe, like Cleveland Neighborhood Progress, that by raising awareness about climate concerns and advancing effective Climate Resilience strategies, we will improve quality of life for current residents, and attract new residents to the Glenville neighborhood, and neighborhoods throughout the city.

Our climate action plan called "Greening Glenville" has to date;

- Distributed over 300 rain barrels and compost bins along with holding "how to" workshops
- Instituted resident based recycling programs at three of the apartment buildings that we own and manage
- Partnered with Glenville High School teachers to create a curriculum around sustainability issues

- Promoted the consumption of locally grown produce through a weekly farmers' market (thereby reducing transportation costs)
- Partnered with local bicycle advocacy groups to promote the use of bicycles as a viable means of transportation.

As you move from the planning into the implementation phase of this initiative, we will dedicate staff time to the coordination of new and improved community outreach and capacity building programs and will work to bring our neighborhood master plan into alignment with the plan recommendations. We are very interested in the outcomes of this work; particularly, empowering residents to play an active role in Climate Resilience. We look forward to partnering with you as we refine and begin to implement the plan recommendations.

Sincerely,

John Anoliefo
Executive Director

SLAVIC VILLAGE SVD DEVELOPMENT

June 26, 2015

Mr. Joel Ratner
President and CEO
Cleveland Neighborhood Progress
11327 Shaker Boulevard, Suite 500W
Cleveland, Ohio 44104

Dear Mr. Ratner,

Slavic Village Development (SVD) is pleased to express support for Cleveland's Climate Resiliency and Urban Opportunity Draft Implementation Plan to be submitted July 1st for consideration by The Kresge Foundation. We are confident that the recommendations outlined in this collaboratively-generated plan will increase Cleveland's climate resiliency through vacant land strategies, land use adaptation and community network building. We are eager to join Cleveland Neighborhood Progress in the implementation of this plan.

SVD is committed to working with Cleveland Neighborhood Progress, the City of Cleveland, and numerous other community stakeholders to engage the public in and promote the local Climate Resilience dialogue through focus groups and community outreach events, as well as an information campaign aimed at raising awareness about climate concerns, refining strategies for neighborhood-scale actions with regional impacts, and building social capital to help communities withstand future challenges.

We believe, like Cleveland Neighborhood Progress, that by raising awareness about climate concerns and advancing effective Climate Resilience strategies, we will improve quality of life for current residents, and attract new residents to Slavic Village as well as other neighborhoods throughout the city. To date, we have partnered with Northeast Ohio Regional Sewer District to construct seven natural stormwater retention sites and develop Fleet Avenue as Cleveland's first true "complete and Green Street" to handle increasing volumes of precipitation and encourage bicycle and transit use. We are also constructing a neighborhood-wide trail network to support walking and biking, pursued a strategy of neighborhood building based on walkability, and are leveraging our economically- and ethnically-diverse constituency to create stronger social ties and a more resilient neighborhood.

As you move from the planning into the implementation phase of this initiative, we will dedicate staff time to the coordination of new and improved community outreach and capacity building programs and will work to bring our neighborhood master plan into alignment with the plan recommendations. We are very interested in the outcomes of this work; particularly, empowering residents to play an active role in Climate Resilience. We look forward to partnering with you as we refine and begin to implement the plan recommendations.

Sincerely,

Christopher Alvarado
Executive Director

GREATER CLEVELAND COMMUNITY SHARES

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Appendix B:

Adaptation Actions and Strategies

Prepared by:

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Cleveland Urban Design Collaborative
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		Mitigation	Adaptation	Social Cohesion		
	Category	Lessen overall demand for energy and increase renewable energy	Anticipate and prepare for climate changes and shocks	Foster social cohesion	**Timeframe**	**Cost**
Community Engagement						
Continuation/expansion of Climate Ambassador program	Program	Climate Ambassadors can help educate their neighbors about strategies for reducing energy usage.	A strong community network of knowledgeable Climate Ambassadors will help residents and neighborhoods respond to climate changes and shocks.	Climate Ambassador Program encourages neighbors to talk with neighbors about climate change and adaptation strategies. Ambassadors providing two-way communication: communicating about climate and programs from plan implementers to residents AND communicating resident priorities, questions and concerns back to the advisory committee that is implementing the plan.	On-going	
Climate Fair; Green Party Crasher Initiative	Program	Informed residents are more likely to think about their energy consumption and carbon footprint; i.e., knowledge is a powerful tool for changing behavior.	The sometimes scary possibilities of climate change will be easier to discuss with residents in a fun and non-threatening setting; more informed residents will mean greater preparedness in the event of a climate emergency.	People get to know one another the more they engage with their neighbors. Using fairs and various community events as forums for info sharing provides opportunities for building social cohesion.	Short-term, on-going	
Co-op program for vacant land stewardship	Program	Engaging neighbors near the sites they will be caring for reduces travel and gas consumption involved with hiring maintenance companies.	Relationships created through this program foster social cohesion, which enables community members to support each other in the event of climate .shocks	Community volunteers build relationships across neighborhoods by helping to maintain vacant lots and community green spaces	Mid-term	
Cleveland Youth Landscaping: Yard care/snow removal services for elderly residents in high vulnerability areas (based on vulnerability mapping)	Program	The shared provision of services is an energy efficient way to meet the needs of neighborhood residents. Also, the local company uses push and electric mowers. NOTE: They received a Cleveland Climate Action Fund grant to convert their equipment.	The program provides a built-in mechanism for checking on elderly residents and vulnerable households, which will be important in the event of an extended heat wave or other climate emergency.	Intergenerational relationships are created in a mutually beneficial way. Young people are paid for their work; older people receive landscaping and snow removal services.	Short-term, on-going	
Senior visitation program to check on the needs of seniors and increase social time	Program		The program provides a built-in mechanism for checking on elderly residents and vulnerable households, which will be important in the event of an extended heat wave or other climate emergency.	Building relationships with seniors improves community relations and fosters social cohesion. It also provides an important feedback loop to the Advisory Committee.	Mid-term	
Climate -ready renters training	Program		Renters may be especially vulnerable to the effects of climate change and the impacts of climate shocks. This program tailors a response strategy to their needs.	Helps renters know their rights when it comes to climate-related issues such as mold growth, ventilation, and other issues.	Short-term, on-going	
City of Cleveland Department of Aging/World Health Organization Age Friendly City Initiative	Program		CNP will work to coordinate the climate resiliency aspects into the plan.	Will create an inclusive and accessible environment for older adults with varying needs and capacities.	Short-term, on-going	
Professionals initiative (quarterly training)	Program	CDC staff, city staff, and others receive training and updates on climate issues and strategies for improving energy efficiency at the household, neighborhood, and citywide scale.	Builds a network of well-informed practitioners who can assist with the day-to-day realities of climate change and in the event of a climate emergency.	Fosters greater cohesion between CDCs and city staff, and the residents they serve.	Short-term, on-going	

		Mitigation	Adaptation	Social Cohesion		
	Category	Lessen overall demand for energy and increase renewable energy	Anticipate and prepare for climate changes and shocks	Foster social cohesion	**Timeframe**	**Cost**
Weatherization/Mold Prevention						
Expanded home weatherization efforts/investments in areas identified in the vulnerability mapping.	Program	Weatherization will improve the energy efficiency of existing housing stock.	Weatherization (especially insulation and operable windows) will keep indoor temperatures lower during heat waves and increase the passive survivability of the city's existing housing stock.	Weatherization fairs and outreach efforts will help build relationships between neighbors and may help to identify vulnerable households.	Short-term	
Mold Prevention Toolkit	Program		Increased precipitation and flooding will promote mold growth, which contributes to allergies and respiratory illnesses. The toolkit will help people identify, correct, and prevent the spread of mold in their homes.	Public education programs about where to look for mold growth and how to eliminate it will bring neighbors together around this prevalent public health issue.	Short-term	
Impacts of weatherization initiatives on actual houses in Cuyahoga County. Can we improve interior temperatures in real homes? How do these tie to existing programs like HWAP?	Research	Weatherization reduces energy demands, but we need more data about the effectiveness of weatherization programs in order to target funding to the interventions and households where weatherization improvements will be most effective. We also need data about anticipated and actual energy savings, since high utility bills, especially during the winter months, are a pressing concern for residents.	More research is also needed as to the effects of weatherization during extended periods of high heat. Are current weatherization efforts resulting in more comfortable indoor temperatures during extended periods of high heat and extreme cold? How do weatherized homes compare to non-weatherized homes?	High energy costs are a major concern for many city residents. Providing detailed information about the connection between weatherization and lower utility bills is a useful way to draw residents into broader conversations about climate change.	Mid-term	
Urban Heat Island Effects/High Heat Response						
Installation of weather stations in each of the neighborhoods of Cleveland/ Cuyahoga County to help with heat island/ heat emergency/ stormwater management over time.	Research	Understanding the variations in microclimates around the city will enable us to better target efforts to reduce urban heat island effects through reforestation, reduction in impervious surfaces, green roofs, and other means.	Anticipating and preparing for climate changes will be easier if we can monitor variations and fluctuations in temperature, rainfall, wind speeds, and other conditions at the neighborhood scale.	While many residents may be unaware or uninterested in issues of 'climate,' most Clevelanders engage in frequent conversations about the weather. Public education programs at weather stations can help residents better understand and prepare for the impacts of climate variability and change.	Mid-term	
Cooling Center communication network: establish block-club-based mechanism to extend landline robocall service to new neighbors and those who do not have landlines and therefore do not get notice of the cooling center locations and hours.	Program		Anticipating climate emergencies by establishing the communications network needed to protect the most vulnerable households	Developing a communications strategy at the block club level will strengthen relationships with neighbors and help to better target citywide efforts.	Short-term	

		Mitigation	Adaptation	Social Cohesion		
	Category	Lessen overall demand for energy and increase renewable energy	Anticipate and prepare for climate changes and shocks	Foster social cohesion	**Timeframe**	**Cost**
Reforestation						
Energy Savings Trees Program: Strategic tree planting and online interface for residents to see the energy savings they could get with trees	Program	Deciduous trees planted on the south and west sides of houses will help to keep interiors cooler and reduce energy costs.	Trees help absorb storm surges and reduce stormwater runoff, providing a protective buffer for city neighborhoods in extreme weather.	Some residents have concerns about tree planting and urban reforestation efforts, largely due to the damage caused by tree roots and falling limbs, and the maintenance efforts required for fall leaf removal. A program that targets trees to the areas where they can provide the most benefits and a toll that enables residents to measure energy savings will help build public awareness of the value of trees in urban neighborhoods.	Mid-term	
Target reforestation efforts to vacant lots in headwaters areas	Project	Capturing rainfall at the top of the watershed (headwaters areas) can help reduce combined sewer overflows and the amount of water in the sewer system. This in turn reduces the amount of rainwater that is processed through the city's water treatment plants. Pumping and treating water requires a lot of electricity, so reducing the amount of water moving through the sewers will lessen the overall demand for energy.	Trees help absorb storm surges and reduce stormwater runoff, providing a protective buffer for city neighborhoods in extreme weather.	Headwaters areas form linear paths throughout the city. Targeting reforestation efforts on vacant land in headwaters areas will create green connections throughout the city that can be used for walking, biking, and linking residents to neighborhood resources and amenities.	Long-term	
Tree planting initiative for side lot expansions, especially on south and west sides of houses	Program	Deciduous trees planted on the south and west sides of houses will help to keep interiors cooler and reduce energy costs.	Targeted tree planting will keep indoor temperatures lower during heat waves and increase the passive survivability of the city's existing housing stock.	A program to purchase trees in bulk, distribute to residents, and offer planting/watering instructions is a way to share information about the value of trees and initiate a broader conversation about climate change and preparedness strategies.	Mid-term	
Targeted reforestation effort for city parks and school sites.	Project	Parks and school properties can become green anchors in city neighborhoods, to help capture stormwater, reduce flooding risks, and reduce ambient air temperatures at the neighborhood scale, reducing overall energy demands.	Trees help absorb storm surges and reduce stormwater runoff, providing a protective buffer for city neighborhoods in extreme weather.	Increased tree canopy for parks and school sites may enable these spaces to function more effectively as neighborhood gathering spaces, particularly for older residents who may be more interest in passive recreation than programmed sports and activities.	Mid-term	
Identify tree species that produce less pollen	Research	Planting trees that procude less pollen means less allergic reactions and ashthma attacks, reducing trips to the drug store for medicine or the doctor/urgent care for treatment.	Climate changes may be impacting the amount of pollen trees are producing. Identifying low pollen tree species will enable us to expand the city's tree canopy while limiting public health concerns related to allergies and respiratory illnesses.	Public education about trees and pollen production will help residents make more informed choices when selecting trees and plants for their own properties.	Short-term	

		Mitigation	Adaptation	Social Cohesion		
	Category	Lessen overall demand for energy and increase renewable energy	Anticipate and prepare for climate changes and shocks	Foster social cohesion	**Timeframe**	**Cost**
Stormwater Management						
Wet-Weather Runoff Reduction Credit Program	Program	Reducing stormwater runoff lessens energy demands by reducing the amount of stormwater that has to be pumped to treatment plants.	Reducing impervious surfaces helps to reduce flooding risks and urban heat island effects.	Public education programs to promote the credit program are an opportunity to foster conversations about broader climate related issues.	Mid-term	
Complete & Green Streets Initiative: accelerated implementation of existing policy	Policy	Increased tree canopy over existing pavement and new roads (i.e. Opportunity Corridor) will lessen energy demand by reducing ambient air temperatures during heat waves; and also absorb stormwater at the source to reduce energy needs for pumping and treating stormwater.		Complete and green streets encourage mobility for all and increase residents' ability to access neighborhood amenities and resources by bike, on foot, and via public transit.	Long-term	
Climate resilience criteria for NEORSD green infrastructure grants	Policy	The sewer district's green infrastructure grants program focuses on reducing stormwater runoff, but the co-benefits of green infrastructure also include the mitigation of urban heat island effects and potential reductions in energy usage at the household and neighborhood level.		Green infrastructure grants provide an opportunity to engage residents in greening efforts and increase public understanding of the relationships between stormwater management and climate change.	Mid-term	
Stormwater management on scattered vacant sites. How many sites, and in what configuration, are needed to achieve a significant, measurable improvement in water quality?	Research	The sewer district's green infrastructure program is mostly focused on larger sites and projects. Complementing these projects with smaller, scattered site interventions could reduce the amount of stormwater that is conveyed through the sewer system and treated at water treatment plants. Less water being pumped and treated translates to reduced energy usage.	Large pipes and sewer interceptors have been designed based on current and anticipated wet weather flows. If the weather becomes increasingly unpredictable and stormwater volumes exceed projections, the sewer district's existing and planned gray infrastructure system may need to be adapted to changing circumstances. Complementing large installations with smaller scale, scattered-site green infrastructure may offer greater flexibility in adapting to changing circumstances.	Green infrastructure on scattered sites in city neighborhoods enable people to see, experience, and interact with these installations, increasing public understanding of stormwater management and providing community amenities and gathering places that foster social cohesion.	Mid-term	
Basement and street flooding survey	Research	Identifying problem areas for flooding may help alleviate future flooding projects and energy-intensive clean-up efforts.	Flooding issues are likely to worsen due to the effects of climate change. Getting a baseline understanding of problems today will help us prepare for the future.	Engaging residents in this survey process will open up new conversations about emergency preparedness.	Mid-term	

		Mitigation	Adaptation	Social Cohesion		
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Urban Agriculture						
Small food producing sites within 1/4 mile of every resident	Project/Policy	Visible and nearby community gardens may encourage residents to eat less processed and energy-intensive foods.	Food producing sites may provide important nutritional support in the event of major weather events that interrupt the regional, national, or global food supply.	Community gardens provide a place for residents to gather and work together, while also increasing access to healthy food.	Short-term, on-going	
Larger food producing sites in strategic locations to offer greater food security	Project	Urban agriculture at the commercial scale may reduce energy demands by reducing the distance food has to travel before being consumed.	Food producing sites may provide important nutritional support in the event of major weather events that interrupt the regional, national, or global food supply.		Long-term, on-going	
Season-extending infrastructure (greenhouses, hoop houses) to offer year-round food security	Project	Greenhouses and hoop houses can help extend the growing season, although the net effect on energy demand is unknown, since year round food production will require supplemental heating in most cases.	Year-round food producing sites may provide important nutritional support in the event of major weather events that interrupt the regional, national, or global food supply.		Mid-term, on-going	
Urban agriculture research on the impacts of climate change and agricultural diseases	Research	If the weather becomes increasingly unpredictable, research and annual/seasonal alerts can help local growers better time their planting season and reduce crop losses due to late freezes or other weather-related problems.	Current best practices in urban agriculture may need change as the climate conditions change. Research into local changes will be needed to help local growers anticipate climate variations and maintain productive farms and food-producing gardens.	Local growers have established networks in Cleveland. Providing better data on local growing conditions will help foster stronger ties within the urban farming community and also allow for better outreach to home gardeners.	Mid-term	
Energy Generation						
Small scale solar farms on vacant land and at city recreation centers	Project	Dispersed green power generation will help reduce reliance on fossil fuels.	Dispersed green power generation could provide supplemental power in the event of widespread power outages.	Solar energy cooperatives could help build community networks based on shared green energy generation and usage.	Long-term	

		Mitigation	Adaptation	Social Cohesion		
	Category	Lessen overall demand for energy and increase renewable energy	Anticipate and prepare for climate changes and shocks	Foster social cohesion	**Timeframe**	**Cost**
Infill Development						
Concentrate new development near existing transit.(sustainable patterns of development map)	Policy	Greater density near existing transit will lessen overall energy demands by providing greater transit access for more residents, reducing greenhouse gas emissions.	Climate change is likely to lead to higher energy costs. Concentrating infill development near transit stations and major bus lines will increase mobility options for households of all incomes, but will be especially important for an increasing number of households that can't afford to own, maintain, and fuel a car.	Dense neighborhoods organized around transit create opportunities for social interaction.	Long-term, on-going	
Avoid new development on sites that align with culverts, buried streams, and headwaters	Policy	Building above buried waterways creates a future liability--if a culvert fails, this typically creates sink holes that threaten the stability of buildings in the vicinity. Discouraging construction over buried waterways limits the risk of building losses and the embodied energy they represent.	Heavy storms and volatile weather may accelerate the deterioration of older culverts. Choosing not to build (or re-build) on top of culverts anticipates the possibility of culvert failure and limits anticipated losses.	Culverted streams form linear paths throughout the city. Targeting reforestation efforts on vacant sites that align with culverts preserve opportunities for future stream restoration projects and create green connections throughout the city that can be used for walking, biking, and linking residents to neighborhood resources and amenities.	Long-term, on-going	
Map new/anticipated flood plain areas, based on patterns of increased precipitation.	Research		Increased rainfall may cause more frequent flooding, including some areas that were not previously prone to flooding risks. We need to understand how flood plains are changing, and anticipate how they will change, in order to better plan for new development and better protect	Public education about increased rainfall and expanded flood plains may help with emergency preparedness.	Mid-term	
Land use overlay/land bank tool for discouraging new construction in expanded flood plain areas.	Policy	Discouraging construction in flood plain areas may help prevent problems with flooding in the future and reduce energy expenditures associated with post-flood clean-up.	No-build zones in flood plain areas may prevent future flood damage by not putting people and buildings in harm's way.	Helping people understand the topography of greater Cleveland and the risks of building in flood zones will help foster a shared understanding of how to live with unpredictable weather and increased rainfall.	Long-term	
Retrofits for housing in areas that are prone to flooding.	Program	Although sump pumps consume energy, the targeted installation of these devices may result in a net energy savings if anticipated flooding damage is averted.	There are existing houses in areas that are prone to flooding, or likely to experience flooding in the future. Providing the most vulnerable households with the tools and knowledge to reduce flooding damage is one way to prepare for future climate changes and shocks.	Public education about increased rainfall and expanded flood plains may help with emergency preparedness.	Mid-term	

Appendix C:

Climate Change in Cleveland Literature Review

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1. EXECUTIVE SUMMARY

Taking action around climate change is a key component of the Sustainable Cleveland 2019 initiative. By integrating sustainability into the City of Cleveland's municipal operations, residents' lives, and the priorities of local corporate and institutional partners, the city can reduce greenhouse gas emissions and grow the economy. However, while these efforts will help to slow global warming and create jobs, changes in the climate will continue for many decades because of the inertia of Earth's atmosphere. These climate impacts may add stress to vulnerable populations, infrastructure, and ecosystems.

This appendix describes how climate impacts may affect Cleveland, Ohio. The findings are based on current peer-reviewed scientific literature, climate projections, and assessments conducted for the U.S. Global Change Research Program (http://www.globalchange.gov/). After this brief introduction, the second section of this report outlines the physical changes in temperature, precipitation, and extreme weather events:

- *Increased Temperatures:* From 1956 to 2012, the average annual temperature in Cleveland increased by 2.4°F. By 2070, the average annual temperature may warm by an additional 4°F. These higher temperatures may increase the number of heat-related deaths, reduce water quality in Lake Erie, strain food systems, degrade air quality, and put pressure on native plants and animals.
- *Changes in Precipitation Patterns:* From 1956 to 2012, the average annual precipitation in Cleveland increased by 25.8%. During the autumn, the increase was greater at 57.4%. Heavy rain events and lake effect snow are expected to increase with a warming climate. This may cause flooding, a reduction in river and stream quality, and increased maintenance costs.
- *Extreme Weather Events:* Weather-related threats in Northeastern Ohio include severe storms, flooding, lake effect snow, tornadoes, temperature extremes, and erosion/landslides. A warming climate and decreasing ice cover on Lake Erie may cause an increase in the frequency and intensity of these extreme weather events, threatening human life and causing significant property damage.

The third, and final section of the report summarizes how the above increased temperatures, changes in precipitation patterns, and extreme weather events may affect local sectors and systems:

- *Public Health:* Increased heat wave frequency and intensity, increased humidity, degraded air quality, reduced water quality, and change in vector borne disease patterns may increase public health risks.
- *Water Quality:* Climate change may exacerbate a range of risks to Lake Erie, including harmful algal blooms, an increased number of combined sewer overflows, and declining beach health.
- *Food Systems:* In the next few decades, longer growing seasons and rising carbon dioxide levels may increase crop yields, though those benefits could be offset by extreme weather events. In the long term, climate change is expected to decrease agricultural productivity.
- *Forests and Land Cover:* The composition of forests is changing as the climate warms. Many tree species are shifting northward, with more southerly varieties replacing them. Iconic tree species (e.g., Buckeye) may slowly be replaced by other species in the next century.
- *Energy and Industry:* Cleveland has an energy-intensive economy with per capita greenhouse gas emissions higher than the national average. Warmer temperatures are expected to reduce building heating loads, but these gains may be offset by increased reliance on air-conditioning.

- *Transportation Systems:* Ice cover declines may lengthen the commercial navigation season on Lake Erie. An increased number of freeze-thaw cycles, flooding and erosion, lake effect snow, and heat waves may cause significant damage to local transportation infrastructure.
- *Fish and Wildlife:* The effects of increased heat stress, flooding, drought, and late spring freezes on natural and developed ecosystems may be magnified by pest prevalence, increased competition from non-native or opportunistic native species, ecosystem disturbances, and land-use change.

2. CLIMATE TRENDS

This section of the report outlines the physical changes in temperature, precipitation, and extreme weather events. Additional detail is available in Appendix D: a historical climatology of Cleveland, Ohio provided by the University of Michigan Climate Center.

2.1. Changes in Temperature

The average annual temperature in Cleveland increased by 2.4°F from 1956 through 2012, with 2012 considered Cleveland's warmest year on record (City of Cleveland Office of Sustainability 2013). The warming trend was greatest during the winter; from December through February the average temperature increased by 3.4°F (Table 1). Climate change projections indicate that the average annual temperature may increase by an additional 1.8 to 5.4 °F by the year 2050 (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012).

Table 1: Changes in Average Temperature in Cleveland from 1956 through 2012

Season	ºF	ºC
Winter (December – February)	3.4	1.9
Spring (March – May)	2.7	1.5
Summer (June – August)	2.6	1.5
Fall (September – November)	0.7	0.4
Annual	2.4	1.3

Source:GLISA (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012)

2.2. Changes in Precipitation Patterns

Annual precipitation increased by 25.8% from 1956 to 2012 (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012). The increase in precipitation varies by season, with both the winter and fall seasons showing the highest increase in total precipitation of 40.4% and 57.8% respectively (Table 2).

Table 2: Changes in Precipitation in Cleveland from 1956 through 2012

Season	Inches	Centimeters	%
Winter (December – February)	2.9	7.3	40.4
Spring (March – May)	1.4	3.5	14.3
Summer (June – August)	0.1	0.2	0.8
Fall (September – November)	5.3	13.3	57.4
Annual	9.8	24	25.8

Source:GLISA (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012)

The average number of days per year exceeding 1.25 inches of precipitation has increased by an average of 1.5 days per year (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012). In addition, heavy rainfall days (top 1% of daily precipitation totals) have increased by 16.3% (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012).

The impacts of changing precipitation levels varies across the United States, with some regions experiencing drought while other regions face flooding. Any changes in precipitation levels is accompanied by a modification of the water supply, mainly due to changes in groundwater recharge (Winkler, Andresen et al. 2014).

2.3. Extreme Weather Events

As atmospheric warming occurs, the likelihood of extreme weather events increases. This is due to increased energy in the atmosphere and a gradual warming of the Great Lakes.

To this end, the annual average ice coverage of the Great Lakes has declined by 71% from the year 1973 to 2010 (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012). For Northeastern Ohio, a warming Lake Erie and decreasing ice cover may cause an increase in the frequency and intensity of heavy precipitation and lake effect snow.

These expected changes have already been recorded by regional weather stations; heavy storm precipitation has increased by 37% from the year 1958 to 2012 in the Midwest (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012). Other extreme events like heat waves, flooding and associated erosion/landslides, are expected to continue (City of Cleveland Office of Sustainability 2013, Winkler, Andresen et al. 2014).

3. CLIMATE IMPACTS

This section of the report summarizes how the above increased temperatures, changes in precipitation patterns, and extreme weather events may affect sectors and systems in Cleveland.

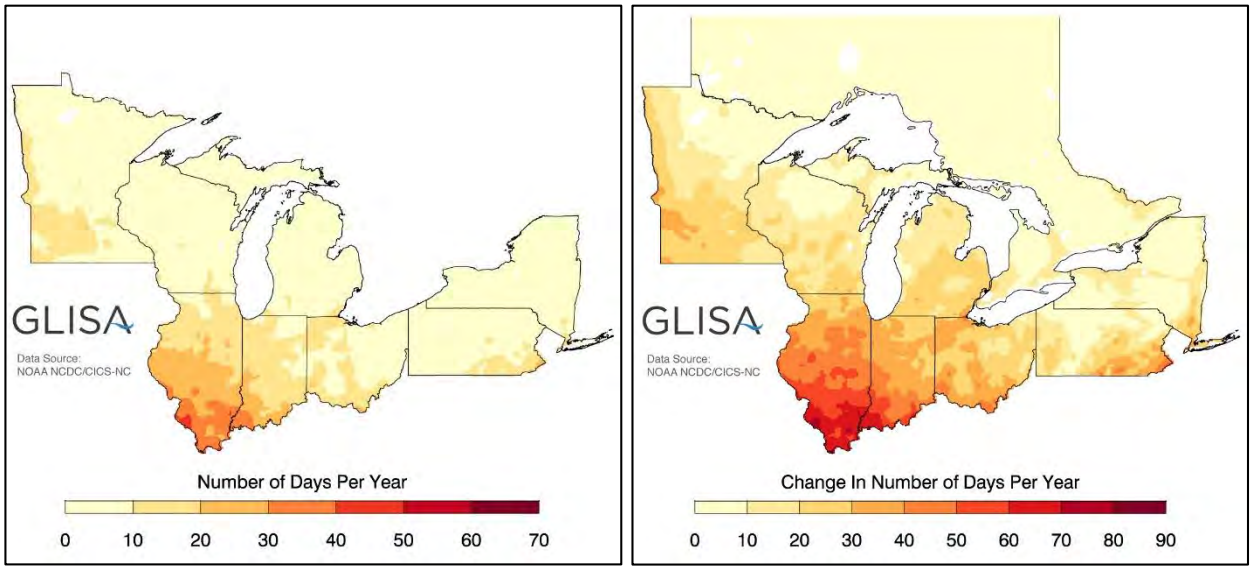
3.1. Public Health

Human vulnerability to the impacts of climate change has a health, social and economic dimension. Of those impacts, heat-related threats are commonly associated with climate change. In Cleveland, the number of days with temperatures over 90 °F has increased by 4.2 days from the year 1956 to 2012 (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012), it is projected that by the year 2070 the number of days will increase by an additional 20-30 days (Figure 2). Changes in vector borne disease patterns, such as the increased risk of the West Nile virus, have also been linked to a changing climate.

In addition to heat waves, increased humidity and degraded air and water quality both impact public health. These impacts are exacerbated if extreme weather events occur, as witnessed with the recent heat wave in India that resulted in the death of over a thousand people and hospitalizing hundreds (Liberto 2015), an event predicted in previous climate change research (Murari, Ghosh et al. 2015).

It is crucial to understand, though climate change is a challenge that faces everyone, the impact is not distributed proportionately. Minorities living in areas characterized by high poverty rates, aging infrastructure, air pollution, degraded urban spaces, lack of access to health care and basic

services are more vulnerable to the negative impacts of climate change. This indicates a need for community based responses that strengthen local ability to prevent morbidity and mortality.



Figures 1 & 2: Historical Number of Days Over 90°F (left) and Projected Change in the Number of Days Over 90°F, Emissions Scenario B1, 2041-2070 (right). S*ource: GLISA, NOAA NCDC/CICS-NC*

3.2. Water Quality

Climate change can have a variety of impacts on water quality. Warming water temperatures accompanied with increased evaporation rates, decreasing water levels intensifies the range of risks to Lake Erie's chemistry and ecology (Baule, Gibbons et al. 2014). This includes harmful algal blooms as a result of reduced water velocities and higher lake water residence time (Whitehead, Wilby et al. 2009). In addition, increased nutrient loading in the lake is intensified by stronger storms and runoff from impervious surfaces (Baule, Gibbons et al. 2014, Winkler, Andresen et al. 2014). Increases in water acidity as a direct consequence of the elevating carbon dioxide levels may also occur (Baule, Gibbons et al. 2014).

The competition for freshwater will also increase the challenges facing water managers to meet the varying needs of communities. Flooding and heavy precipitation events can cause uncontrolled sewer discharges from urban area to surrounding water courses. Erosion and increased storm-induced agricultural runoff can lead to non-point source pollution of watersheds (Winkler, Andresen et al. 2014). With older infrastructure in many neighborhoods of the city, reinforcing the city's overall aging sewer and water infrastructure is critical.

Pollution from agricultural runoff and wastewater discharges results in a decline of beach health, limiting the economic and recreational benefits of Lake Erie. Pollution of beaches also degrades beach habitat for animals and plants, increases public health risks, and reduces surrounding property values (EPA 2015).

3.3. Food Systems

The impacts of climate change on the food systems are complex, with direct correlation to the existing socioeconomic conditions. Existing research discusses the role of climate change on agricultural yields and food quality (Winkler, Andresen et al. 2014). In the Midwest, the frost-

free season has lengthened by a total of 9 days from 1958-2012 (Great Lakes Integrated Sciences + Assessments, Michigan Office of the State Climatologist et al. 2012). In the next few decades, longer growing seasons and rising carbon dioxide levels may increase the yield of some crops.

However, those benefits are expected to be progressively offset by extreme weather events such as flooding, wildfires, and drought. At the same time, spring freeze events during the initial stages of development of crops will increase over time, resulting in production losses. In the long term, climate change is expected to decrease agricultural productivity. The impacts of climate change on food systems also extend to livestock production through warming temperatures, drought, and limited water availability.

3.4. Forests and Land Cover

Changes in land cover is directly associated with impacts on the natural and built environment. While land cover consistently evolves over time as a result of social and economic conditions (Loveland, Mahmood et al. 2012), alterations that result from climate change need to be addressed. For example, the composition of forests is altering as the climate warms. Driven by higher temperatures and increasing concentration of carbon dioxide, changes in the ecological communities and processes of forest are more likely to occur (Winkler, Andresen et al. 2014). Continuous changes in land-use and invasive species can also diminish a city's tree canopy.

Species invasion is becoming more prevalent as a result of climate change. While many tree species are migrating northward to areas with more favorable climate conditions, with more southerly varieties replacing them, iconic tree species will slowly be replaced by other species in the next century (Baule, Gibbons et al. 2014, Winkler, Andresen et al. 2014). Moreover, outbreaks of pathogens, wildfires, and high winds aggravate the risks to the forest sector.

3.5. Energy and Industry

Cleveland has an energy-intensive economy with per capita greenhouse gas emissions higher than the national average (City of Cleveland Office of Sustainability 2013). Warmer temperatures will reduce building heating loads, but these gains may be offset by increased reliance on air-conditioning and cooling requirements for buildings.

Besides changing patterns of energy consumption, climate change will impact energy production. Decreasing hydropower and increasing demands for water used for cooling of power plants impact the efficiency of power generation. Increasing peak demand for electricity will most likely occur in the summer; this will require the need for investments in sufficient energy infrastructure and increased electric generating capacity (Whitehead, Wilby et al. 2009, Wilbanks, Fernandez et al. 2014). The combined effects of increased demand for electricity and depleting water supplies as a result of warming temperatures and evaporation rate place further pressures on existing water resources.

3.6. Transportation Systems

While most transportation system designs take into account extreme weather events by referring to historical records, the evolving impacts of climate change indicate the need for a more reliable predictor of future weather events (National Research Council . Transportation Research, National Research Council . Committee on Climate et al. 2008). Though damages to local transportation infrastructure are anticipated, the accumulated effect will increase the risk of disruption to land, air and marine based transportation systems on a national level (National

Research Council . Transportation Research, National Research Council . Committee on Climate et al. 2008, Baule, Gibbons et al. 2014, Winkler, Andresen et al. 2014).

On a local level, an increased number of freeze-thaw cycles, flooding and erosion, lake effect snow, and heat waves may cause significant damage to existing transportation infrastructure such as heat damage to pavements and rails. These changes require increased maintenance costs and may hinder the construction of new road and highway systems and disrupt traffic movement. On the positive side, reduced annual amounts of snowfall cover may improve mobility and reduce costs related to snow and ice removal.

Ice cover declines will lengthen the commercial navigation season on Lake Erie (Baule, Gibbons et al. 2014). Yet, declining water levels in the Great Lakes region pose new restriction on ship weights. Extreme precipitation events may impede shipping and navigation processes accompanied by physical damage to docks and harbor facilities (Winkler, Andresen et al. 2014).

3.7. Fish and Wildlife

The impact of climate change of fish and wildlife are numerous including habitat fragmentation, life cycle disruption, and the interaction with new species (Winkler, Andresen et al. 2014). Warmer air temperatures and changes in rainfall patterns place certain species at more risk than others. The effects of increased heat stress, flooding, and late spring freezes on natural and developed ecosystems may be magnified by pest prevalence, increased competition from non-native or opportunistic native species, ecosystem disturbances, and land-use change.

Aquatic ecosystems are equally or more sensitive to change in the climate system as humans. Increased water temperatures and atmospheric concentration of carbon dioxide have a direct impact on the fish populations and their life cycles. Some migrating species and hibernation patterns are connected to climatic conditions; with changes to these conditions, a disruption of these patterns is likely to occur. Stress on Lake Erie is also intensified due increased temperature stratification and hypoxic conditions (Winkler, Andresen et al. 2014). Therefore, fish and wildlife planning and management must take into account the impacts of climate change on these systems.

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Appendix D:

Historical Climatology: Cleveland, Ohio

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Historical Climatology: Cleveland, Ohio

GLISA
A NOAA RISA TEAM

Overview and Geography

Cleveland, Ohio is located in Northeastern Ohio on the southern shore of Lake Erie. It's the county seat of Cuyahoga County, the most populous county in the state. Cleveland sits atop a series of bluffs that run perpendicular to the lake. As a result, the land rises quickly from the lakeshore to approximately 800 feet near the location of this climatology station at Hopkins airport.

Relative to the rest of the Great Lakes region, Cleveland typically experiences hot and humid summers and generally mild winters with cold snaps and abundant snowfall. Lake-effect snowfall is a frequent occurrence. By some measures, Cleveland is at the western end of the Lake Erie snow belt. Lake effect snowfall is more pronounced in eastern areas of the city than in western sections where the observations described here were taken.

Summary of Observed Changes

Rising average temperatures: Annual average temperatures warmed by 2.4°F from 1956-2012, faster the national and global rates. Average low temperatures have warmed faster than high temperatures.

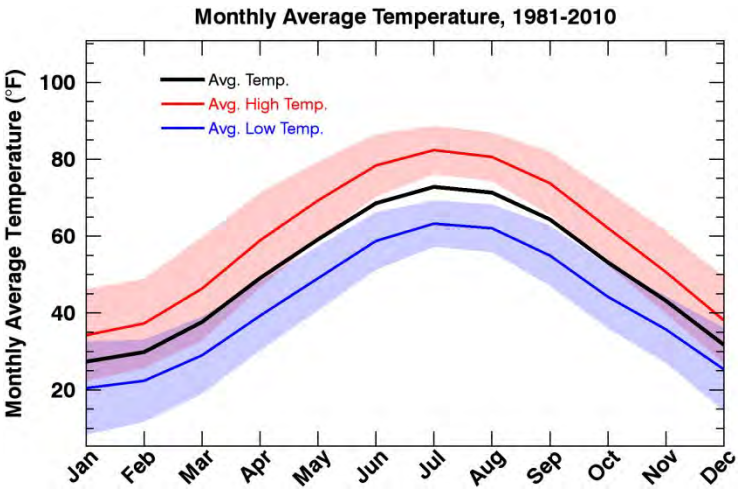
Longer freeze-free season: The freeze-free season (growing season), lengthened by 20 days from 1956-2012.

More precipitation: Total annual precipitation increased steeply by 25.8% from 1956 through 2012 while summer precipitation remained relatively unchanged.

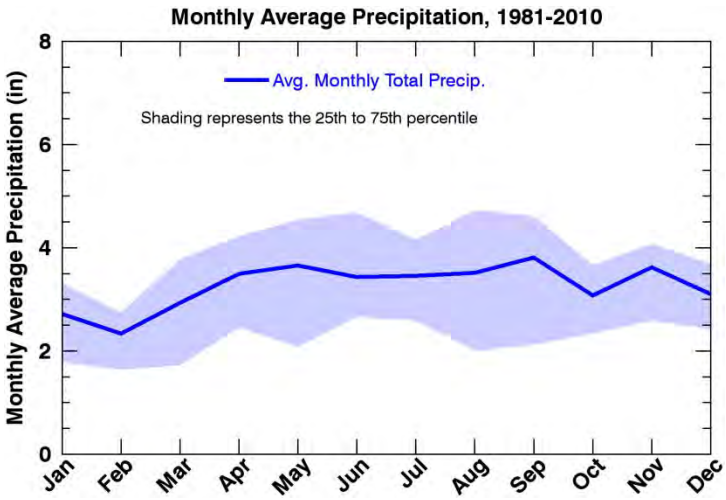
More heavy precipitation: From the 1961-1990 period to the 1981-2010 period, the amount of precipitation falling during the heaviest 1% of precipitation events increased by 22.2%.

Recent Climate Summary: 1981-2010 Temperature and Precipitation

Average Temperature	50.8°F
Average Low Temperature	42.1°F
Average High Temperature	59.4°F
Days/Year that exceed 90°F	7.4
Days/Year that fall below 32°F	108.5
Lowest Annual Average Temperature	48.9°F
Highest Annual Average Temperature	53.6°F
Average Annual Precipitation Total (in)	39.1 in
Lowest Annual Precipitation Total (in)	29.6 in
Highest Annual Precipitation Total (in)	53.9 in
Days/Year that exceed 1.25" of Precipitation	3.6

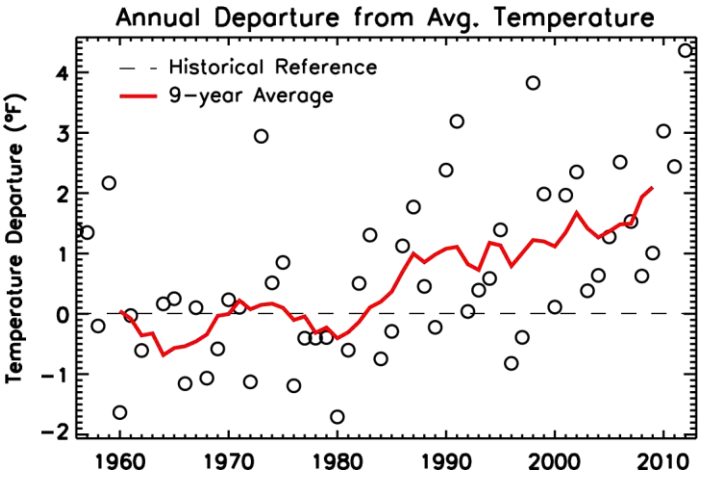


Average monthly temperatures during the 1981-2010 period. Shaded bands represent the standard deviation.

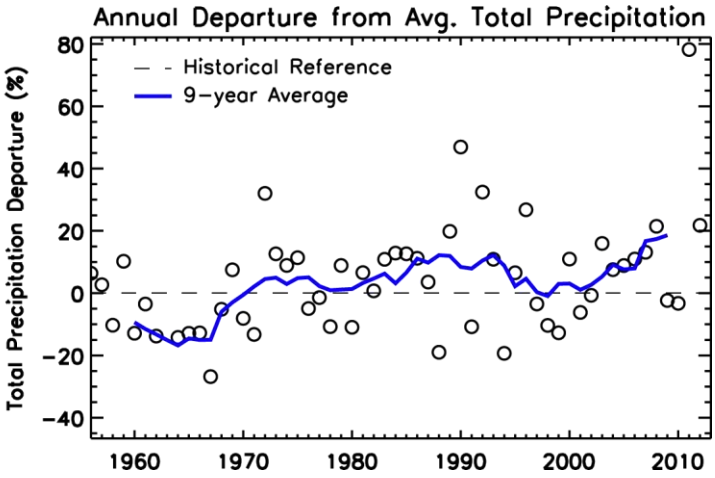


Average monthly total precipitation for the 1981-2010 period. The shaded band represents the 25th to 75th percentile.

Changes in Average Temperature and Precipitation



Annual departures from the 1961-1990 average annual temperature. The solid red line is the 9-year moving average. Open circles represent the departure for a single year.



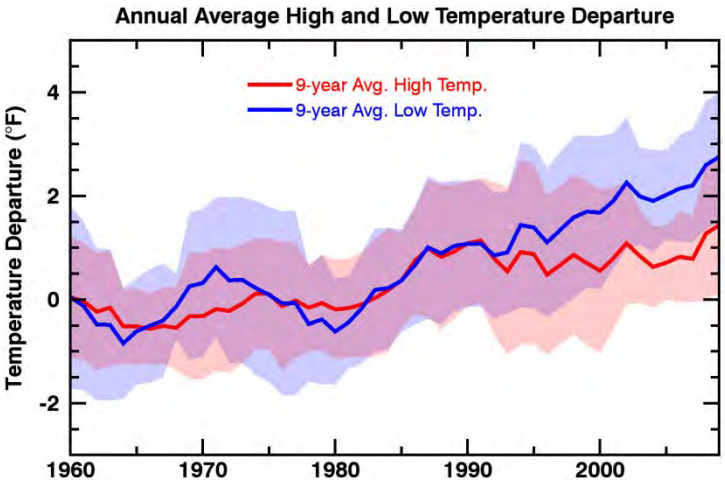
Annual departures from the 1961-1990 average of total annual precipitation. The solid blue line is the 9-year moving average. Open circles represent the departure for a single year.

Changes in Average Temperature from 1956 through 2012	°F	°C
Annual	*2.4*	*1.3*
Winter, December-February	3.4	1.9
Spring, March-May	2.7	1.5
Summer, June-August	2.6	1.5
Fall, September-November	0.7	0.4

Changes in Total Precipitation from 1956 through 2012	in	cm	%
Annual	*9.5*	*24*	*25.8*
Winter, December-February	2.9	7.3	40.4
Spring, March-May	1.4	3.5	14.3
Summer, June-August	0.1	0.2	0.8
Fall, September-November	5.3	13.3	57.4

Typical for the Midwestern United States, temperatures have been rising steadily since the 1960s. Annual average temperatures warmed by 2.4°F from 1956-2012, faster than the national and global rates. While all seasons have warmed, winter has warmed significantly faster and the fall significantly slower.

Annual precipitation totals rose steeply by 25.8% from 1956-2012, which is well above the trend for the surrounding region. Winter, spring, and fall have seen an increase in precipitation, with summer remaining relatively stable a noticeably smaller increase compared to the 1961-1990 average.

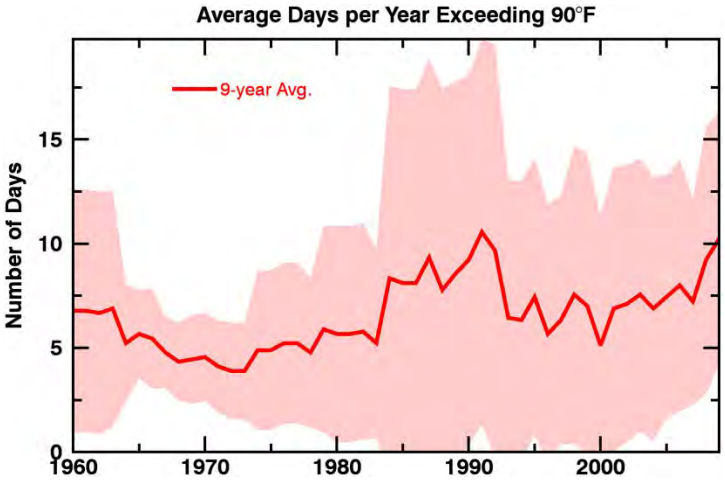


Changes in Average High and Low Temperatures from 1956-2012	°F	°C
Highs	**+1.8**	**1**
Lows	**+3.0**	**1.7**

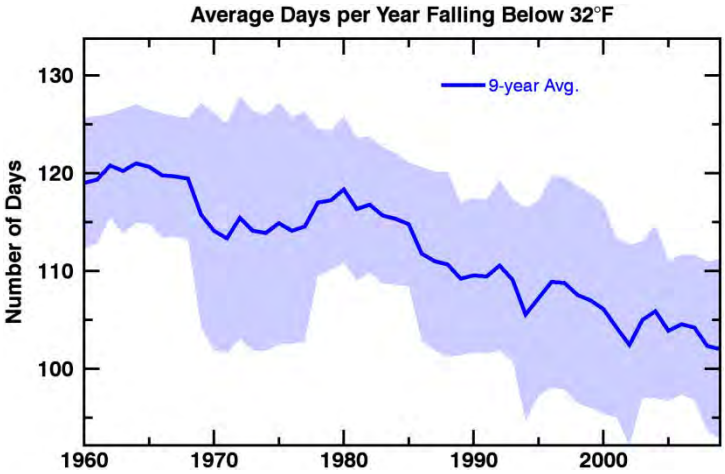
Overnight low temperatures warmed faster than mid-day high temperatures from 1956 through 2012. This may mean that temperatures have been cooling less overnight than they have warmed during mid-day.

Left: Departures from the 1961-1990 average high and low temperatures. The red and blue lines are the 9-year moving averages. The shaded bands represent the standard deviations.

Changes in Hot and Cold Days



The red line represents the 9-year moving average of the number of days per year exceed 90°F. The shaded band represents the standard deviation.

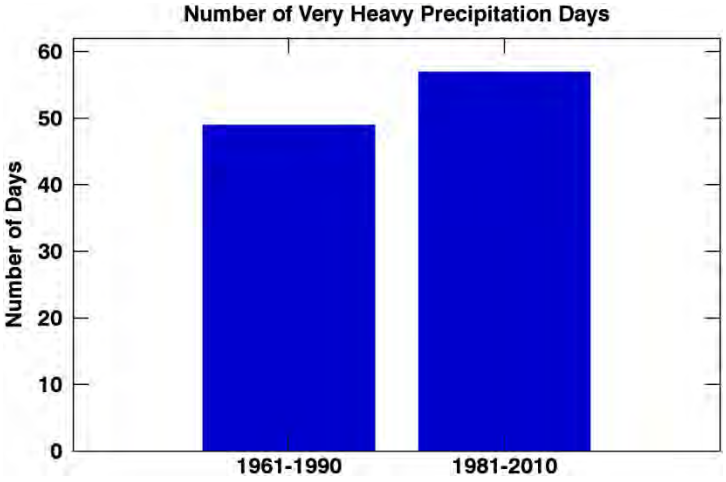


The blue line represents the 9-year moving average of the number of days per year falling below 32°F. The shaded band represents the standard deviation.

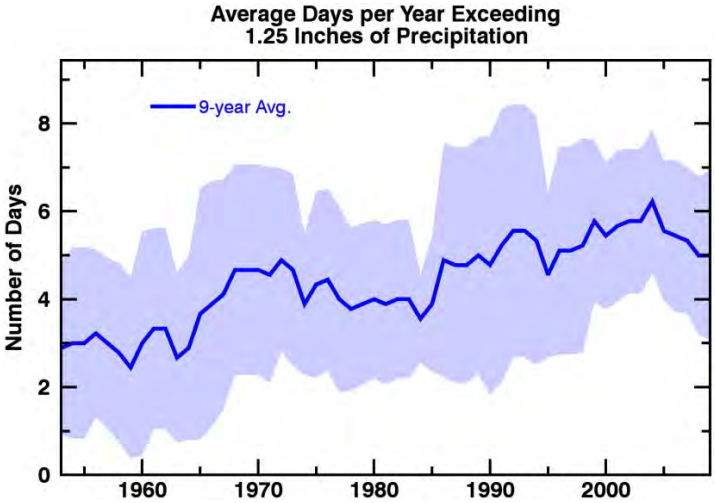
The number of days per year that exceed 90°F has increased slightly by 4.2 days from 1956 through 2012. Even as average temperatures have warmed across the region, the number of days per year exceeding 90°F remains variable throughout the region.

The number of days per year that record a freezing temperature dropped by 19.2 from 1956 through 2012, consistent warmer temperatures, an increase in the growing season and shorter winters.

Heavy Precipitation



The number of daily precipitation totals for the 1961-1990 and 1981-2010 periods that exceeded the size of the heaviest 1% of storms as defined by the 1961-1990 period.

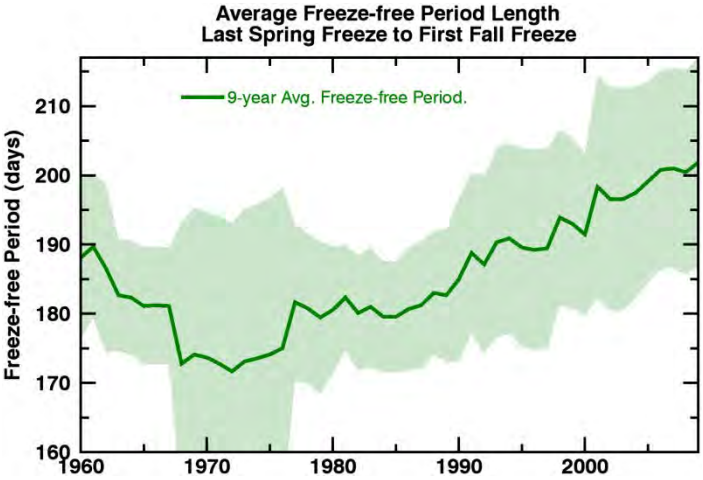


The blue line represents the 9-year moving average of the number of days per exceeding a daily total of 1.25 inches of precipitation. The shaded band represents the standard deviation.

A "Very Heavy" Precipitation Day, as defined by the National Climate Assessment, is in the top 1% of daily precipitation totals. These precipitation events are typically disruptive and can cause infrastructure damage. Cleveland has seen a 16.3% increase in the number of these precipitation events (49 storms from 1961-1990 to 57 storms from 1981-2010). The cumulative change in the precipitation falling during these events was 22.2%.

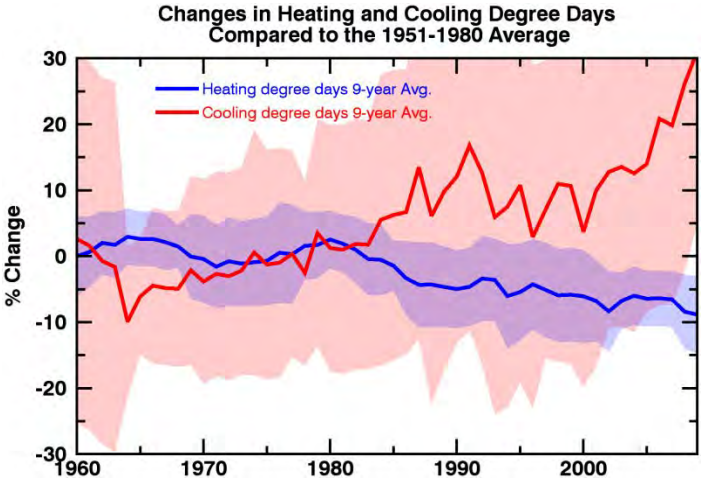
Daily precipitation totals that exceed 1.25" may lead to nuisance flooding and minor infrastructure impacts in some areas. Cleveland now sees approximately 3.6 such days per year, 1.5 more per year, on average, than in the past.

Changes in Seasonality



The freeze-free season (growing season), lengthened by 20 days from 1956-2012. The average date of first freeze is arriving 9.4 days later and the average date of last freeze is arriving 10.6 days earlier. An abnormally short freeze-free period in 1972 of 121 days is responsible for the short-term drop in the 9-year moving average through the late 60s and early 70s.

Left: The green line represents the 9-year moving average of length of the time between the last freeze of spring and the first freeze of fall, the freeze-free period. The shaded band represents the standard deviation.



The percent change in heating and cooling degree day units from the 1961-1990 average. The red and blue solid lines represent the 9-year moving average. The shaded bands show the standard deviation.

Heating and cooling degree days are indexed units, not actual days, which roughly describe the demand to heat or cool a building. Cooling degree days accumulate on days warmer than 65°F when cooling is required. Heating degree days accumulate on days colder than 65°F when heating is required. Extremely hot days accumulate heating degree day units faster than a mildly warm day, and similarly, bitterly cold days accumulate cooling degree day units much faster than a mildly chilly day. Cleveland sees far more days that require heating than it does days that require cooling, and so it accumulates far more heating degree days than cooling degree days in a given year.

From 1956 through 2012, total annual cooling degree days have increased by 28% while heating degree days have fallen by 11%, consistent with warming temperatures. Due to its relatively cool, Midwestern climate, however, the actual decline of 679 heating degree day units has outpaced the increase of 190 cooling degree day units.

Data was recorded at Hopkins Airport, WBAN ID: 14820. While the entire climate record is longer than what is presented here, the station was relocated in 1956 following other systemic changes. As a result, temperature data recorded before that time may be discontinuous with highly reliable data recorded during and after 1956, presented here.

Appendix E:

County and Neighborhood Vulnerability Maps

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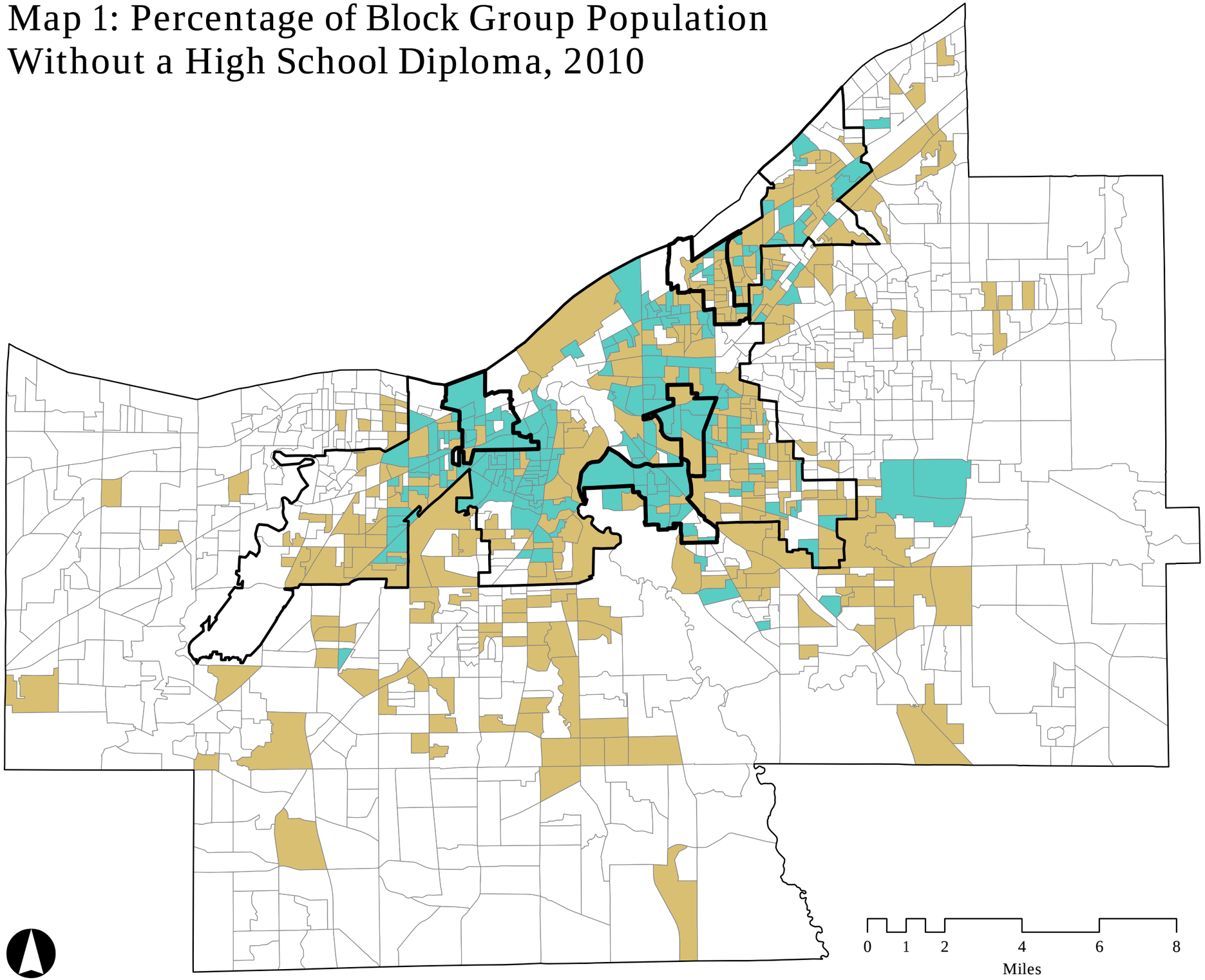
VULNERABILITY MAP MATRIX

				Social Factors					
				Map 1	Map 2	Map 3	Map 4	Map 5	Map 6
				Without a High School Diploma A percent of total population within block group	**Over the Age of 65** A percent of total population within block group	**Non-White** A percent of total population within block group	**Living Below Poverty Level** A percent of total population within block group	**Living in Rental Properties** A percent of total population within block group	**Without a Vehicle** A percent of total population within block group
				Low: 0% - 15% **Medium**: 16% - 28% **High**: 29% - 70%	**Low**: 0% - 15% **Medium**: 16% - 22% **High**: 23% - 67%	**Low**: 0% - 42% **Medium**: 43% - 78% **High**: 79% - 100%	**Low**: 0% - 18% **Medium**: 19% - 36% **High**: 37% - 100%	**Low**: 0% - 38% **Medium**: 39% - 64% **High**: 65% - 100%	**Low**: 0% - 14% **Medium**: 15% - 29% **High**: 30% - 88%
Physical Factors	Map I and I-A	**Land Coverage: Impervious Surface** A percent of total land cover within block group	**Low**: 0% - 43% **Medium**: 44% - 57% **High**: 58% - 89%	I-1	I-2	I-3	I-4	I-5	I-6
	Map T and T-A	**Land Coverage: Tree Canopy** A percent of total land cover within block group	**Low**: 0% - 28% **Medium**: 29% - 41% **High**: 42% - 76%	T-1	T-2	T-3	T-4	T-5	T-6
	Map B	**Buildings Constructed Before 1939** A percent of total buildings within block group	**Low**: 0% - 32% **Medium**: 33% - 60% **High**: 61% - 100%	B-1	B-2	B-3	B-4	B-5	B-6
	Map F amd F-A	**FEMA Flood Zone** A percent of total land cover witihin block group	**Low**: 0% - 3% **Medium**: 4% - 12% **High**: 13% - 82%	F-1	F-2	F-3	F-4	F-5	F-6

Map 1: Percentage of Block Group Population Without a High School Diploma, 2010



Legend:

Social:
Without a High School Diploma

Low	1	0% - 15%
Medium	2	16% - 28%
High	3	29% - 70%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
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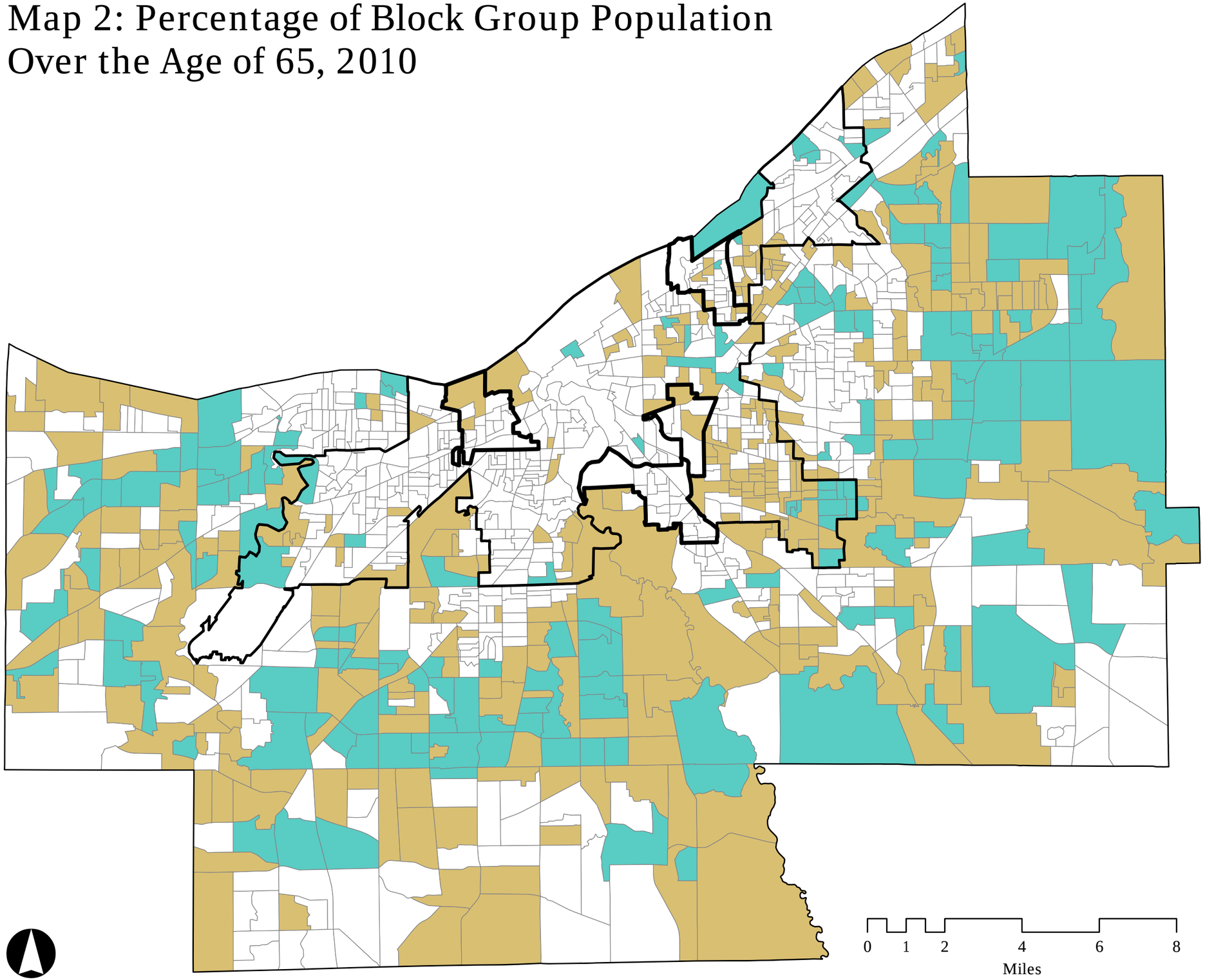
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

Map 2: Percentage of Block Group Population Over the Age of 65, 2010



Legend:

Social:
Over the Age of 65

Low	1	0% - 15%
Medium	2	16% - 22%
High	3	23% - 67%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
NEO CANDO,
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Projection:
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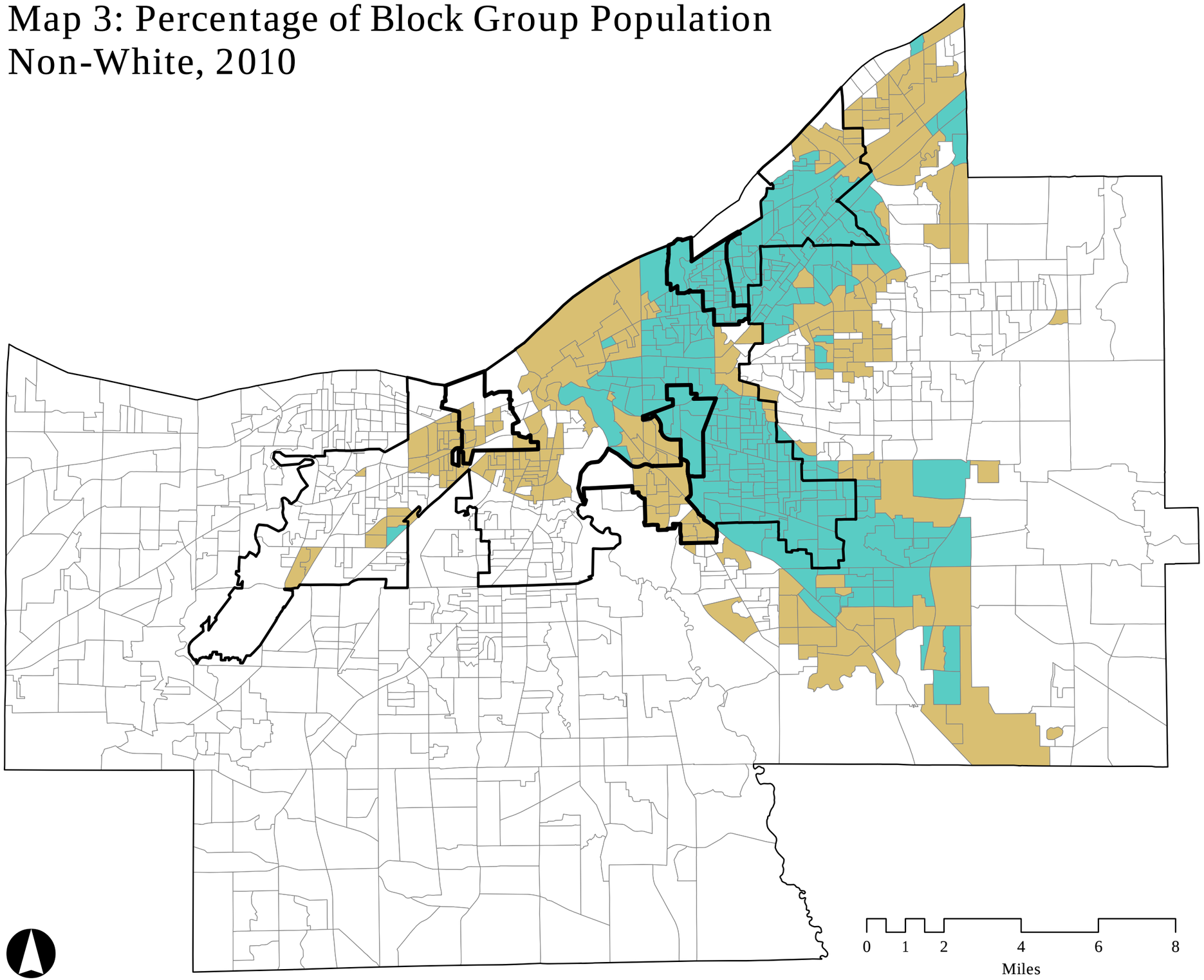
Maps Created:
Tuesday, June 23, 2015

Map 3: Percentage of Block Group Population Non-White, 2010



Legend:

Social:
Non-White

Low	1	0% - 42%
Medium	2	43% - 78%
High	3	79% - 100%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

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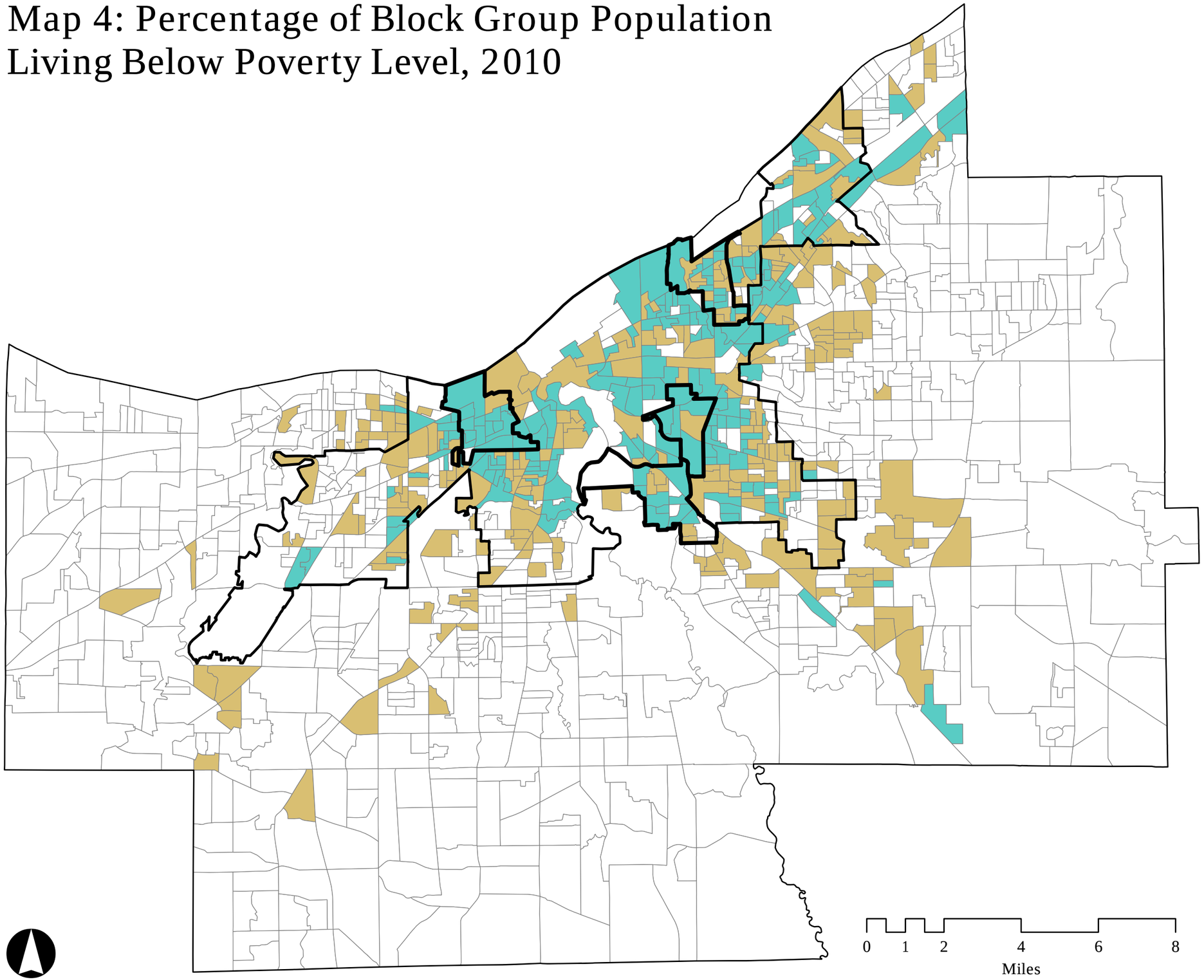
Maps Created:
Tuesday, June 23, 2015

Map 4: Percentage of Block Group Population Living Below Poverty Level, 2010



Legend:

Social:
Living Below Poverty Level

Low	1	0% - 18%
Medium	2	19% - 36%
High	3	37% - 100%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
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Projection:
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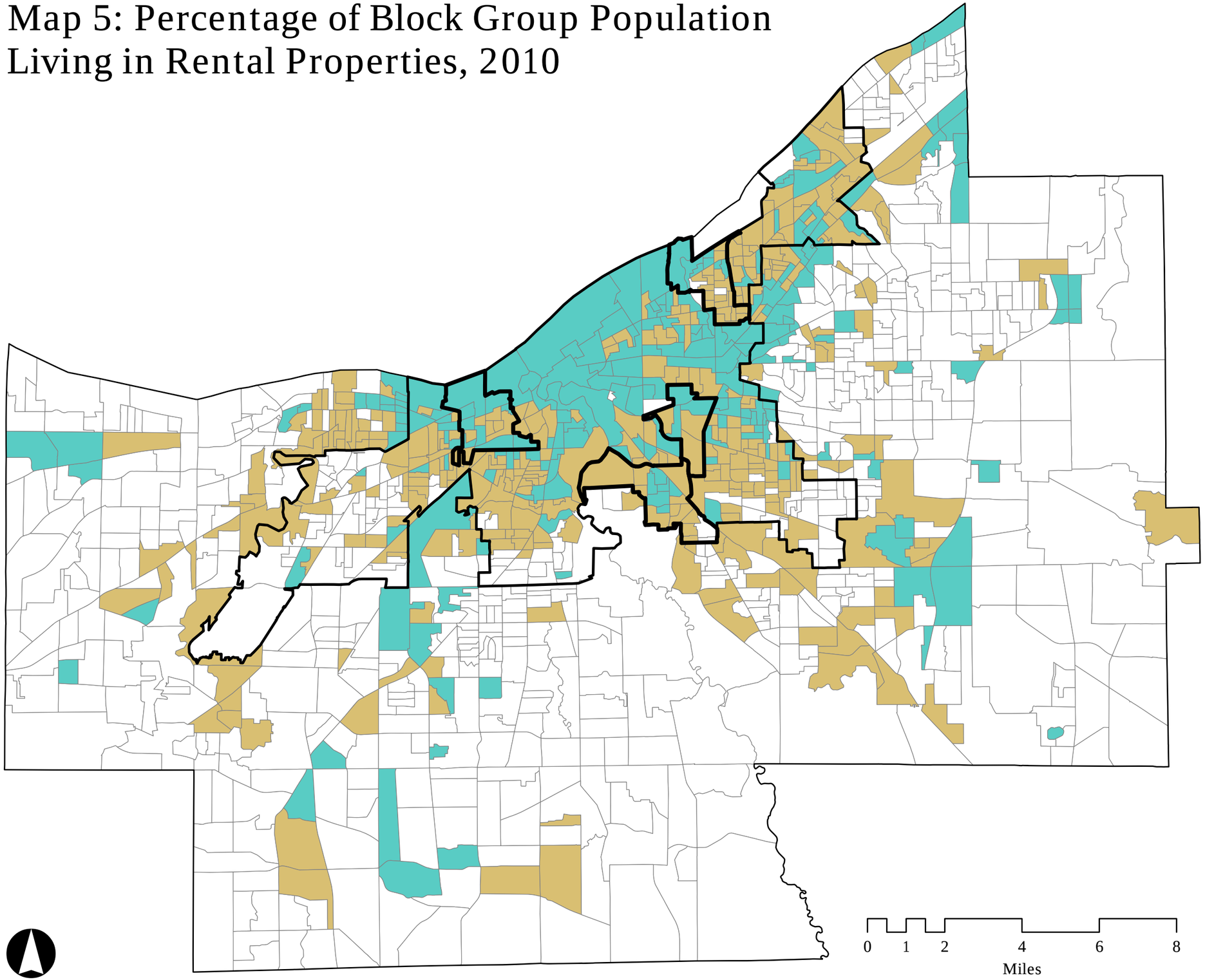
Maps Created:
Tuesday, June 23, 2015

Map 5: Percentage of Block Group Population Living in Rental Properties, 2010



Legend:

Social:
Living Below Poverty Level

Low	1	0% - 38%
Medium	2	39% - 64%
High	3	65% - 100%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
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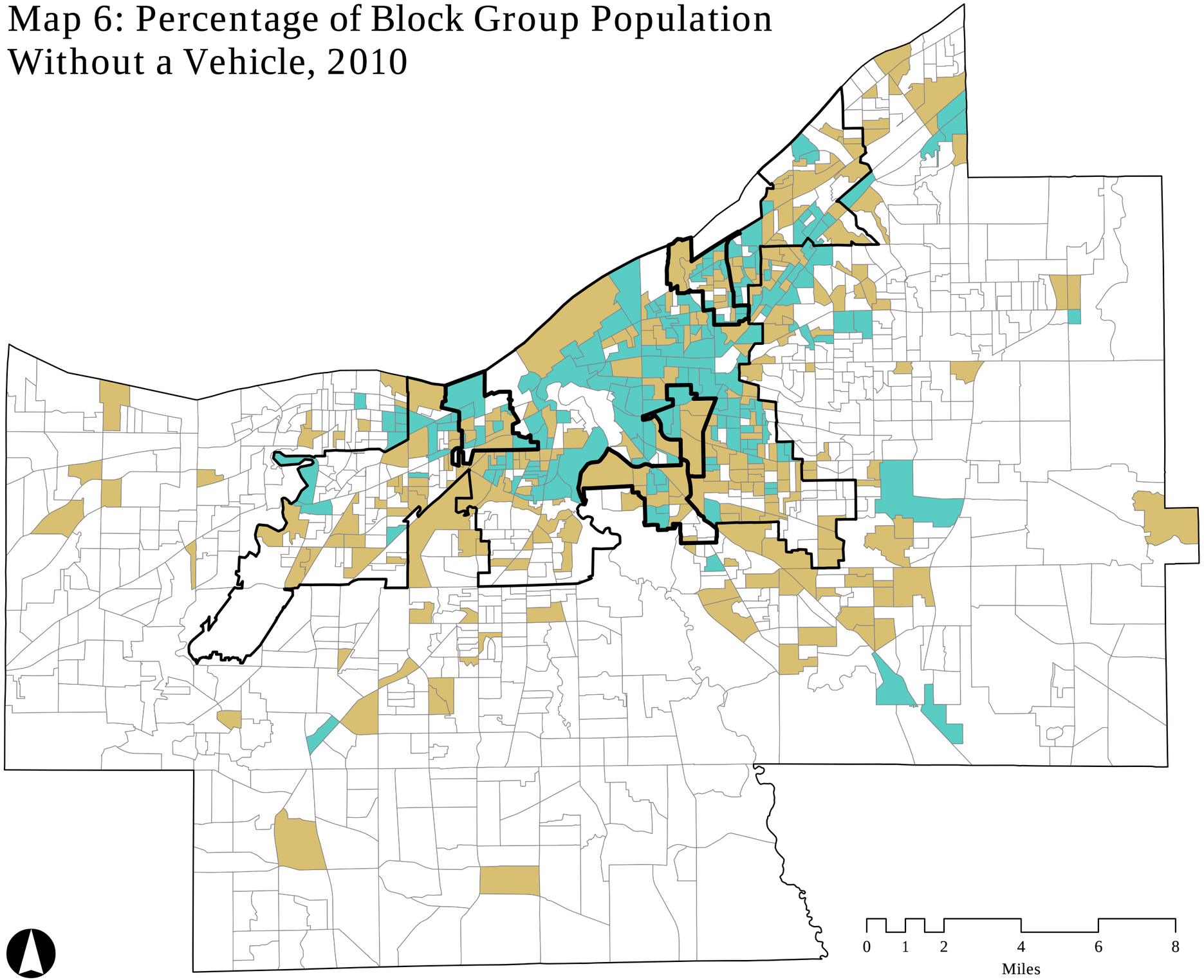
Maps Created:
Tuesday, June 23, 2015

Map 6: Percentage of Block Group Population Without a Vehicle, 2010



Legend:

Social:
Without a Vehicle

Low	1	0% - 14%
Medium	2	15% - 29%
High	3	30% - 88%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
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Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
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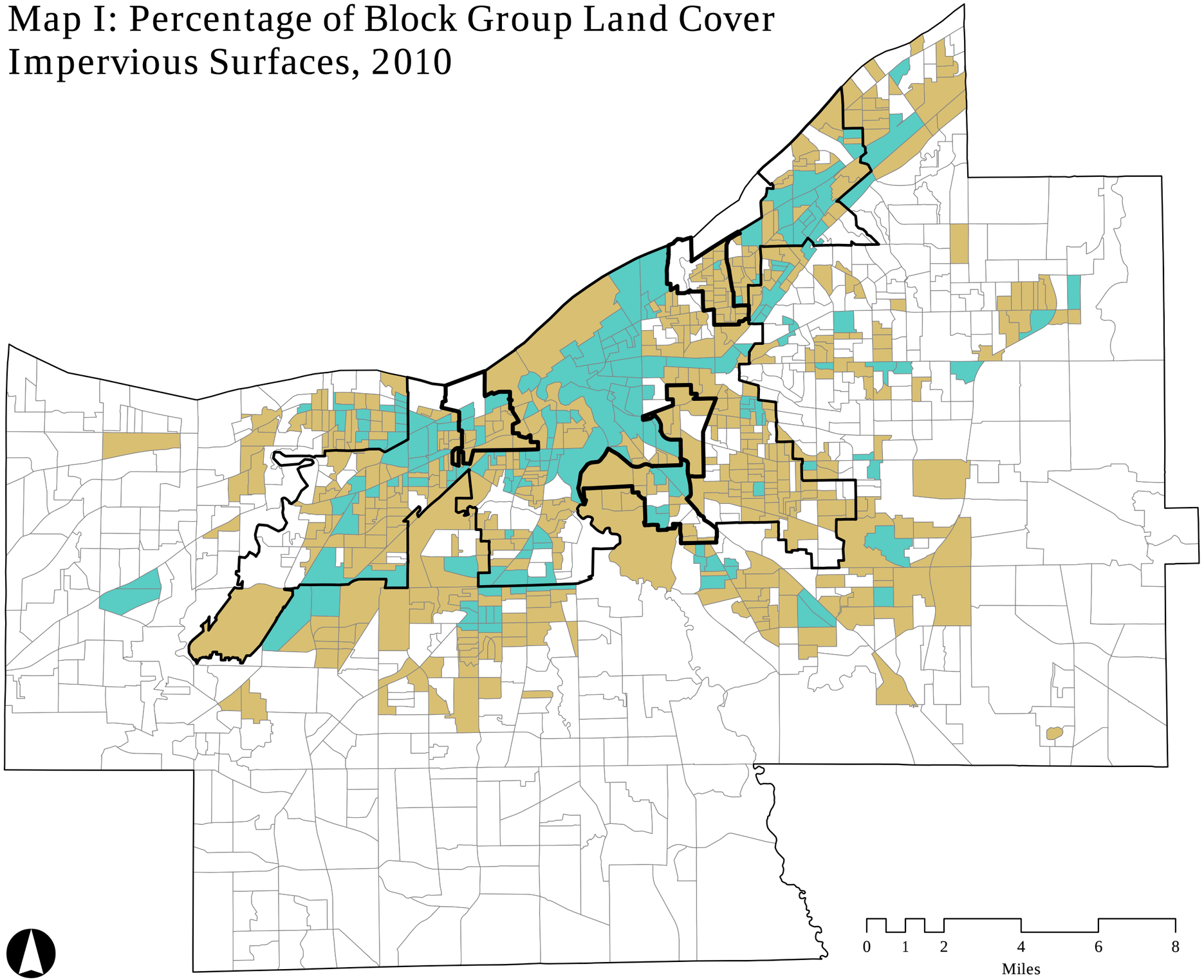
Maps Created:
Tuesday, June 23, 2015

Map I: Percentage of Block Group Land Cover Impervious Surfaces, 2010



Legend:

Physical:
Impervious Surfaces

Low	1	0% - 43%
Medium	2	44% - 57%
High	3	58% - 89%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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FEMA Flood Map Service Center

Projection:

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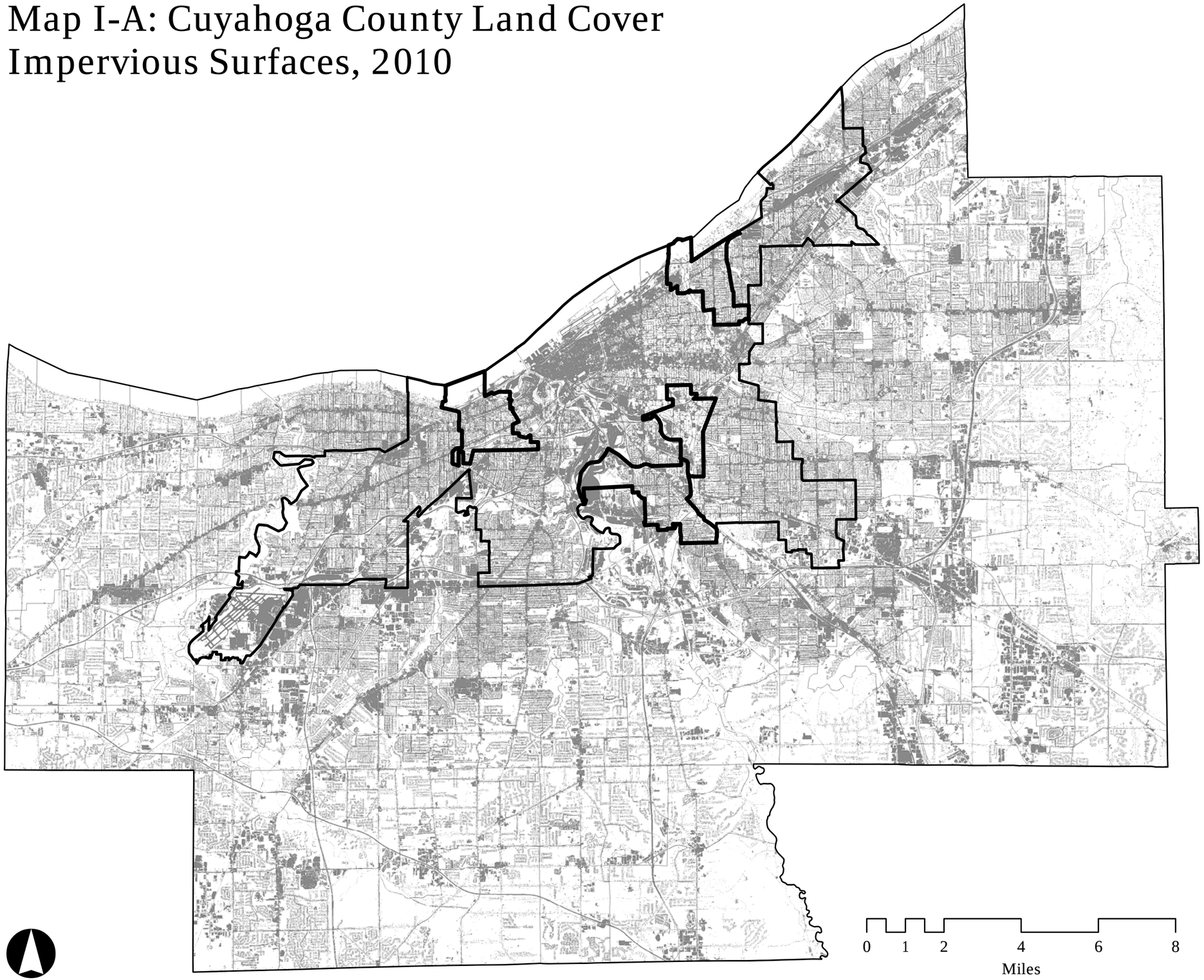
Maps Created:

Wednesday, June 24, 2015

Map I-A: Cuyahoga County Land Cover Impervious Surfaces, 2010



Legend:

Impervious Surfaces

- Buildings
- Roads / Railroads
- Other Paved Surfaces

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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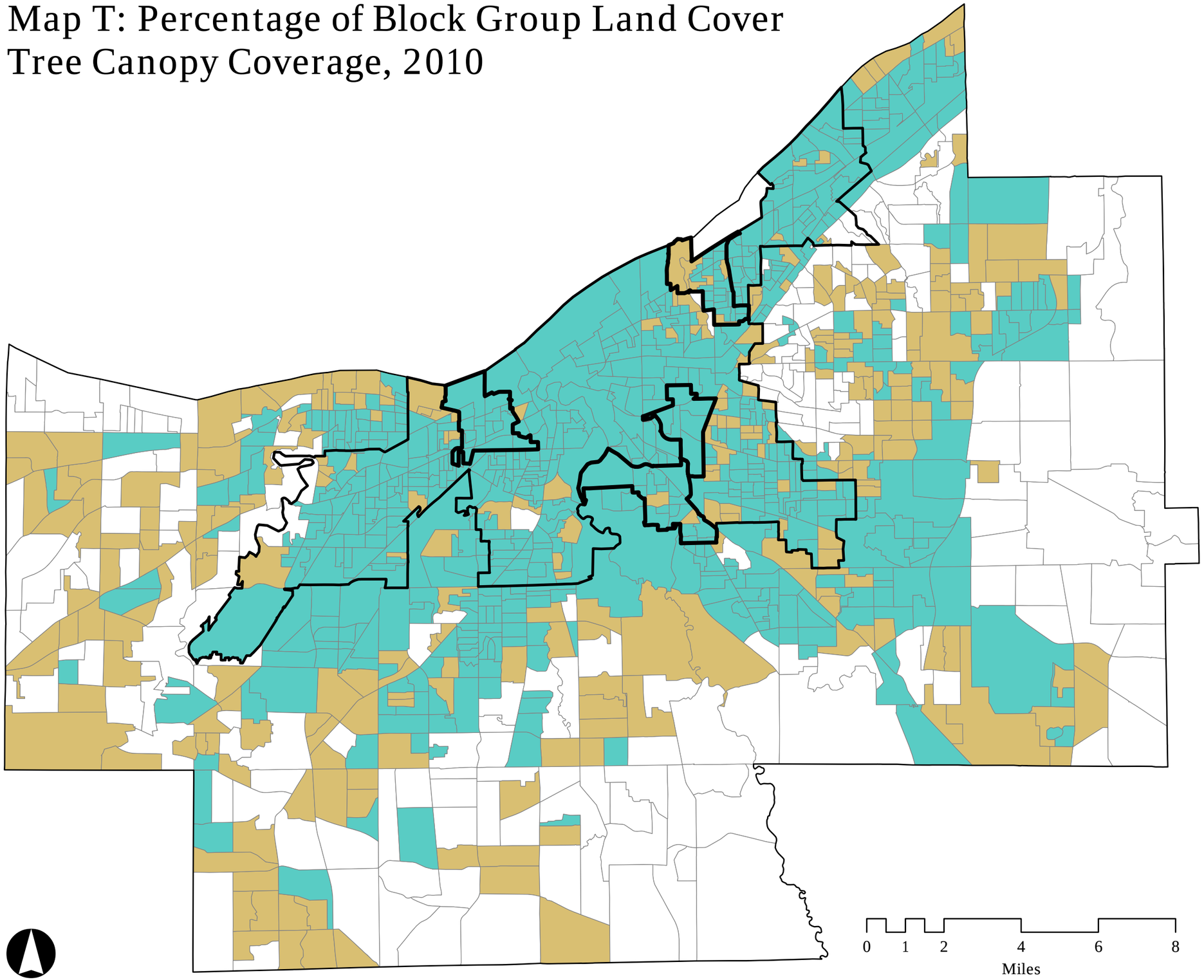
Maps Created:

Wednesday, June 24, 2015

Map T: Percentage of Block Group Land Cover Tree Canopy Coverage, 2010



Legend:

Physical:
Tree Canopy Coverage

High	1	42% - 76%
Medium	2	29% - 41%
Low	3	0% - 28%

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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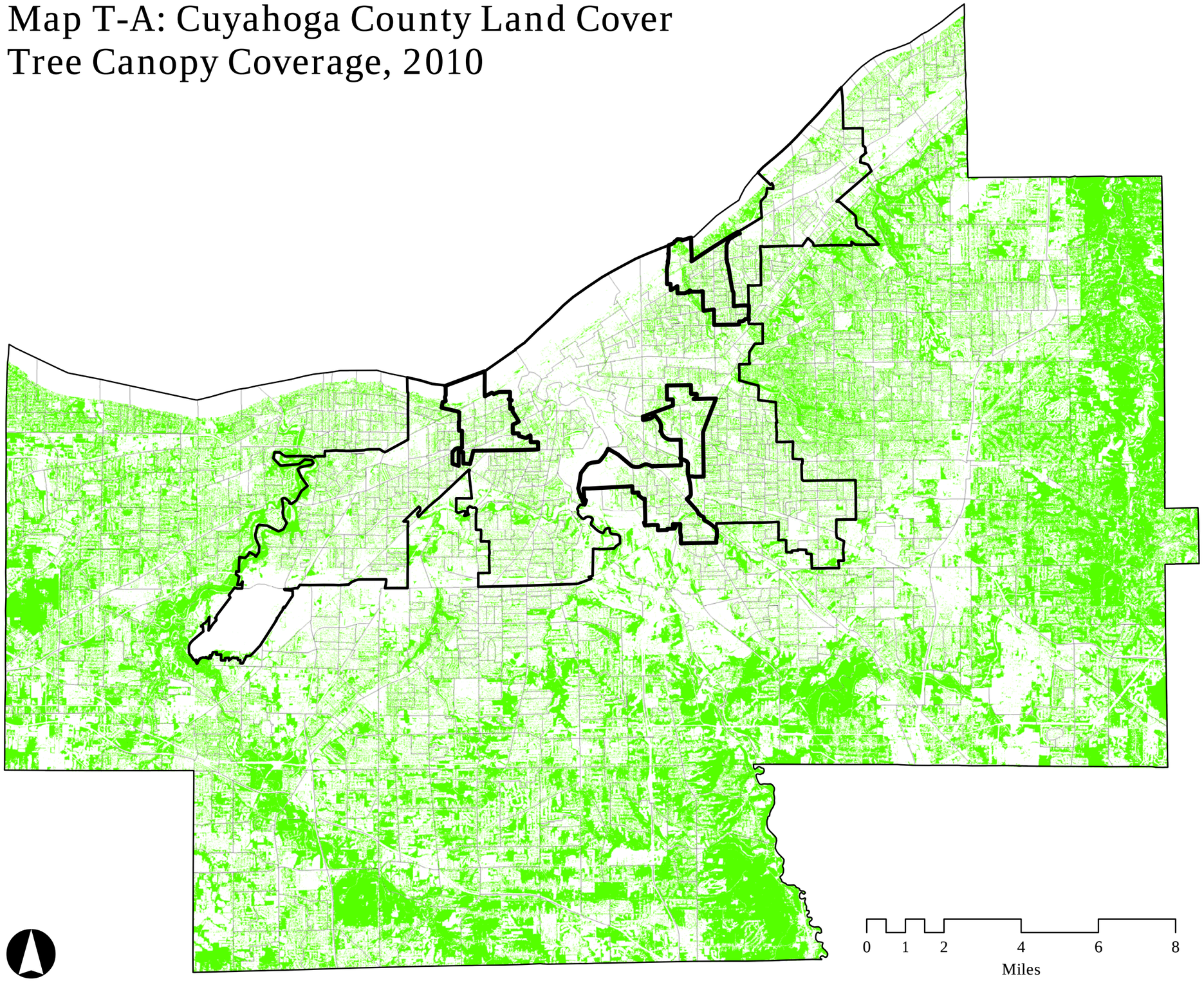
Maps Created:

Wednesday, June 24, 2015

Map T-A: Cuyahoga County Land Cover
Tree Canopy Coverage, 2010



Legend:

Tree Canopy Coverage

- Tree Canopy Over Vegetation
- Tree Canopy Over Building
- Tree Canopy Over Road
- Tree Canopy Over Paved Srf

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
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FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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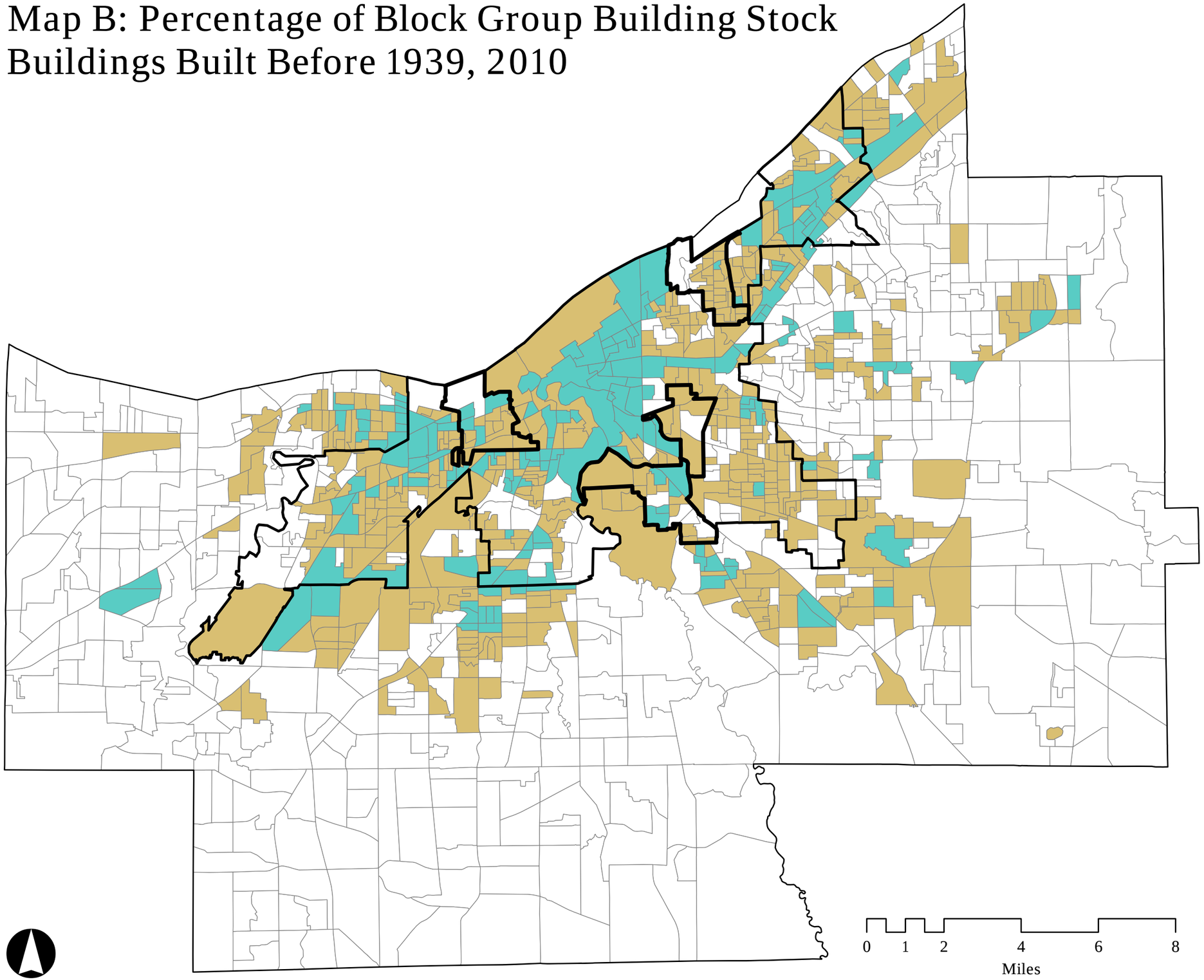
Maps Created:

Wednesday, June 24, 2015

Map B: Percentage of Block Group Building Stock Buildings Built Before 1939, 2010



Legend:

Physical:
Buildings Built Before 1939

Low	1	0% - 32%
Medium	2	33% - 60%
High	3	61% - 100%

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
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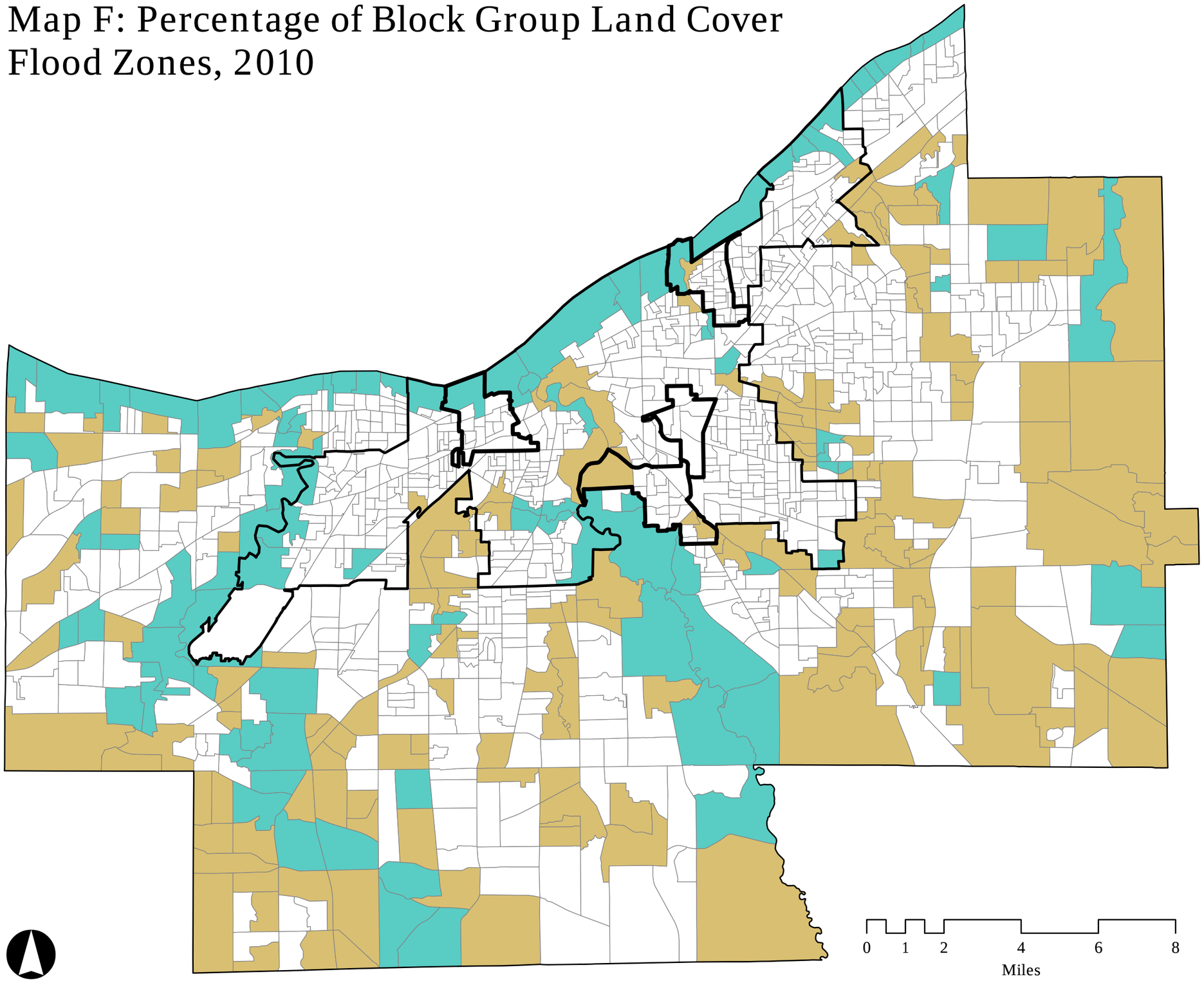
Maps Created:
Wednesday, June 24, 2015

Map F: Percentage of Block Group Land Cover Flood Zones, 2010



Legend:

Physical:
Flood Zones

Low	1	0% - 3%
Medium	2	4% - 12%
High	3	13% - 82%

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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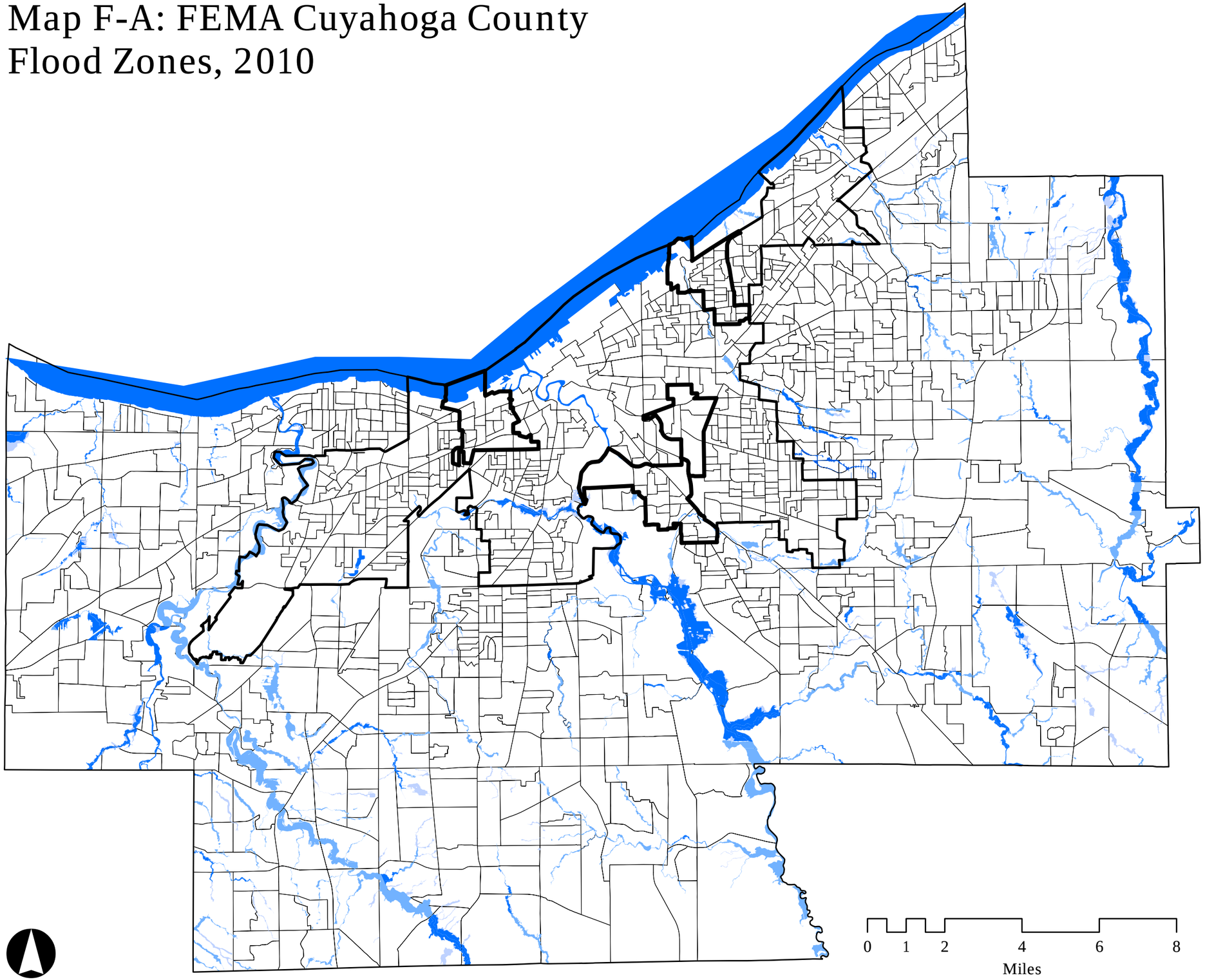
Maps Created:

Wednesday, June 24, 2015

Map F-A: FEMA Cuyahoga County Flood Zones, 2010



Legend:

FEMA Flood Zones

- 0.2 PCT Annual Chance
- A
- AE
- AH

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

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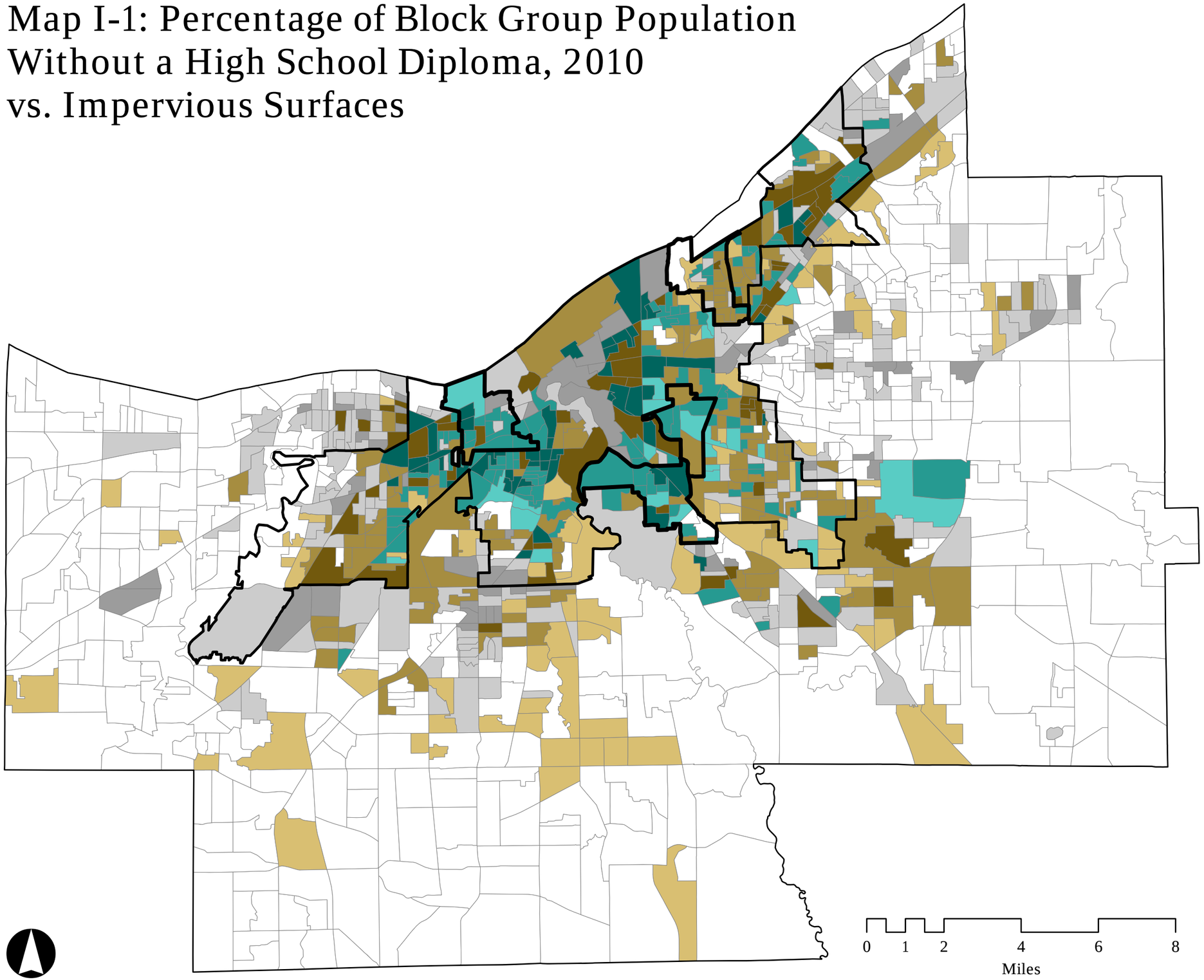
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Wednesday, June 24, 2015

Map I-1: Percentage of Block Group Population Without a High School Diploma, 2010 vs. Impervious Surfaces



Legend:

Social: Without a High School Diploma

Physical: Impervious Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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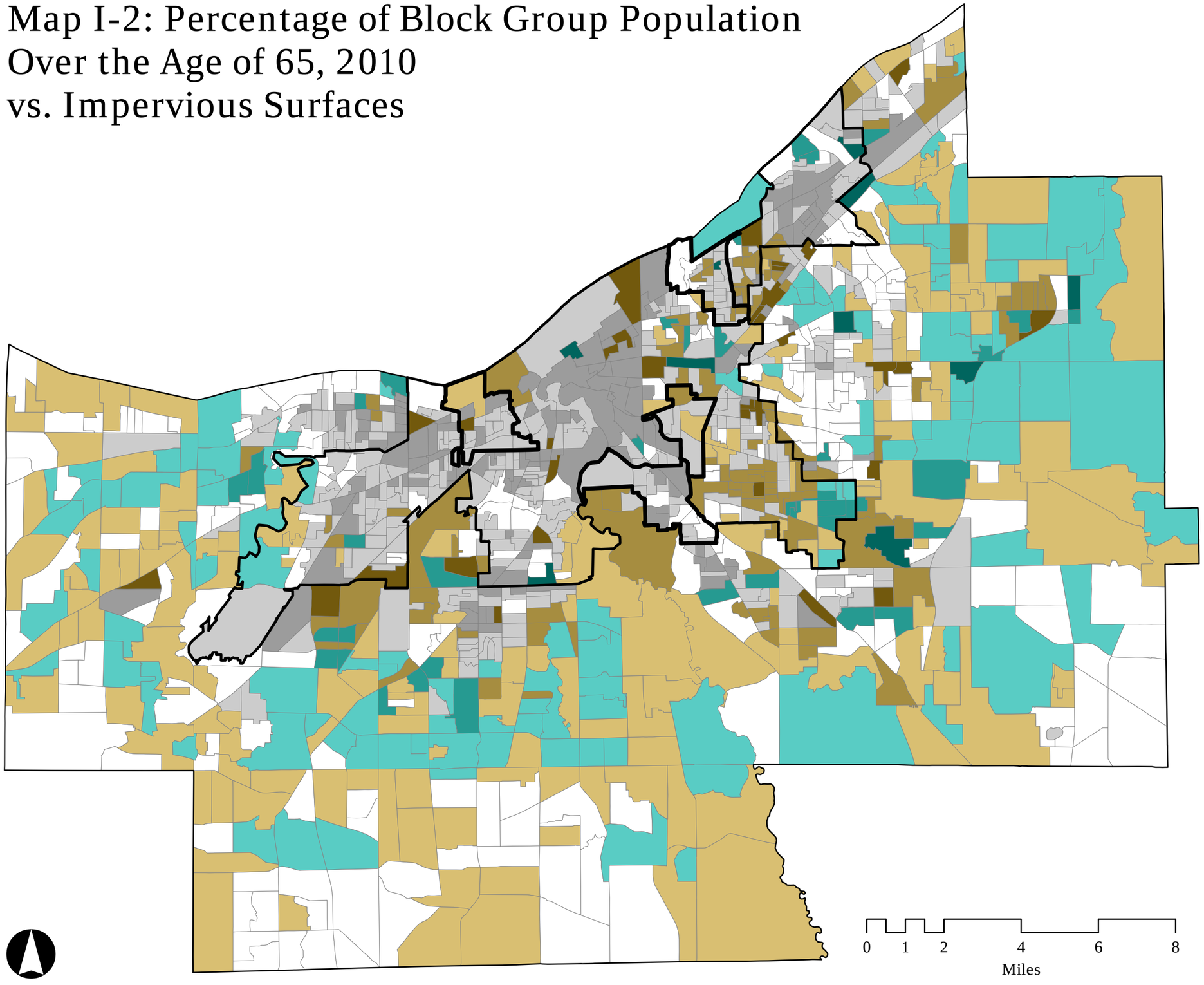
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map I-2: Percentage of Block Group Population Over the Age of 65, 2010 vs. Impervious Surfaces



Legend:

Social: Over the Age of 65

Physical: Impervious Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

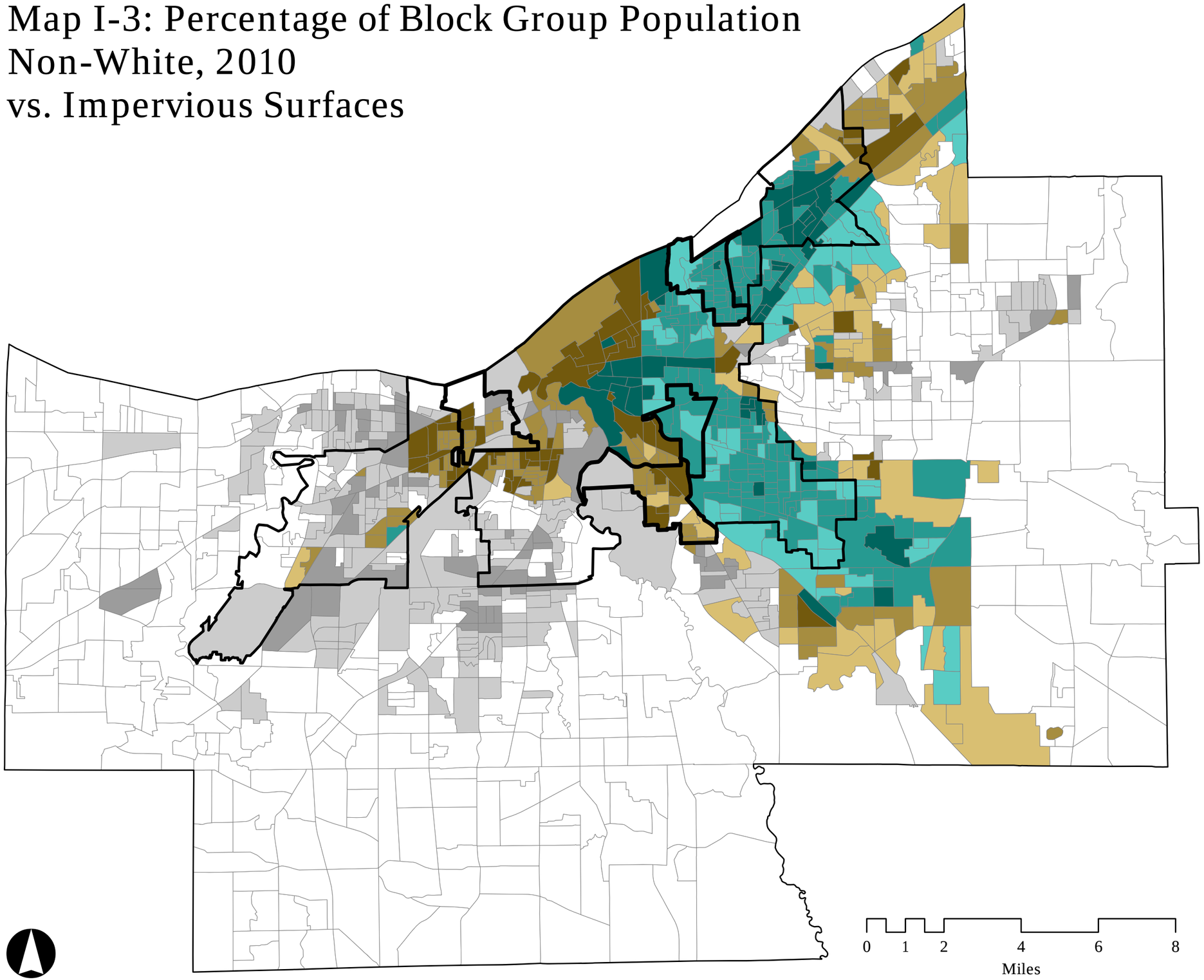
Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map I-3: Percentage of Block Group Population Non-White, 2010 vs. Impervious Surfaces



Legend:

Social: Non-White

Physical: Impervious Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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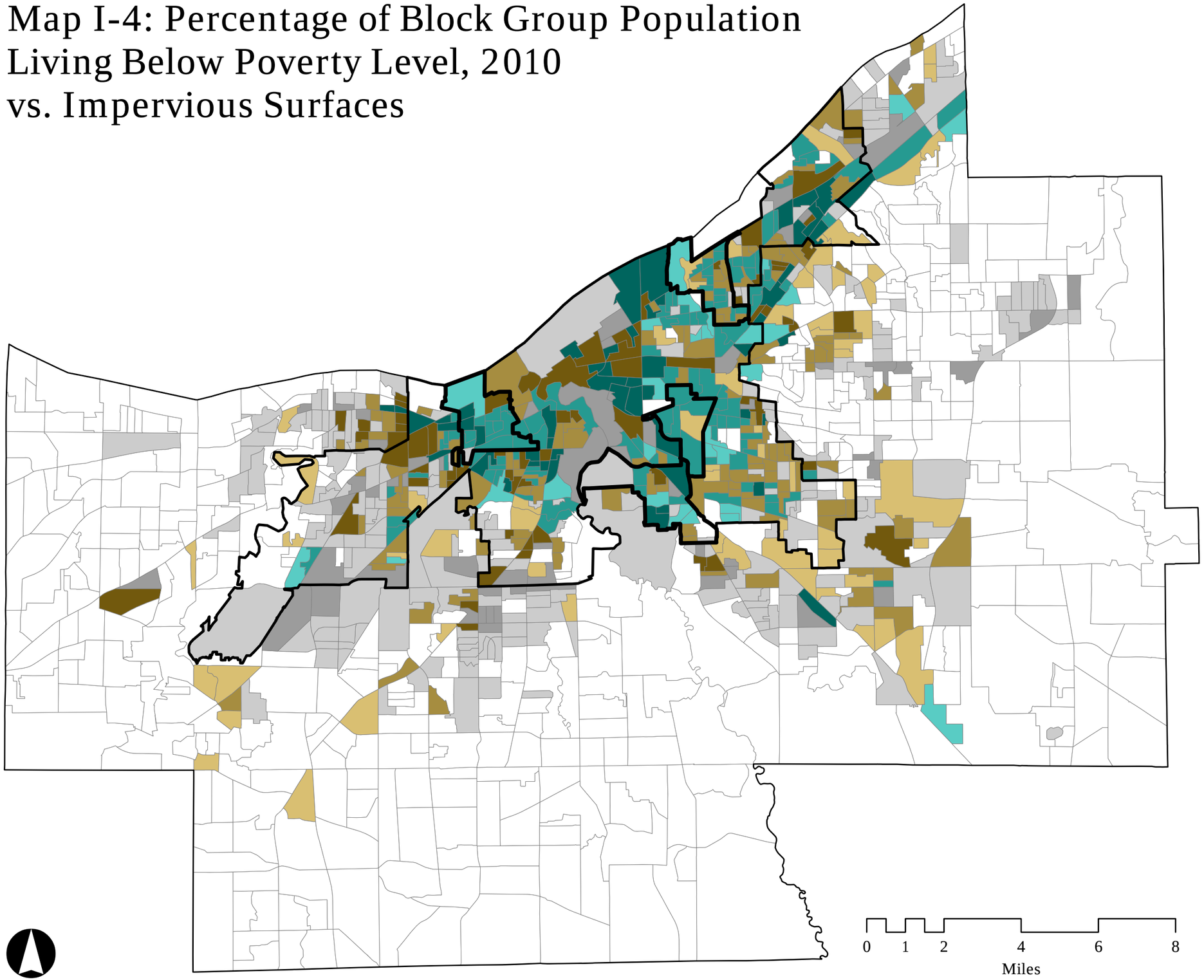
Maps Created:

Monday, June 22, 2015

Map I-4: Percentage of Block Group Population Living Below Poverty Level, 2010 vs. Impervious Surfaces



Legend:

Social: Living Below Poverty Level

Physical: Impervious Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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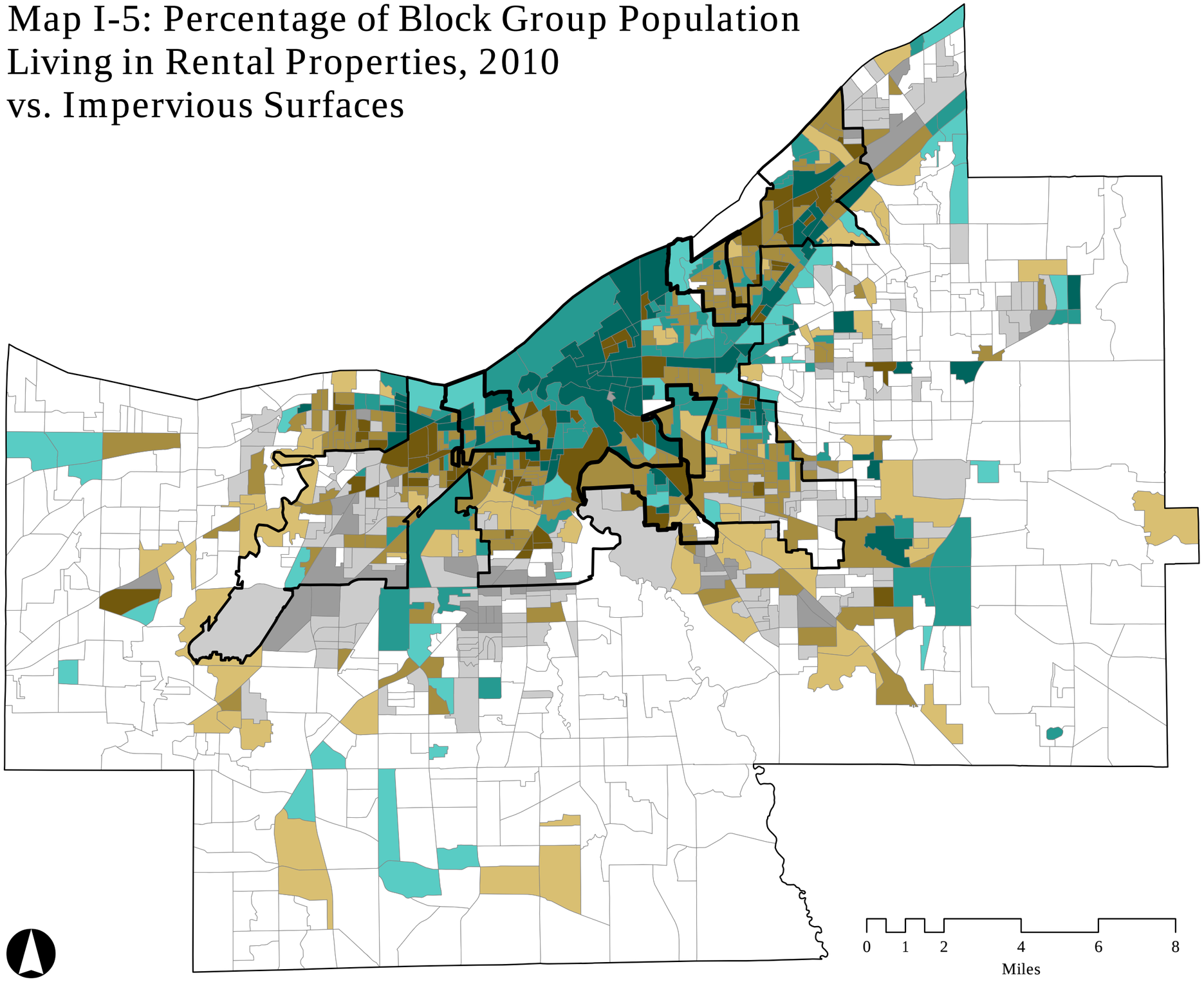
Maps Created:

Monday, June 22, 2015

Map I-5: Percentage of Block Group Population Living in Rental Properties, 2010 vs. Impervious Surfaces



Legend:

Social: Living in Rental Properties

Physical: Impervious Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

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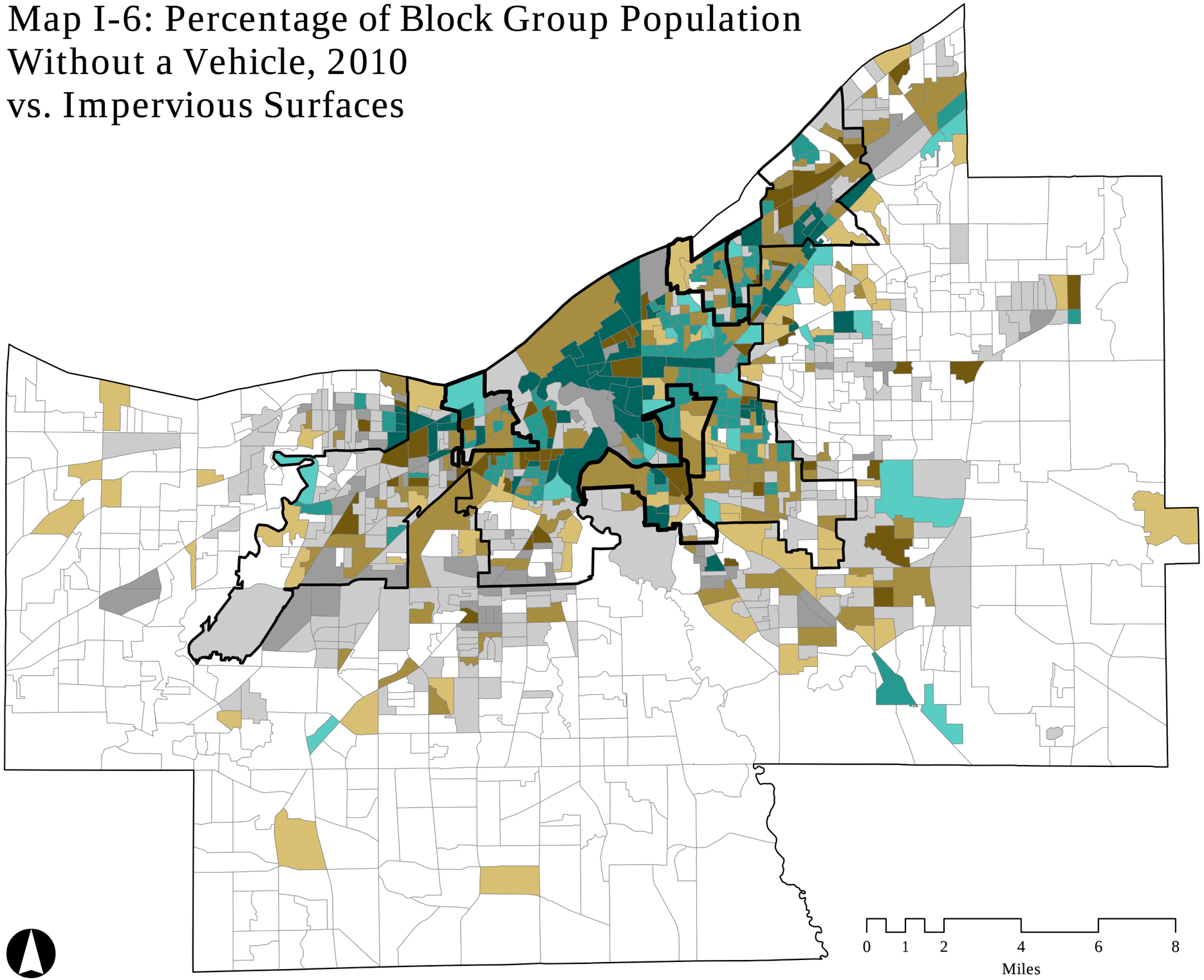
Maps Created:

Monday, June 22, 2015

Map I-6: Percentage of Block Group Population Without a Vehicle, 2010 vs. Impervious Surfaces



Legend:

Social: Without a Vehicle		Physical: Impervious Surfaces
Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

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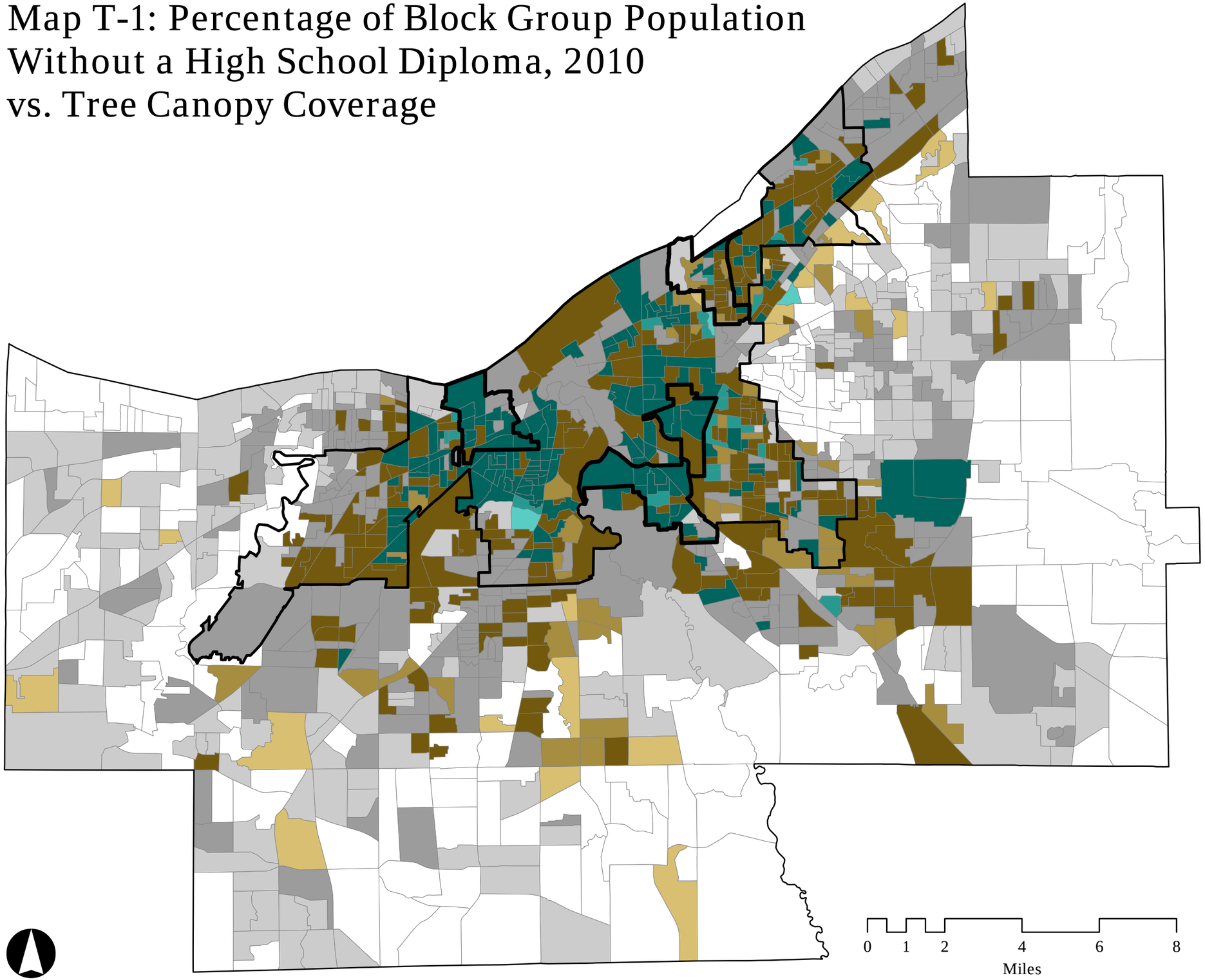
Maps Created:

Monday, June 22, 2015

Map T-1: Percentage of Block Group Population Without a High School Diploma, 2010 vs. Tree Canopy Coverage



Legend:

Social: Without a High School Diploma

Physical: Tree Canopy Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
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Projection:

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Maps Produced By:

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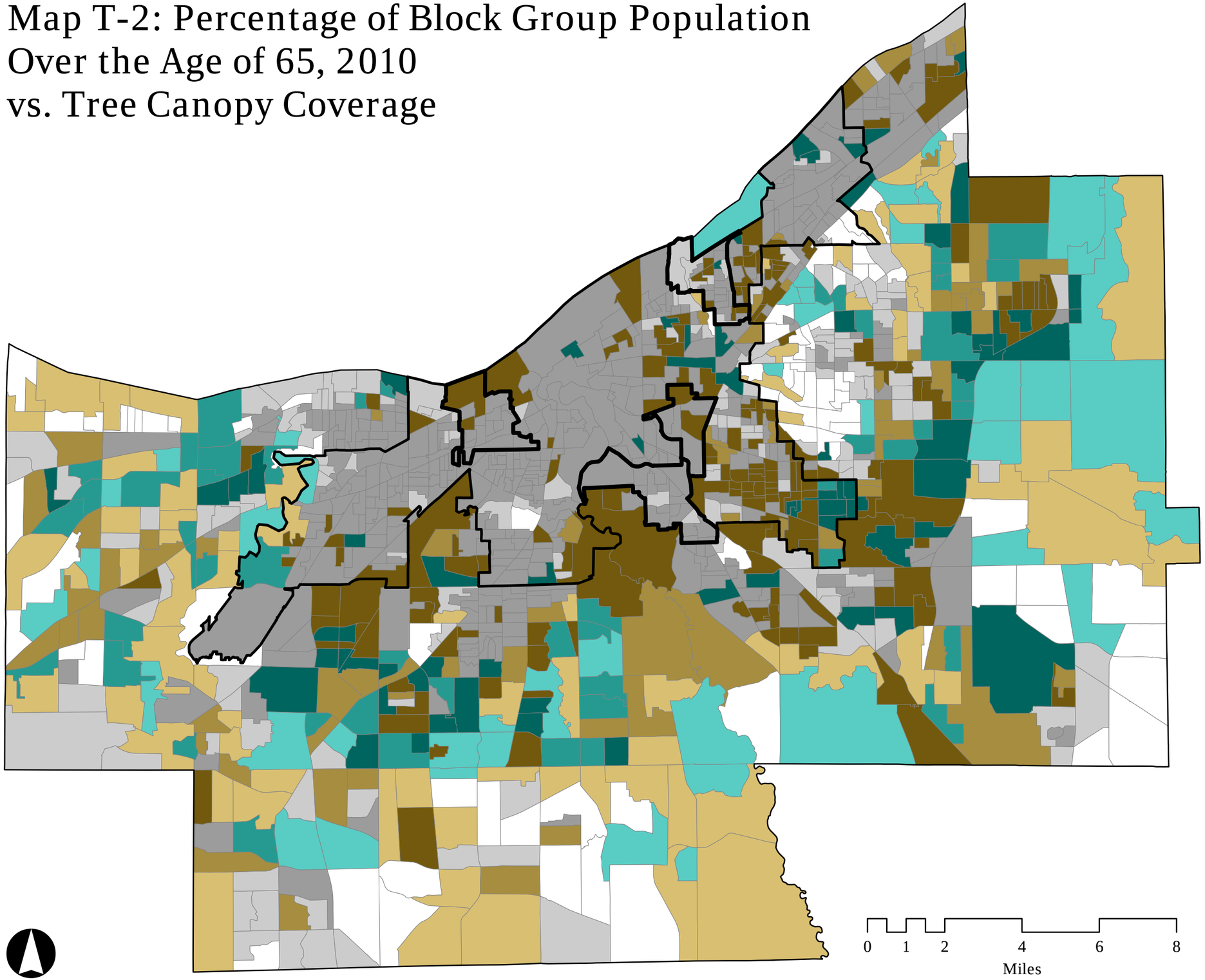
Maps Created:

Monday, June 22, 2015

Map T-2: Percentage of Block Group Population Over the Age of 65, 2010 vs. Tree Canopy Coverage



Legend:

Social: Over the Age of 65

Physical: Tree Canopy Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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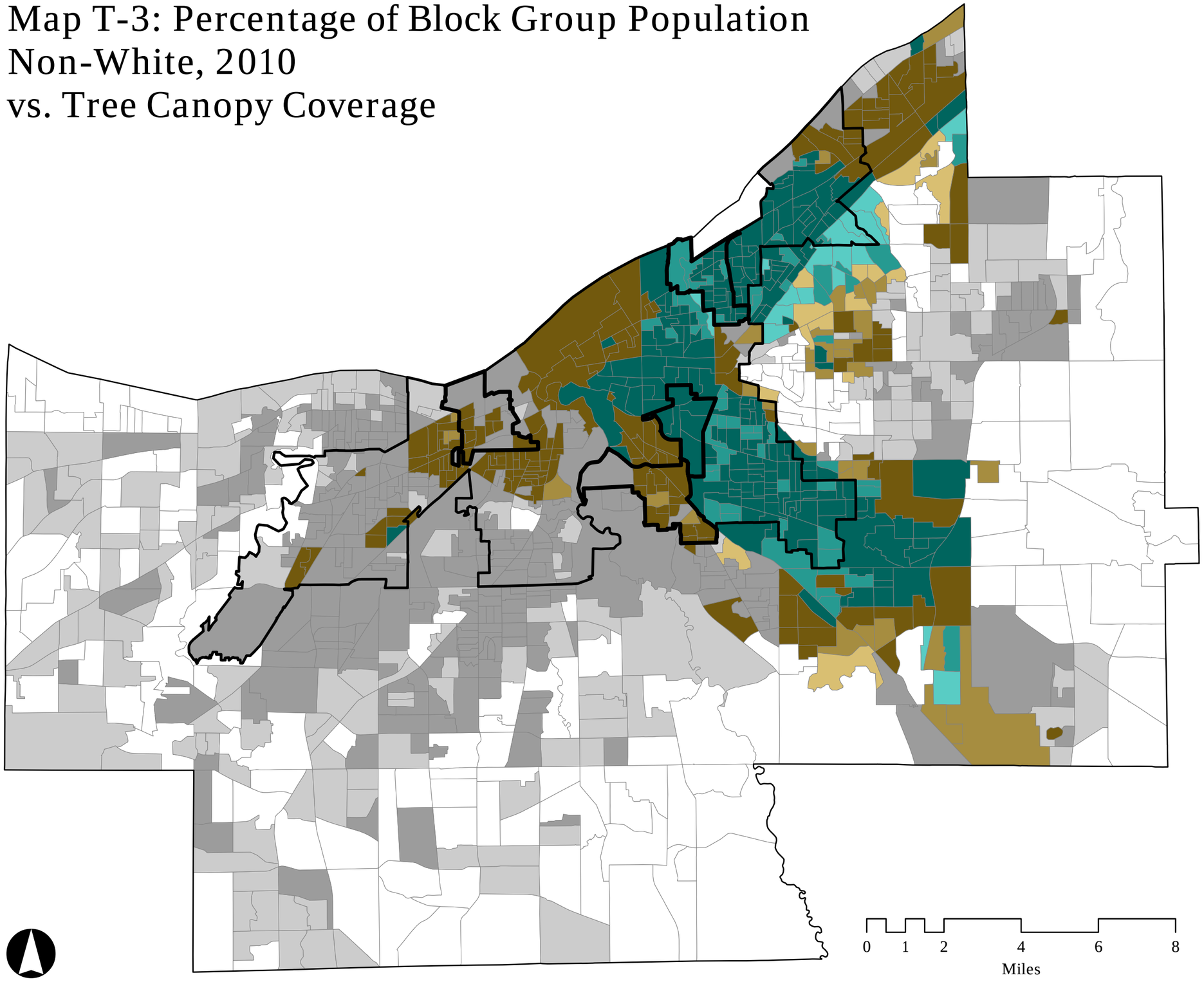
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map T-3: Percentage of Block Group Population Non-White, 2010 vs. Tree Canopy Coverage



Legend:

Social: Non-White		Physical: Tree Canopy Coverage
Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Northeast Ohio Data Collaborative
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

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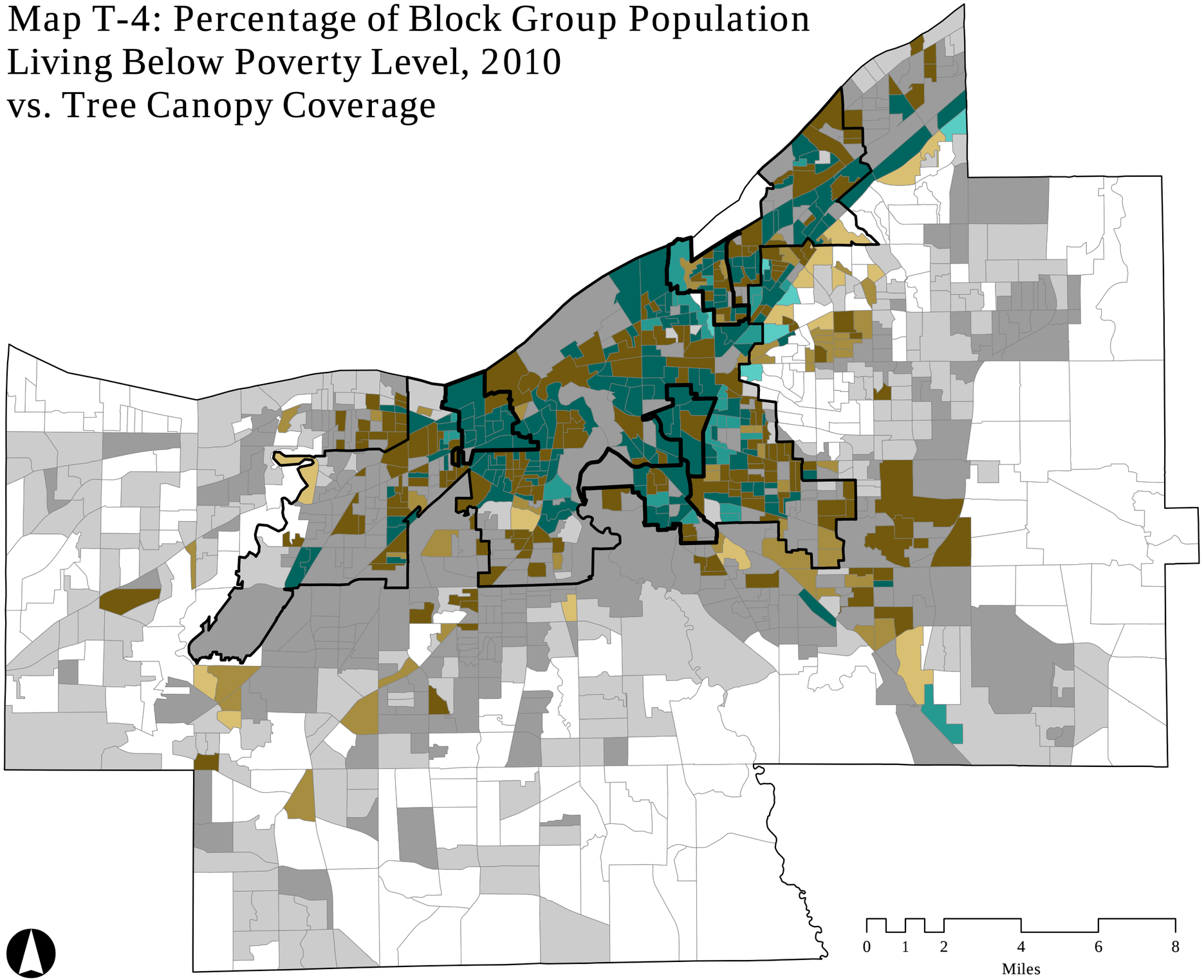
Maps Created:

Monday, June 22, 2015

Map T-4: Percentage of Block Group Population Living Below Poverty Level, 2010 vs. Tree Canopy Coverage



Legend:

Social: Living Below Poverty Level

Physical: Tree Canopy Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

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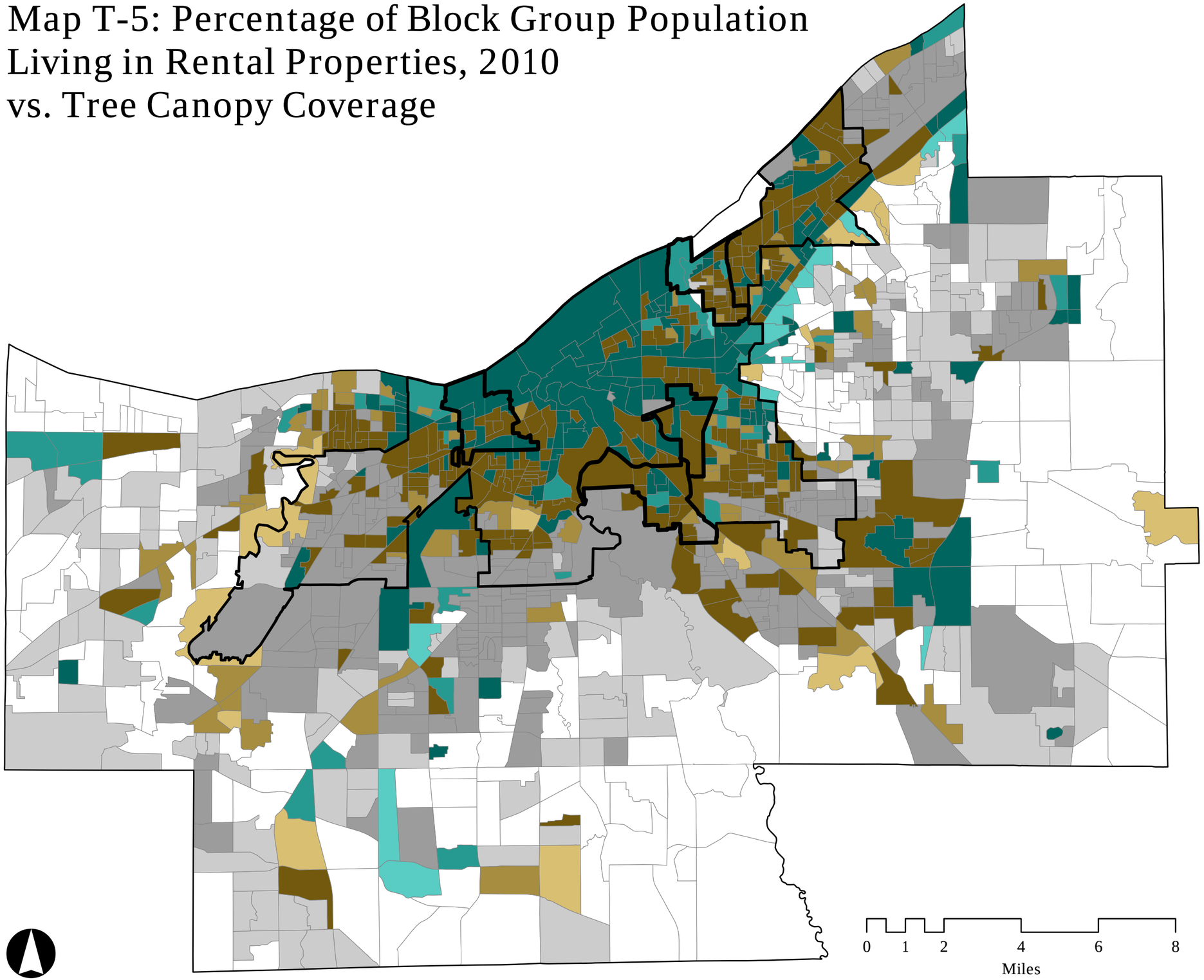
Maps Created:

Monday, June 22, 2015

Map T-5: Percentage of Block Group Population Living in Rental Properties, 2010 vs. Tree Canopy Coverage



Legend:

Social: Living in Rental Properties

Physical: Tree Canopy Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

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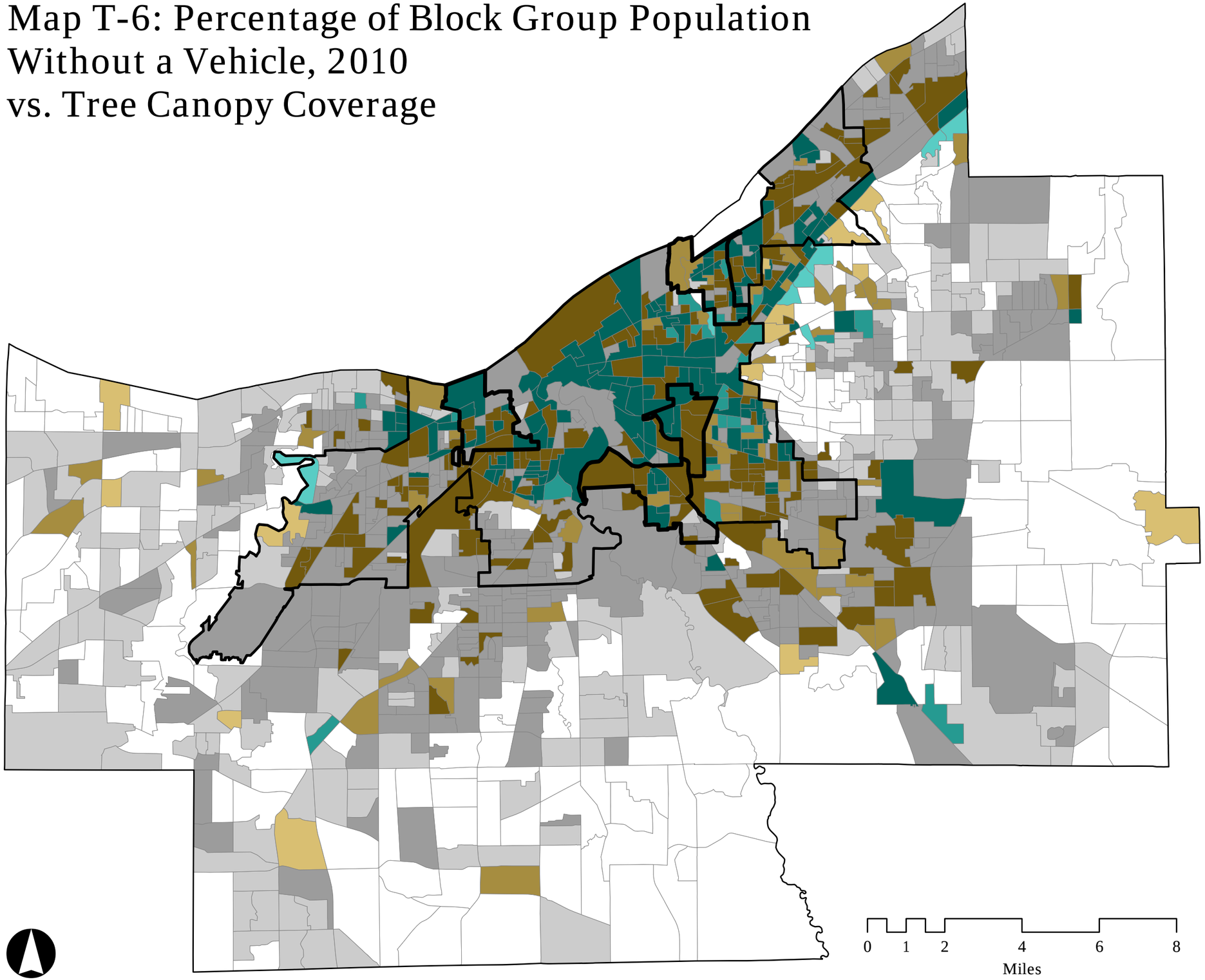
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map T-6: Percentage of Block Group Population Without a Vehicle, 2010 vs. Tree Canopy Coverage



Legend:

Social: Without a Vehicle

Physical: Tree Canopy Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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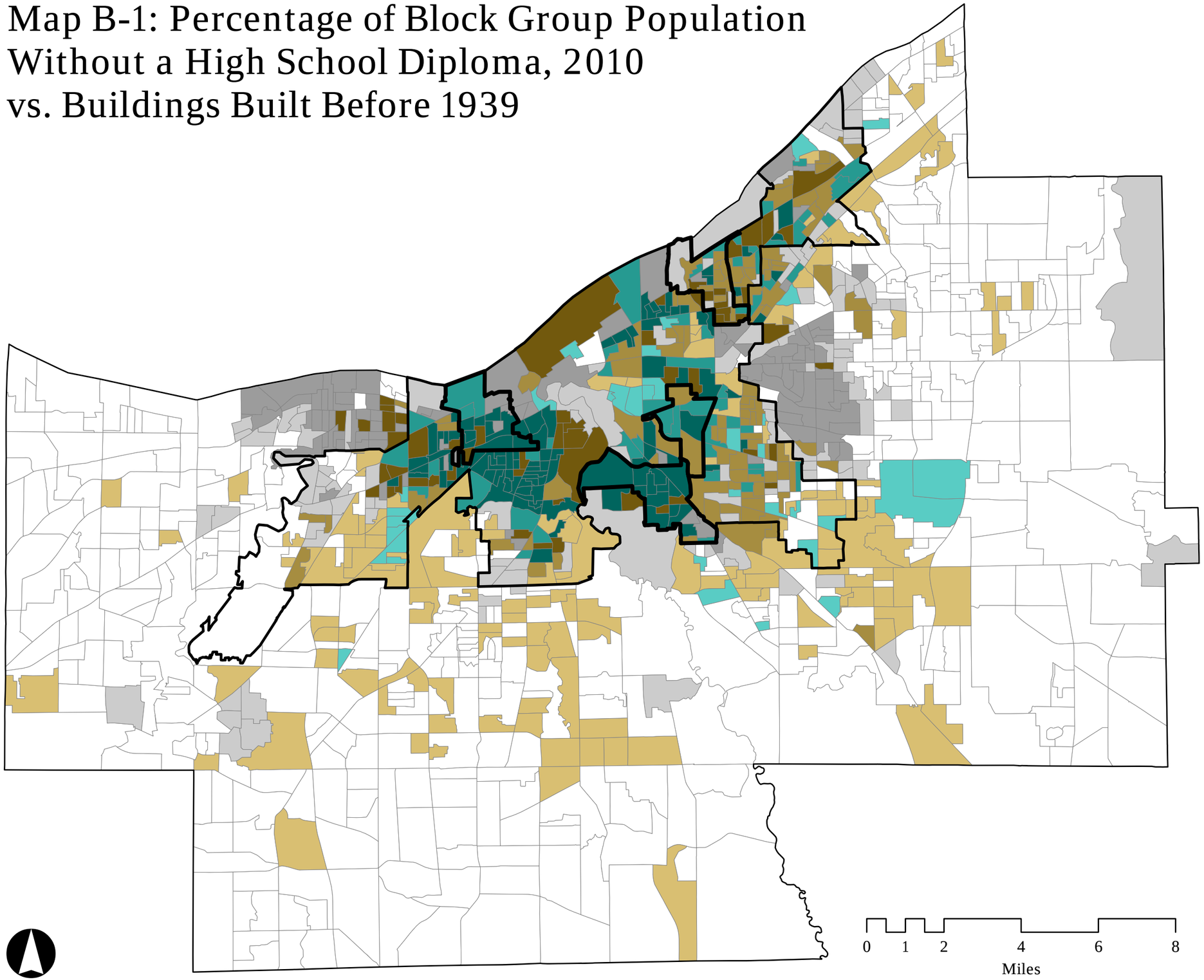
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map B-1: Percentage of Block Group Population Without a High School Diploma, 2010 vs. Buildings Built Before 1939



Legend:

Social: Without a High School Diploma

Physical: Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

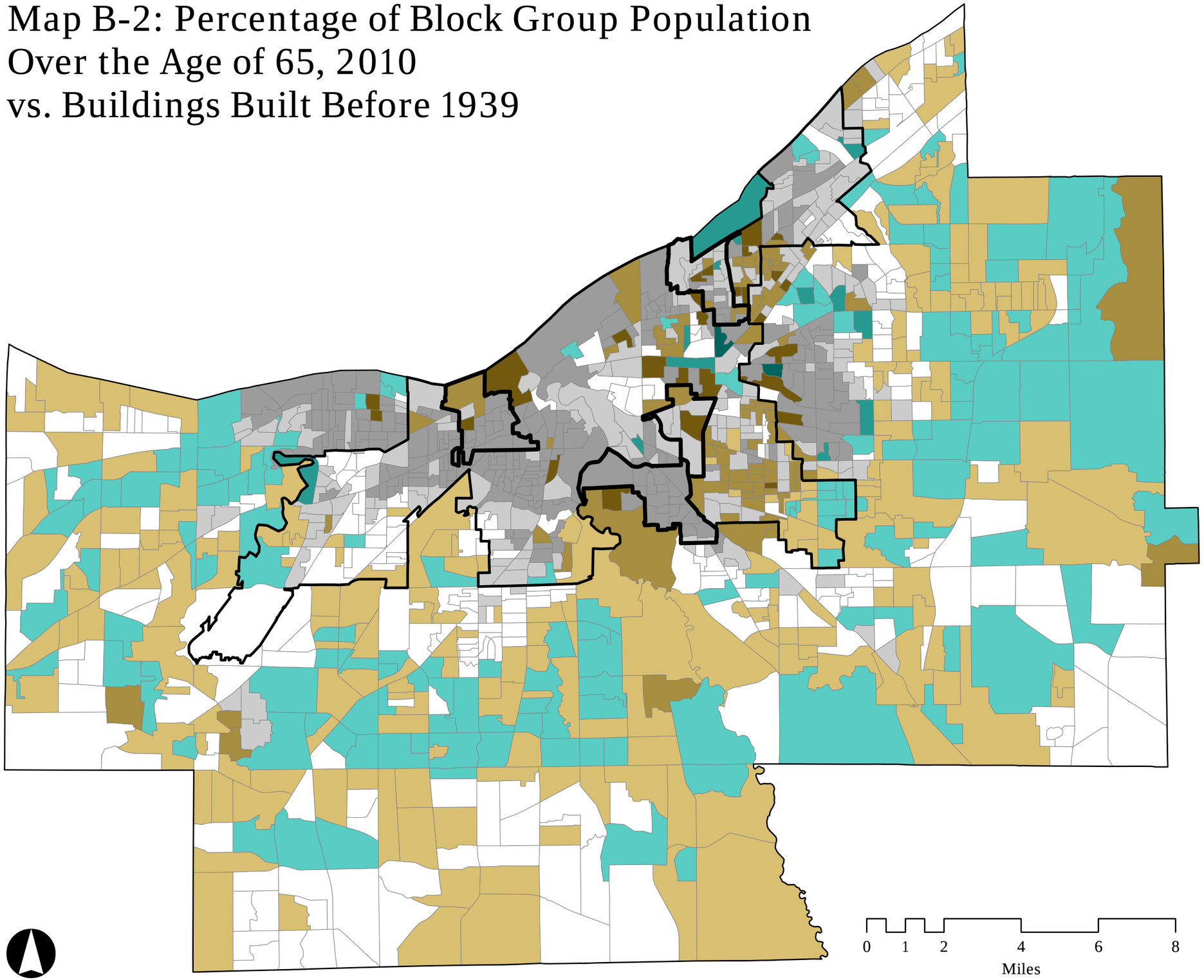
Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map B-2: Percentage of Block Group Population Over the Age of 65, 2010 vs. Buildings Built Before 1939



Legend:

Social: Living in Rental Properties

Physical: Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
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Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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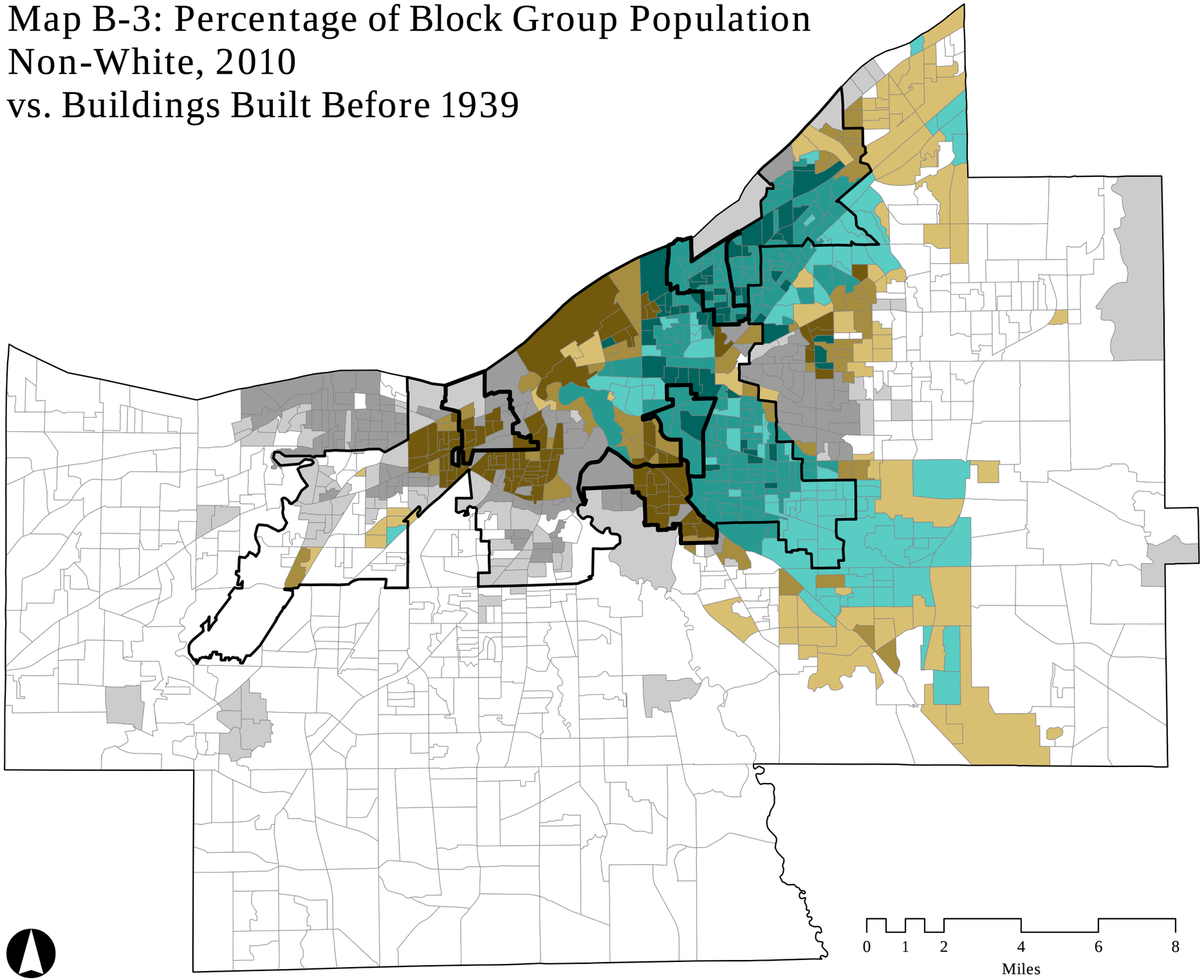
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map B-3: Percentage of Block Group Population Non-White, 2010 vs. Buildings Built Before 1939



Legend:

Social: Non-White

Physical: Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
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Projection:

NAD 1983, Ohio State Plane North

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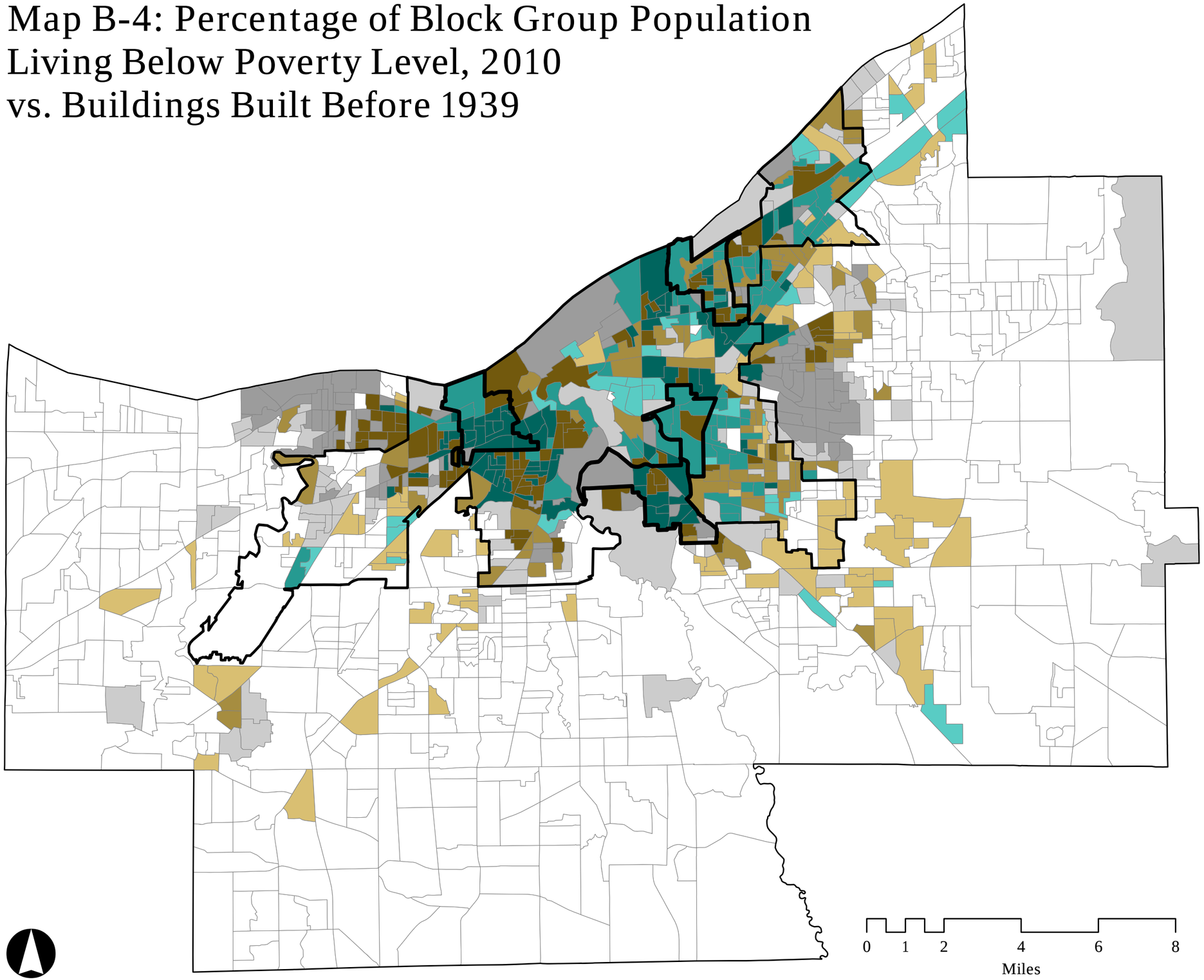
Maps Created:

Monday, June 22, 2015

Map B-4: Percentage of Block Group Population Living Below Poverty Level, 2010 vs. Buildings Built Before 1939



Legend:

Social: Living Below Poverty Level

Physical: Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Cuyahoga County GIS Department,
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Projection:

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Maps Produced By:

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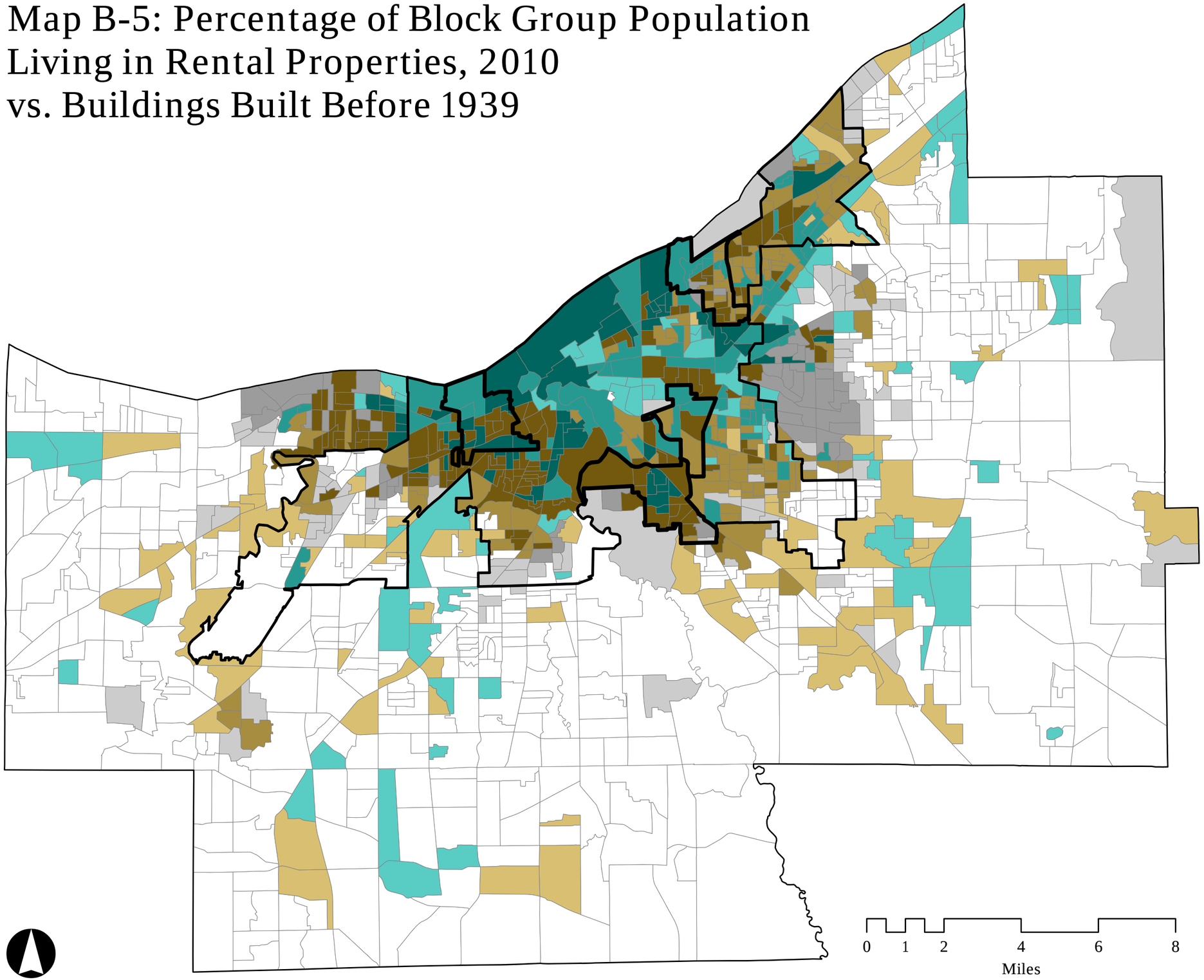
Maps Created:

Monday, June 22, 2015

Map B-5: Percentage of Block Group Population Living in Rental Properties, 2010 vs. Buildings Built Before 1939



Legend:

Social: Living in Rental Properties

Physical: Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Projection:

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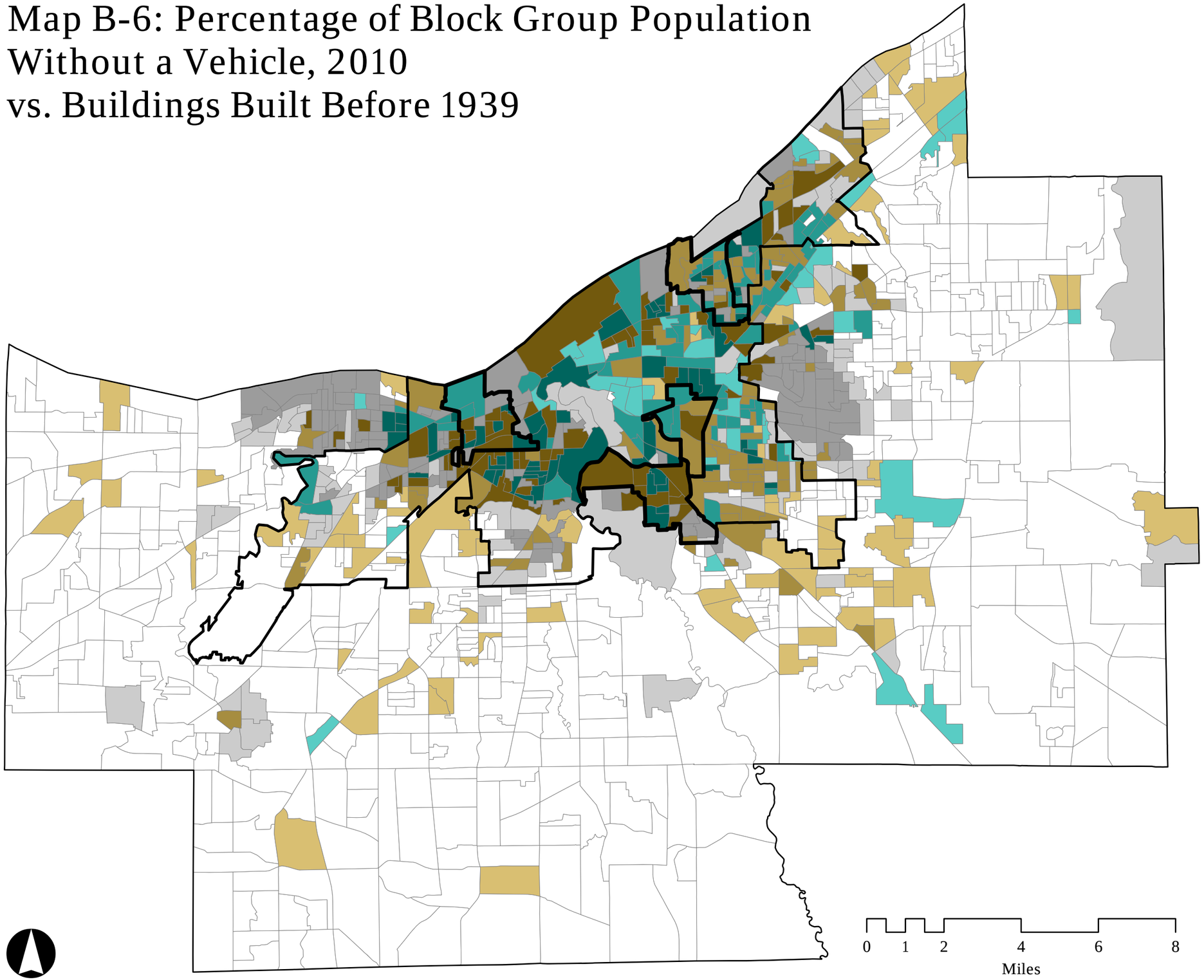
Maps Created:

Monday, June 22, 2015

Map B-6: Percentage of Block Group Population Without a Vehicle, 2010 vs. Buildings Built Before 1939



Legend:

Social: Without a Vehicle

Physical: Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Projection:

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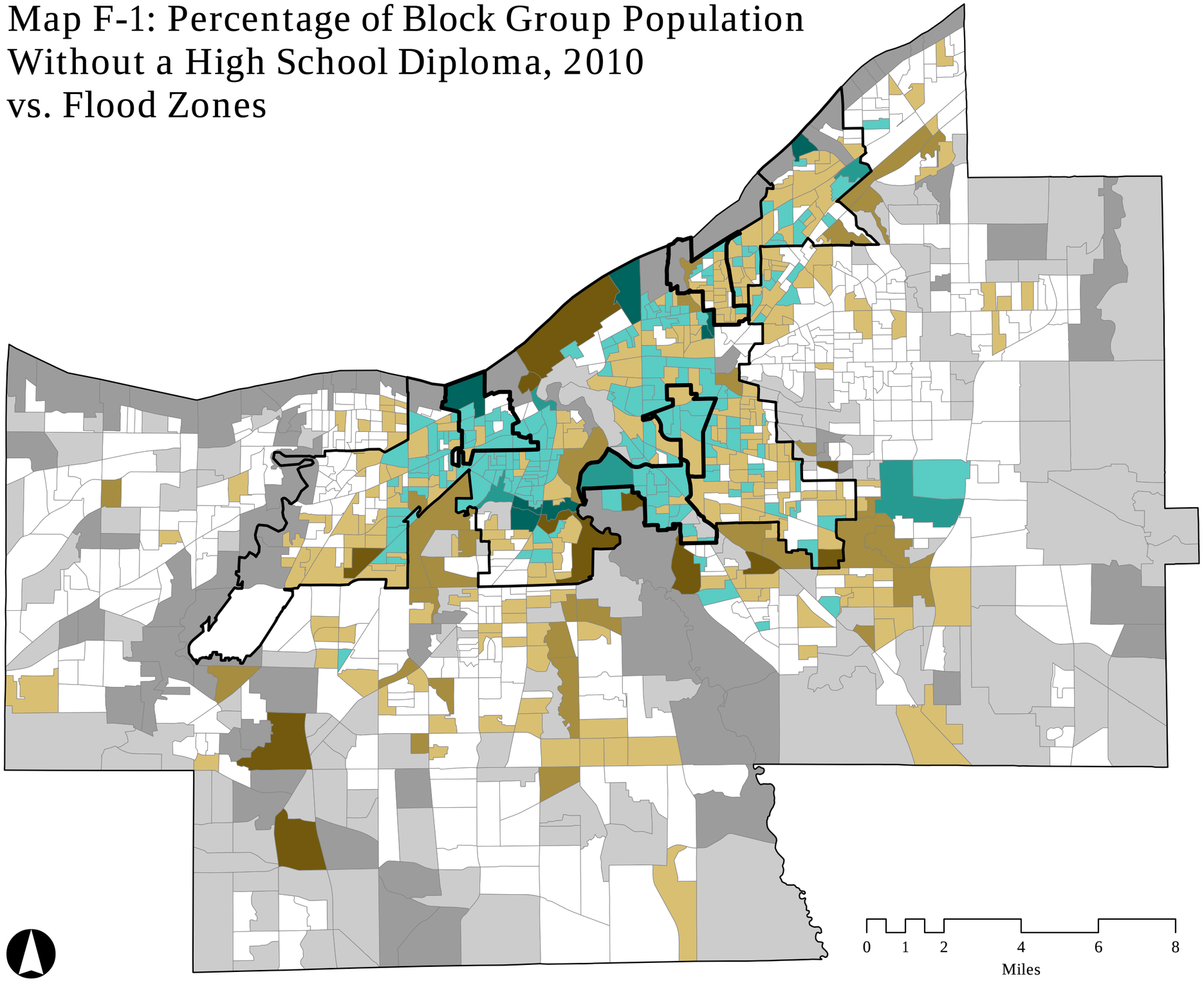
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map F-1: Percentage of Block Group Population Without a High School Diploma, 2010 vs. Flood Zones



Legend:

Social: Without a High School Diploma

Physical: Flood Zone

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

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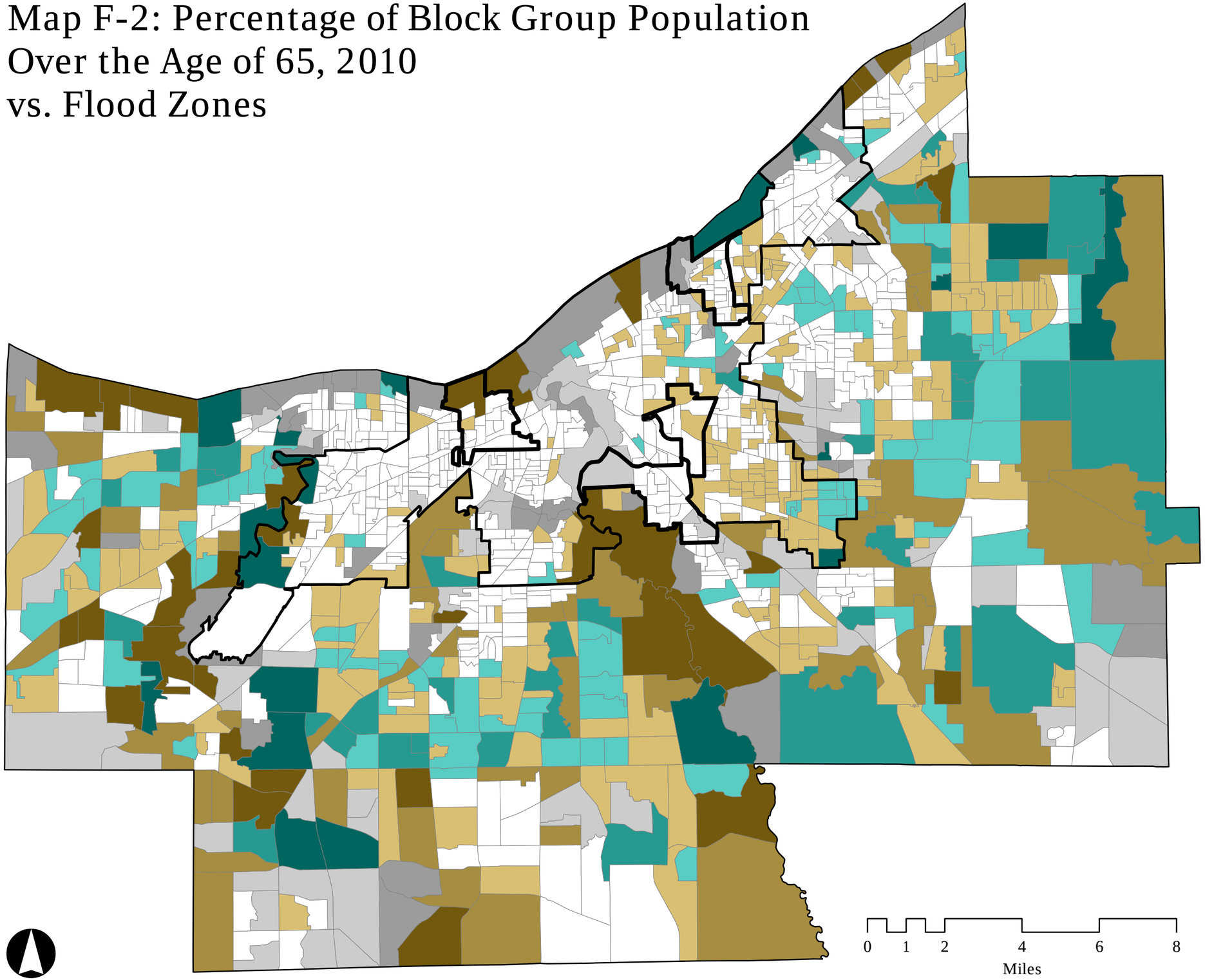
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map F-2: Percentage of Block Group Population Over the Age of 65, 2010 vs. Flood Zones



Legend:

Social: Over the Age of 65		Physical: Flood Zone
Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

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Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
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FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

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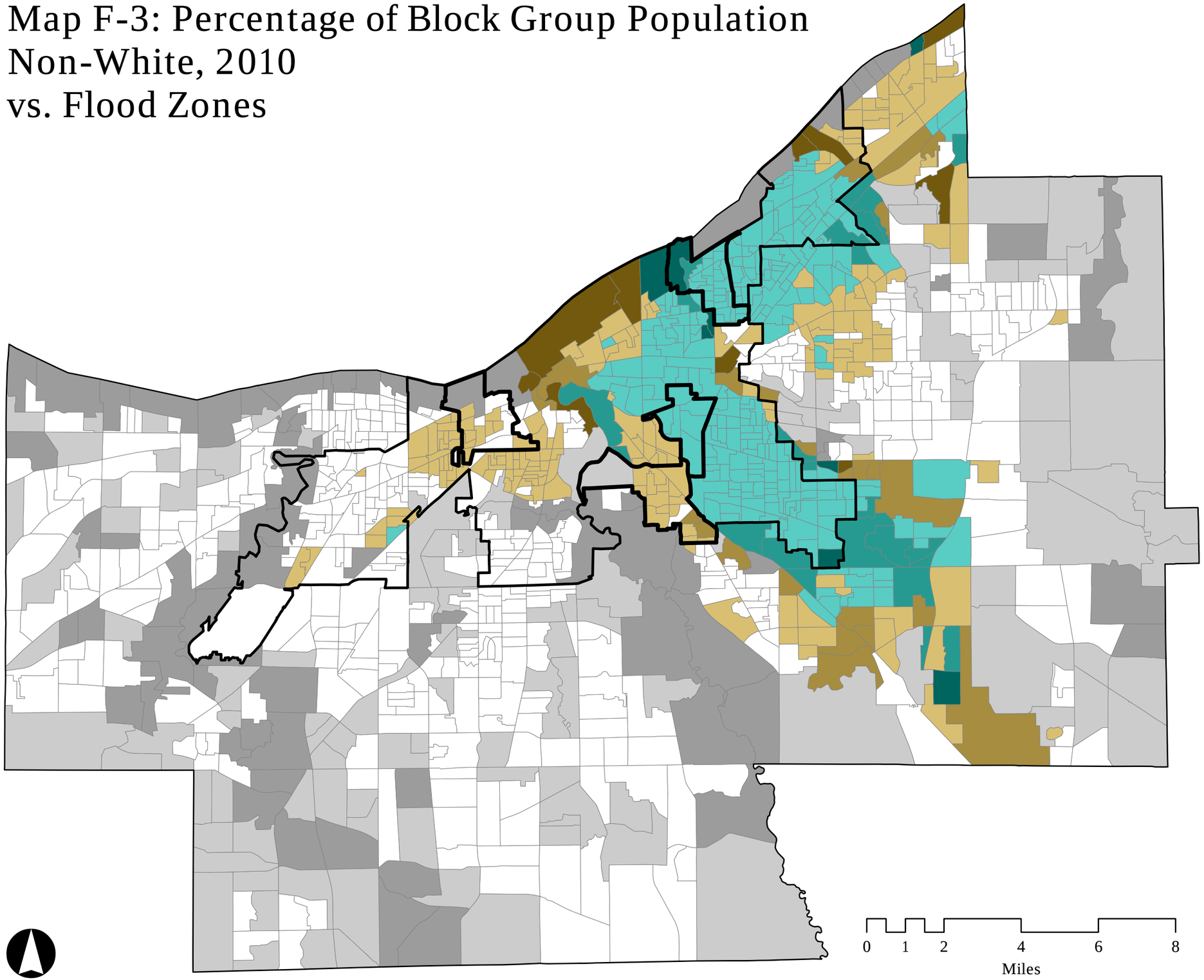
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map F-3: Percentage of Block Group Population Non-White, 2010 vs. Flood Zones



Legend:

Social: Non-White

Physical: Flood Zone

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

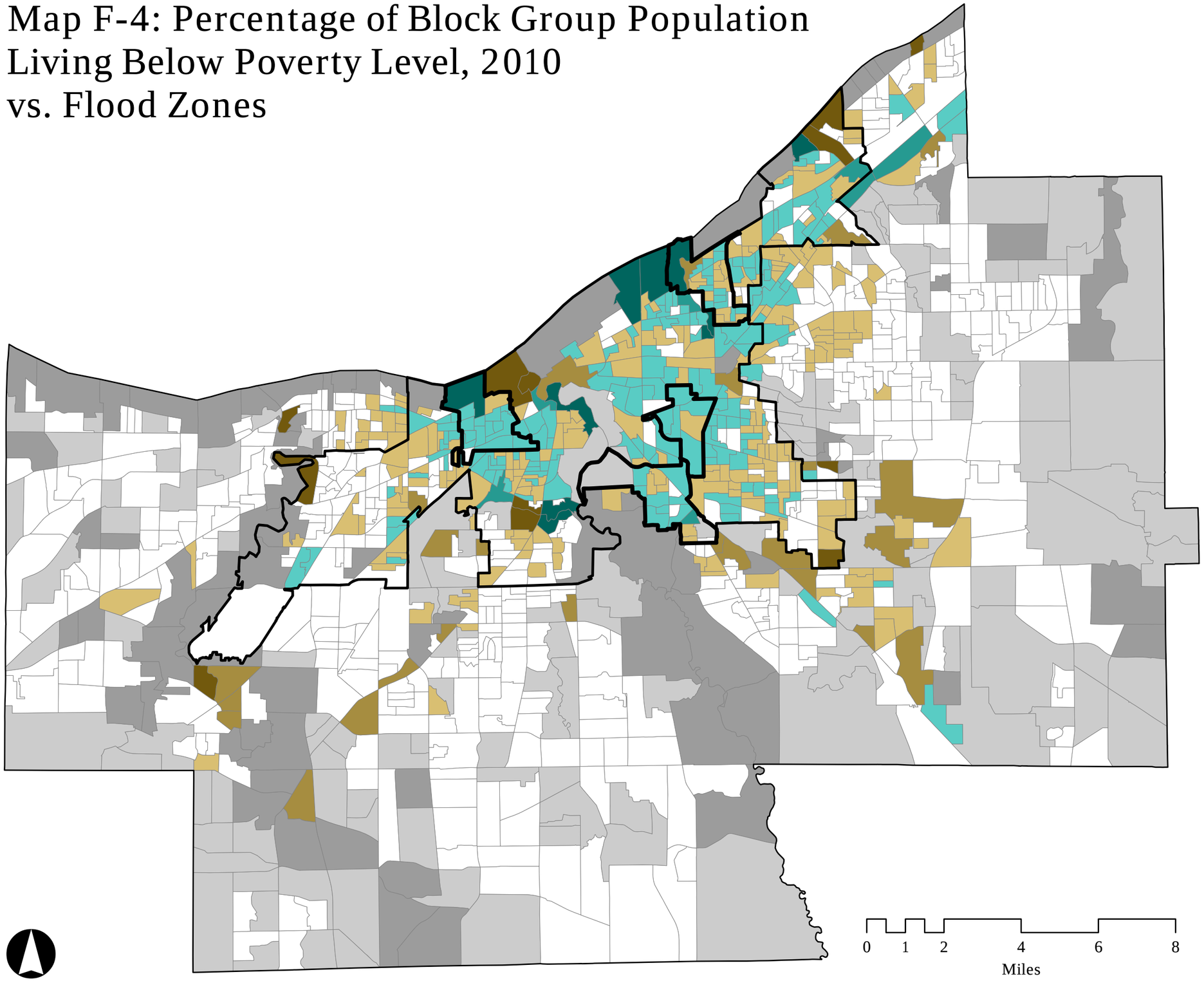
Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map F-4: Percentage of Block Group Population Living Below Poverty Level, 2010 vs. Flood Zones



Legend:

Social: Living Below Poverty Level

Physical: Flood Zone

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

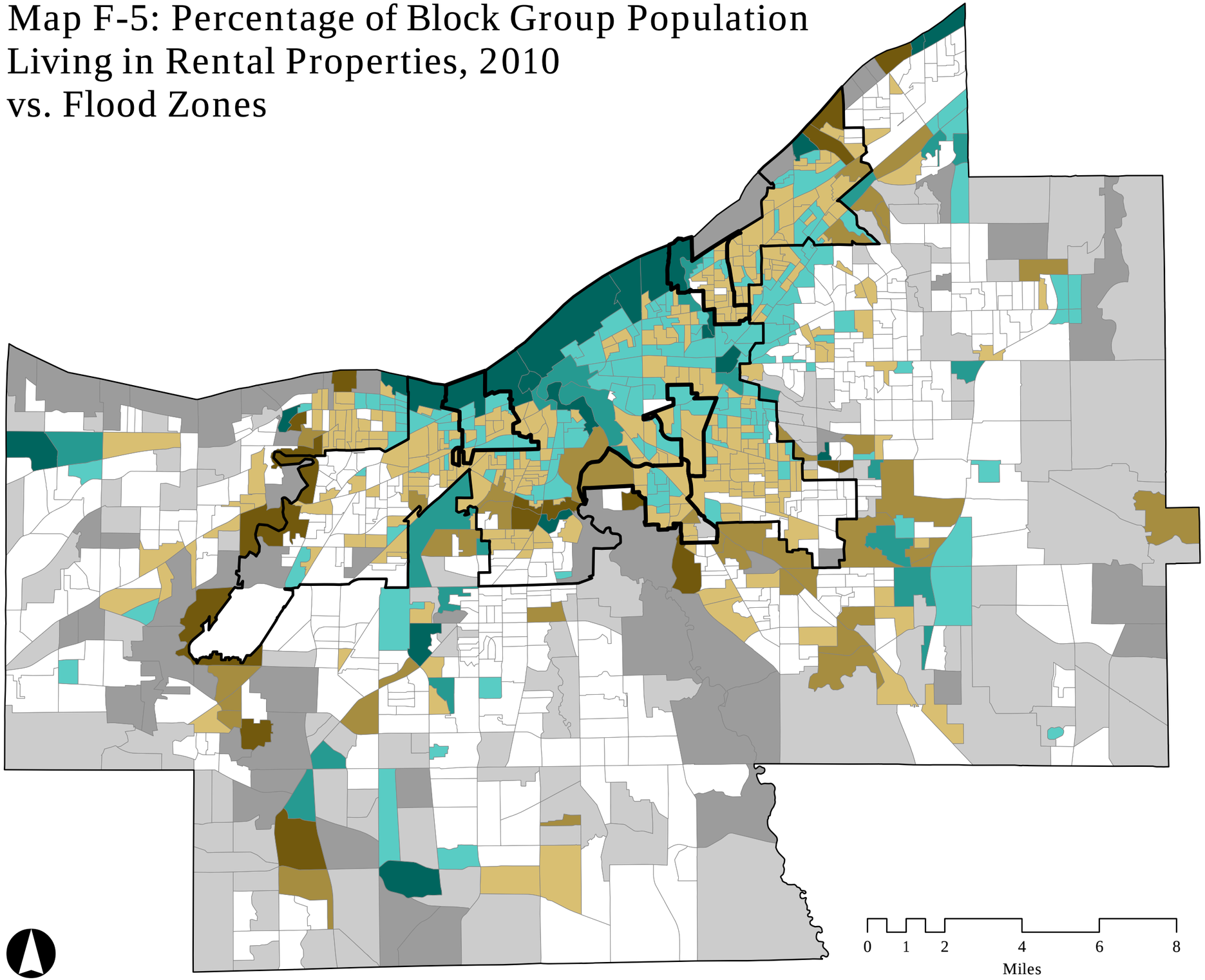
Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map F-5: Percentage of Block Group Population Living in Rental Properties, 2010 vs. Flood Zones



Legend:

Social: Living in Rental Properties

Physical: Flood Zones

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

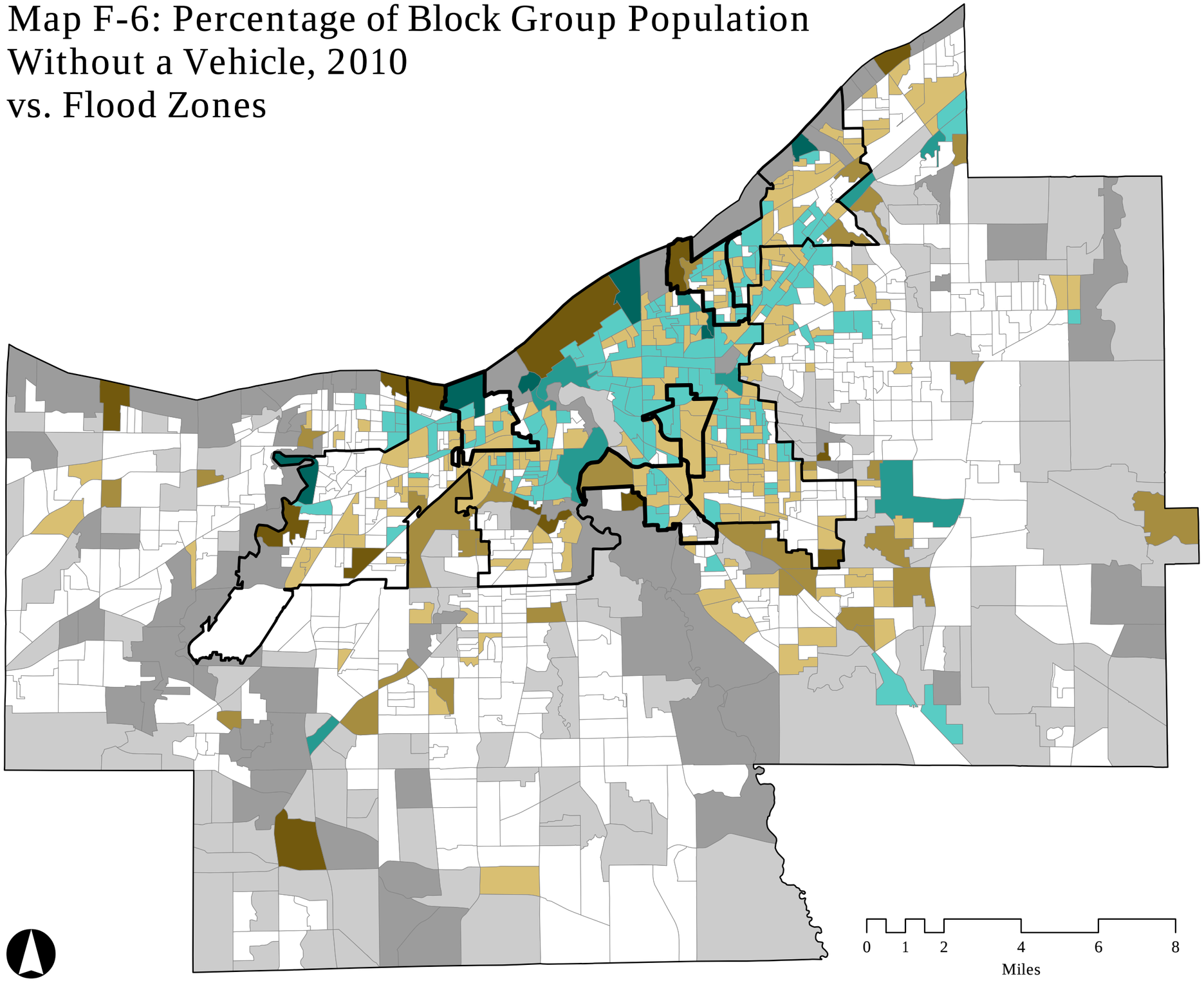
Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map F-6: Percentage of Block Group Population Without a Vehicle, 2010 vs. Flood Zones



Legend:

Social: Living Without a Vehicle

Physical: Flood Zones

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:

Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above the mean.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

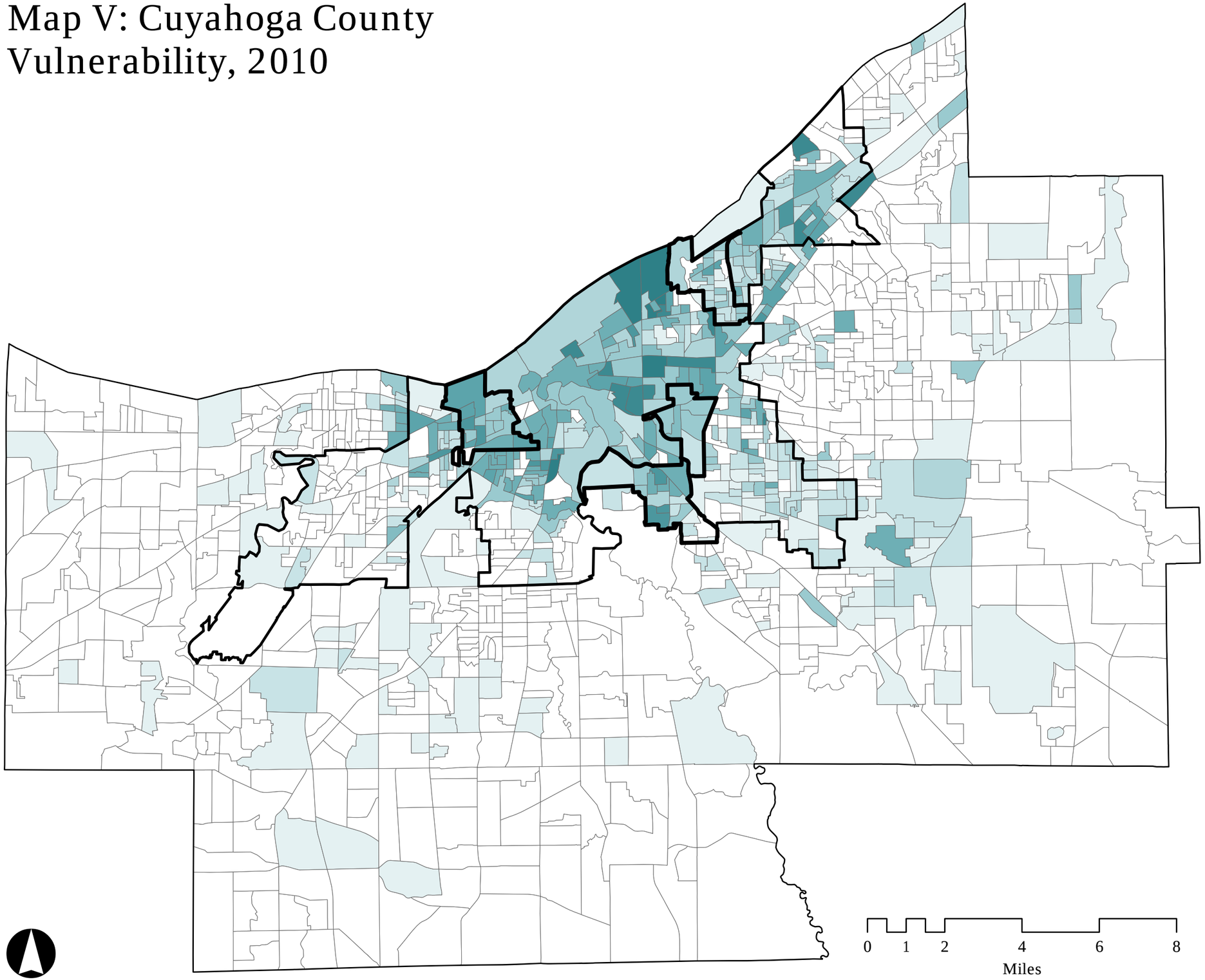
Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Monday, June 22, 2015

Map V: Cuyahoga County Vulnerability, 2010



Legend:

Vulnerability

- 0 Least Vulnerable
- 1
- 2
- 3
- 4
- 5
- 6
- 8
- 9
- 10
- 12 Most Vulnerable

Note:

Vulnerability values for each block group are determined by the overall count of "High/High" values in the social and physical factor comparison. For example, a "High" value in the percent without a vehicle paired with a "High" value for impervious surfaces represents one vulnerability value.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

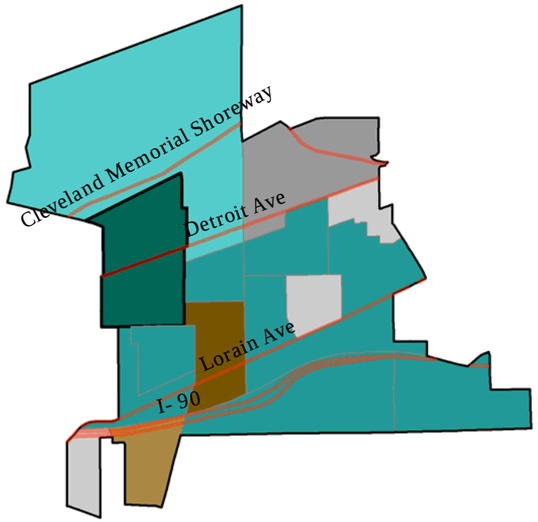
Maps Created:

Thursday, June 25, 2015

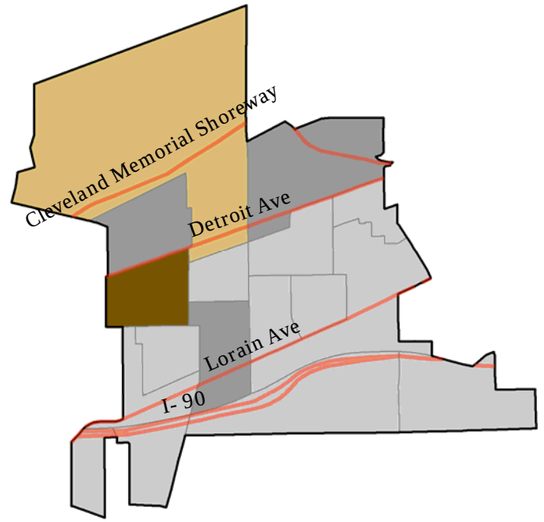
NEIGHBORHOOD VULNERABILITY MAP MATRIX

		Neighborhoods			
		Detroit-Shoreway	**Glenville**	**Kinsman**	**Slavic-Village**
Physical Factors vs. Social Factors	**Land Coverage: Impervious Surface vs. Social Factors**	D-1	G-1	K-1	S-1
	Land Coverage: Tree Canopy vs. Social Factors	D-2	G-2	K-2	S-2
	Buildings Constructed Before 1939 vs. Social Factors	D-3	G-3	K-3	S-3
	FEMA Flood Zone vs. Social Factors	D-4	G-4	K-4	S-4

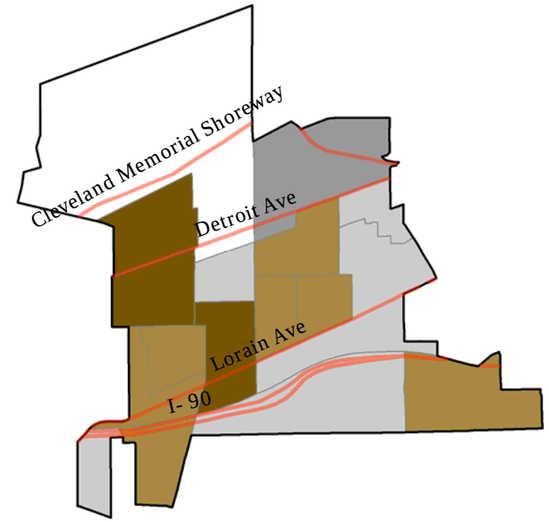
Map D-1: Detroit-Shoreway Impervious Surfaces



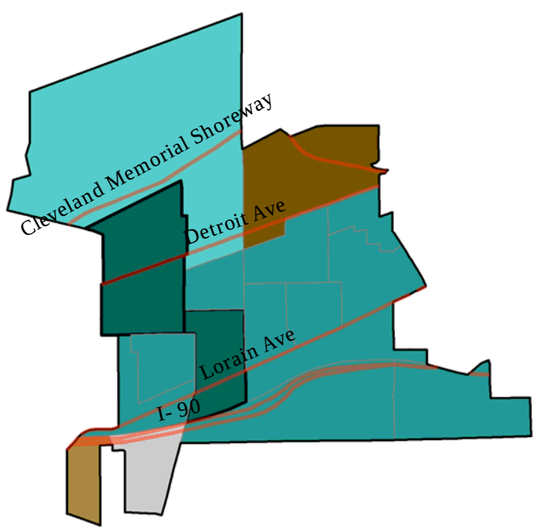
Percent Without High School Diploma



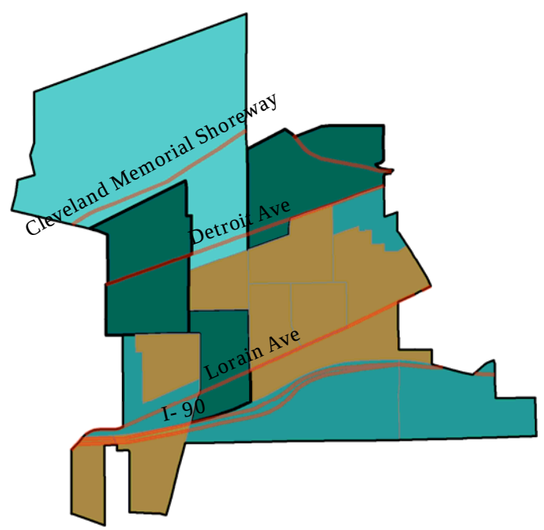
Percent Over the Age of 65



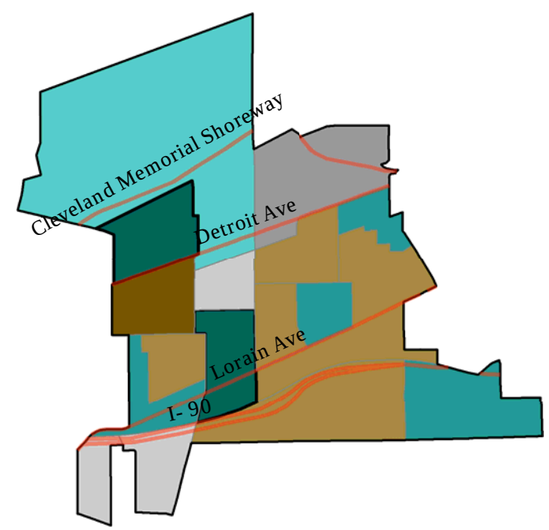
Percent Non-White



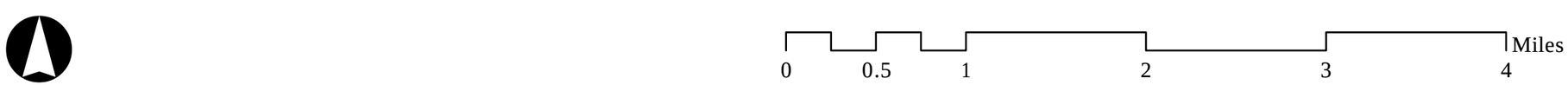
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Impervious
Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

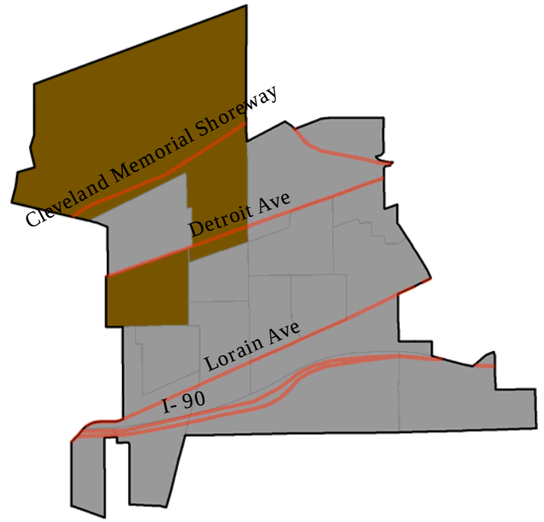
Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

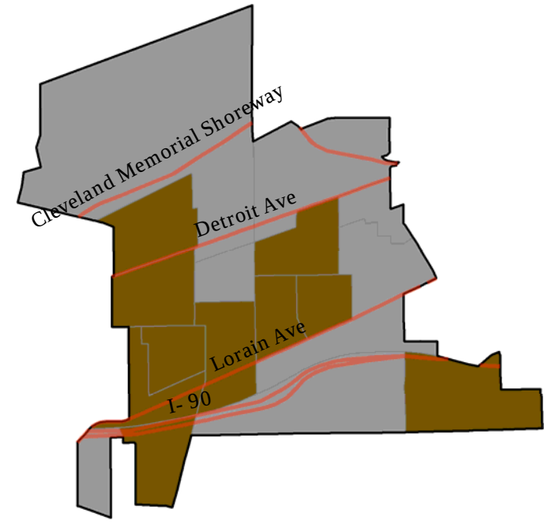
Maps Created:
Tuesday, June 23, 2015

Map D-2: Detroit-Shoreway Tree Canopy Coverage

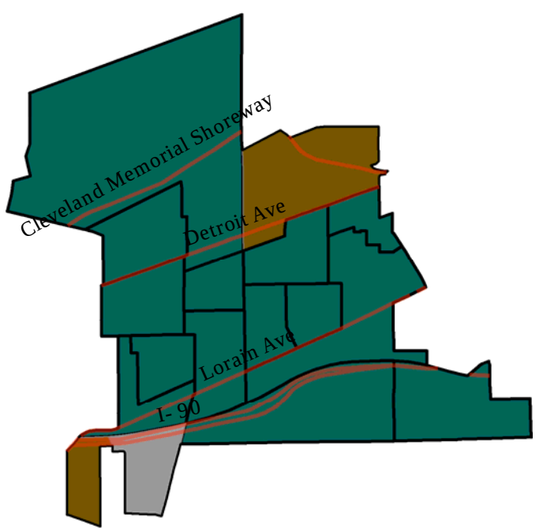
Percent Without High School Diploma



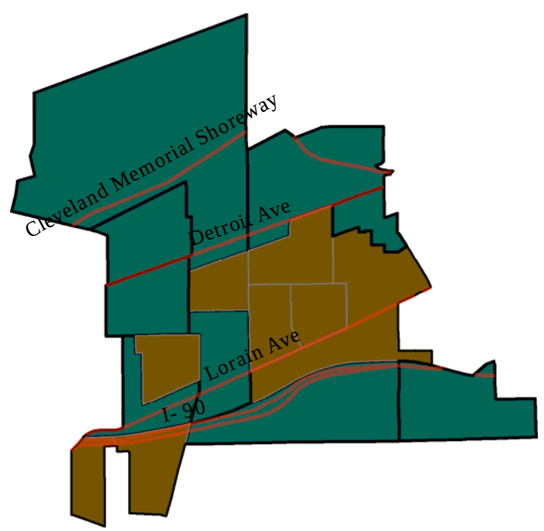
Percent Over the Age of 65



Percent Non-White

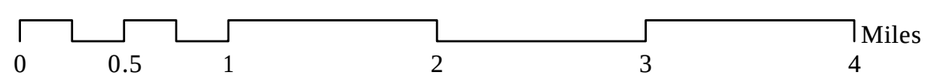


Percent Living Below Poverty Level



Percent Living in Rental Properties

Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Tree Canopy
Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

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Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

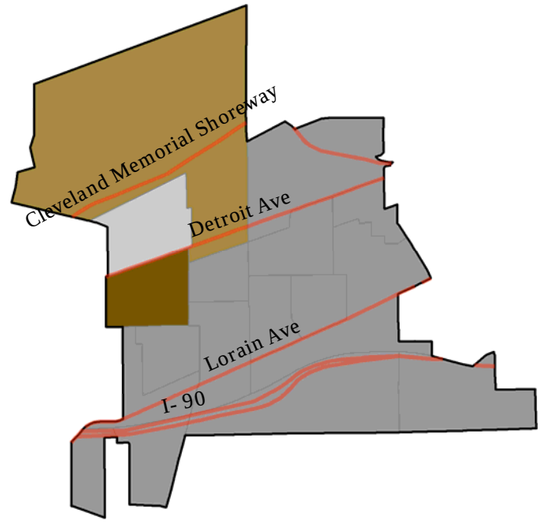
Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

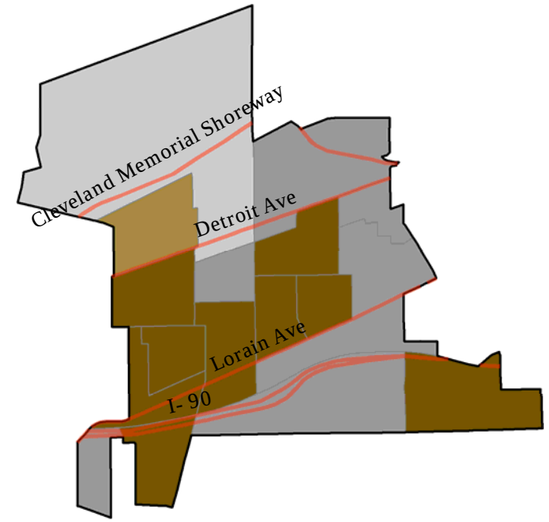
Maps Created:
Tuesday, June 23, 2015

Map D-3: Detroit-Shoreway Buildings Built Before 1939

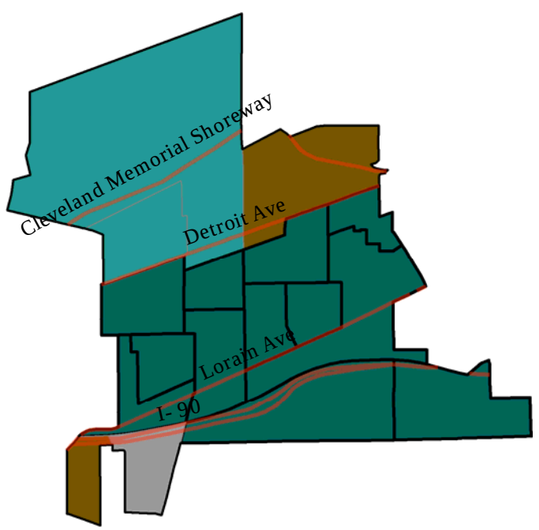
Percent Without High School Diploma



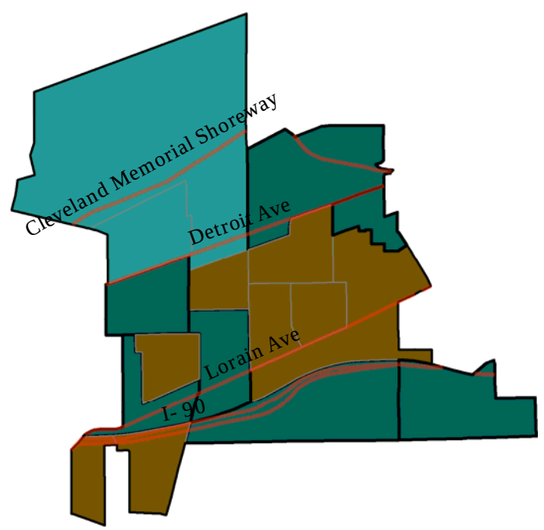
Percent Over the Age of 65



Percent Non-White

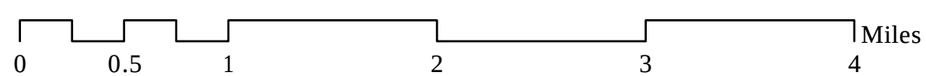


Percent Living Below Poverty Level



Percent Living in Rental Properties

Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Buildings Built
Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

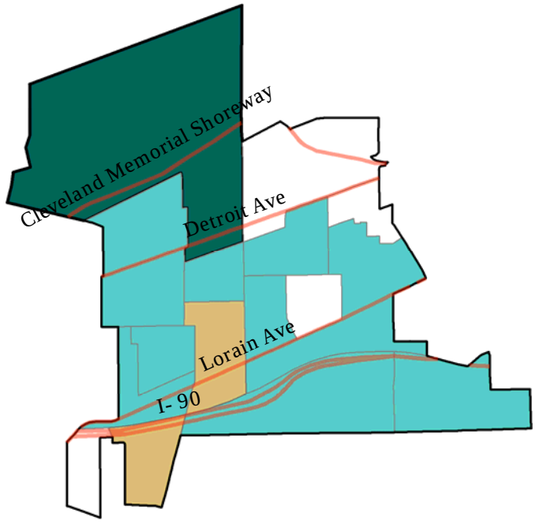
Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

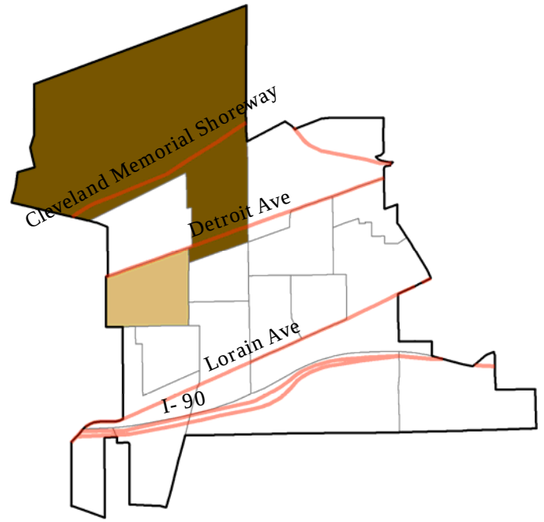
Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

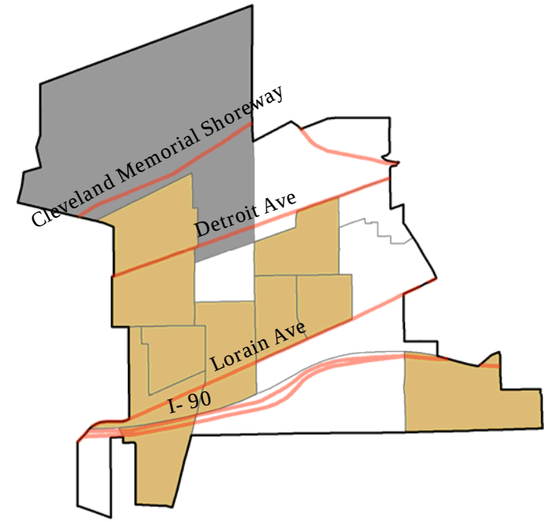
Map D-4: Detroit-Shoreway Flood Zones



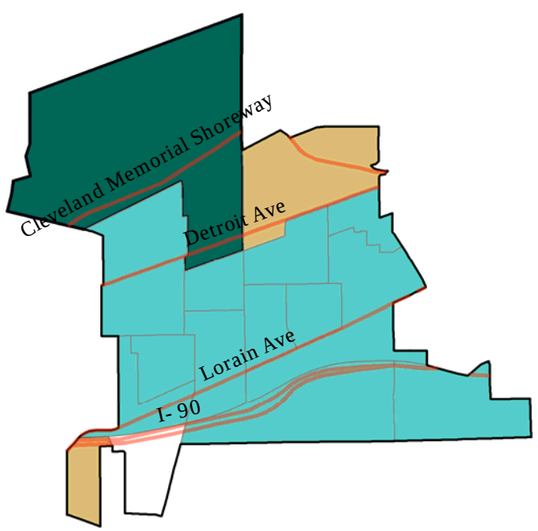
Percent Without High School Diploma



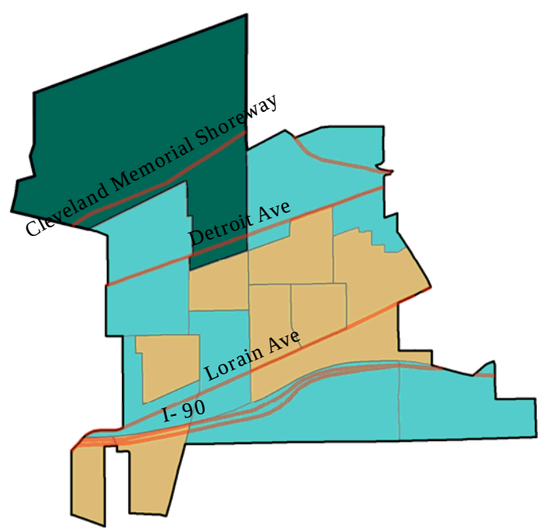
Percent Over the Age of 65



Percent Non-White

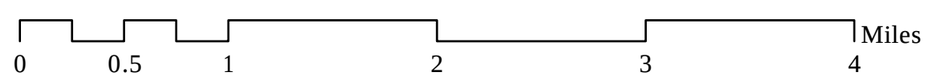


Percent Living Below Poverty Level



Percent Living in Rental Properties

Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Flood
Zones

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

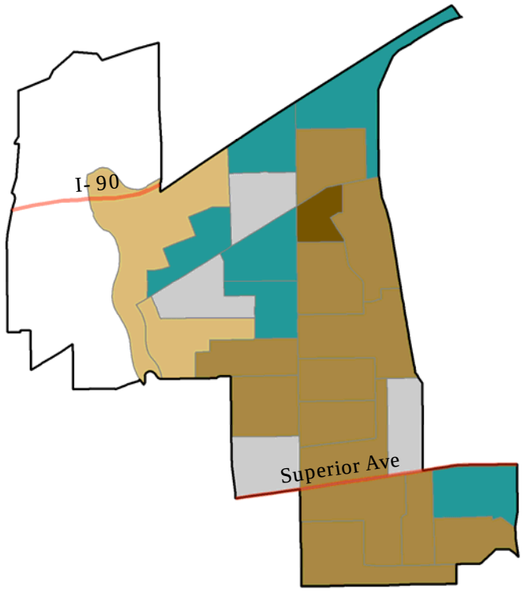
Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

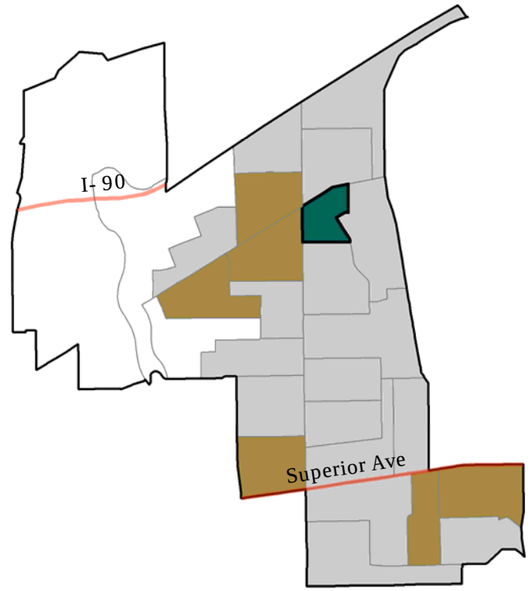
Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

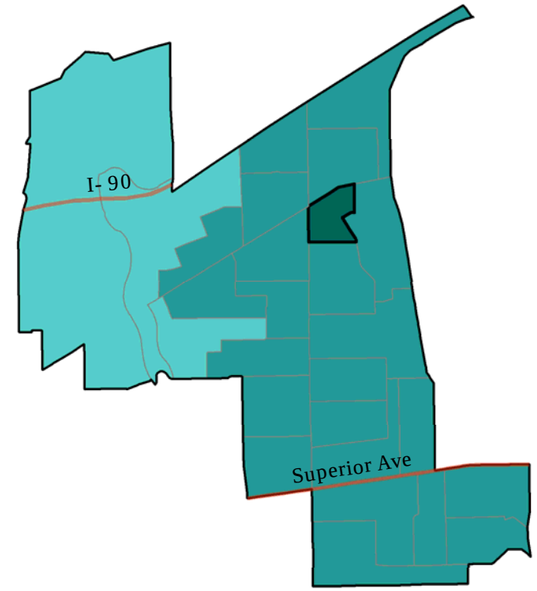
Map G-1: Glenville Impervious Surfaces



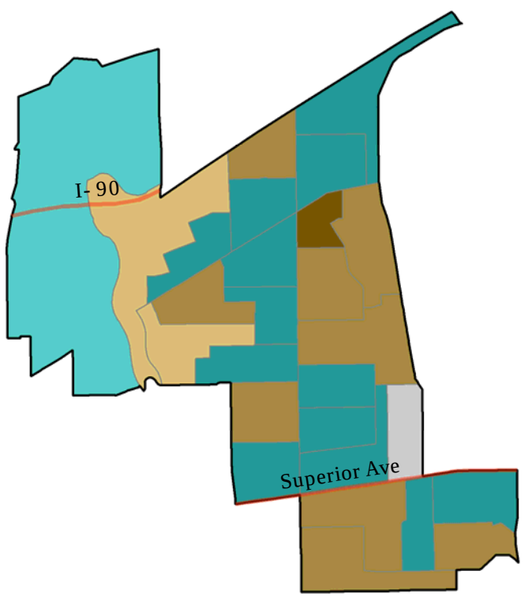
Percent Without High School Diploma



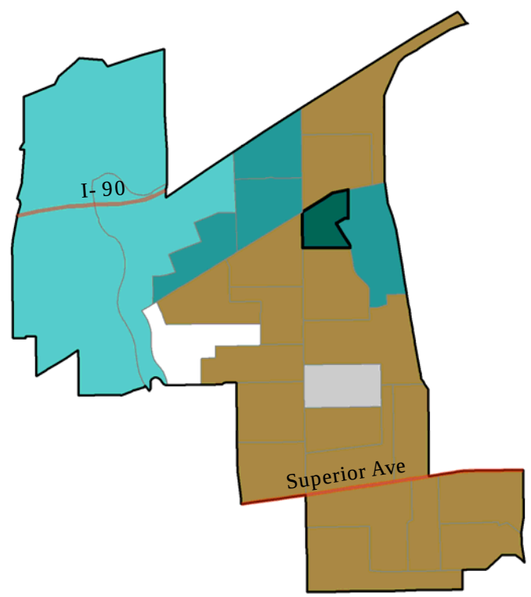
Percent Over the Age of 65



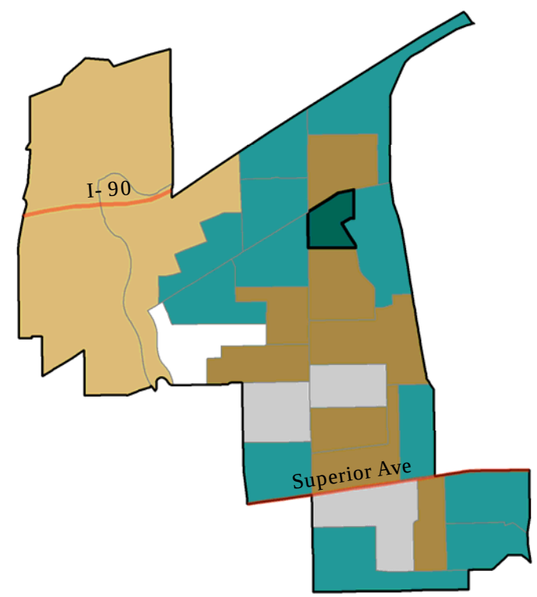
Percent Non-White



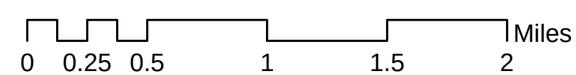
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Impervious
Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
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and Kristen Zeiber
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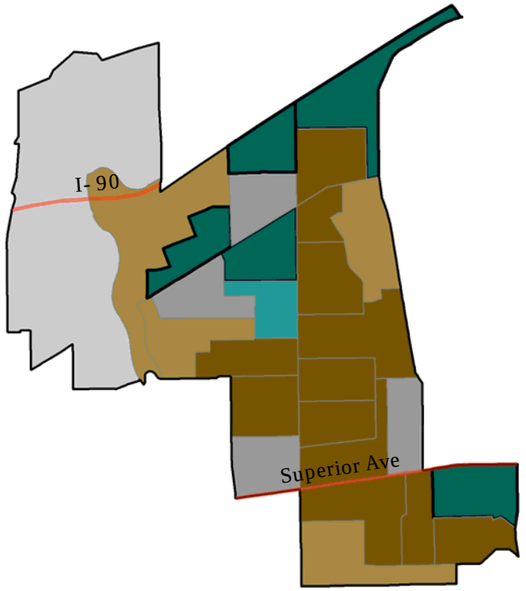
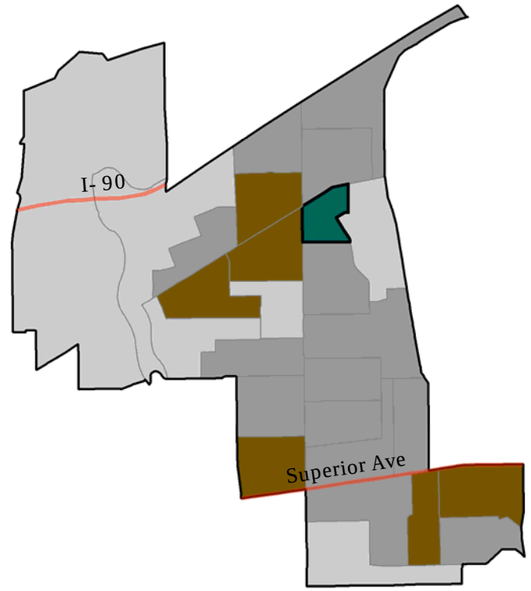
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

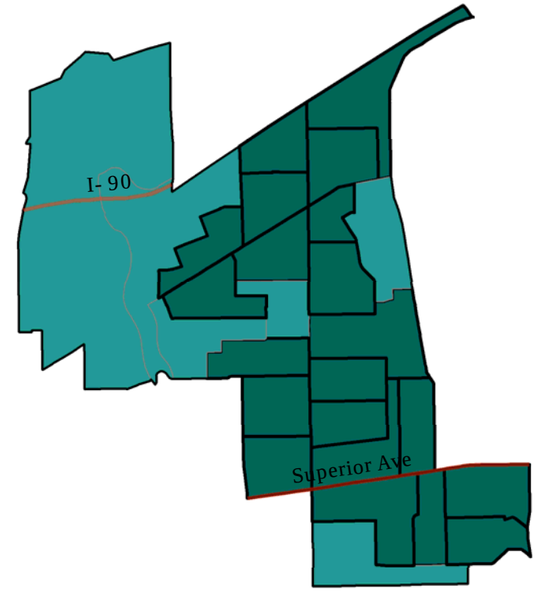
Map G-2: Glenville Tree Canopy Coverage



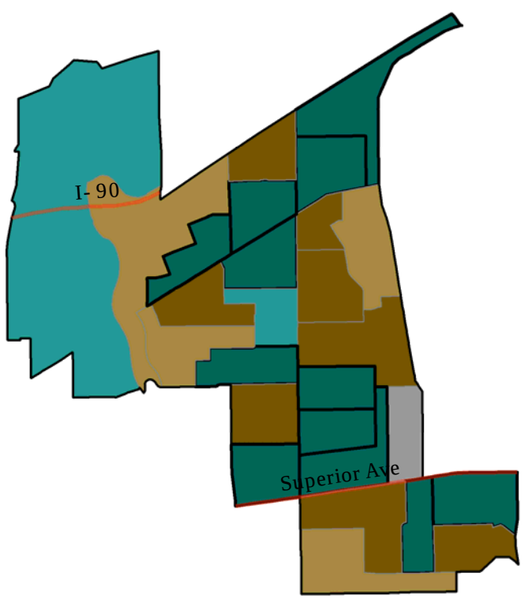
Percent Without High School Diploma



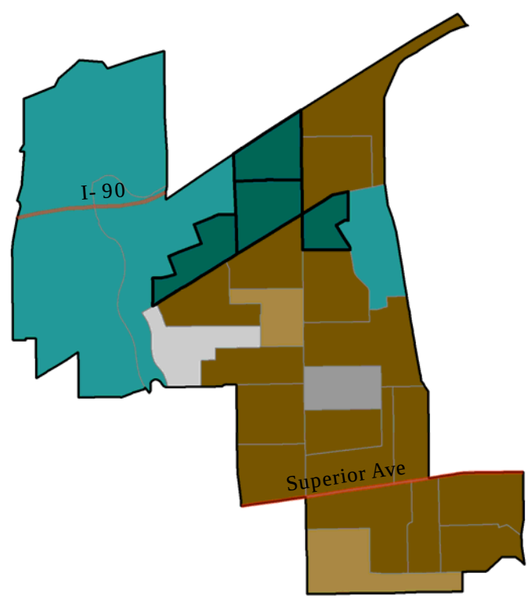
Percent Over the Age of 65



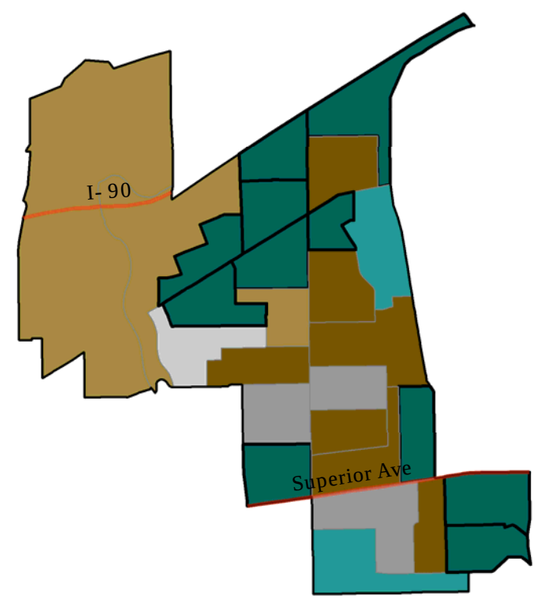
Percent Non-White



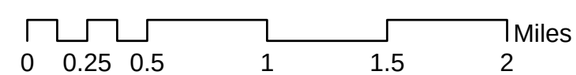
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Tree Canopy
Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

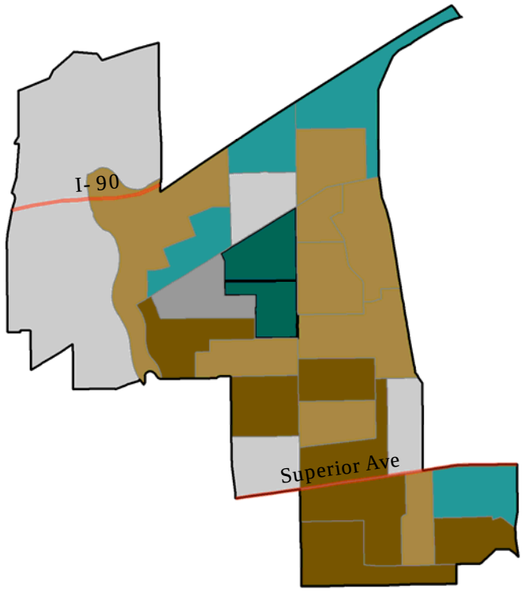
Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

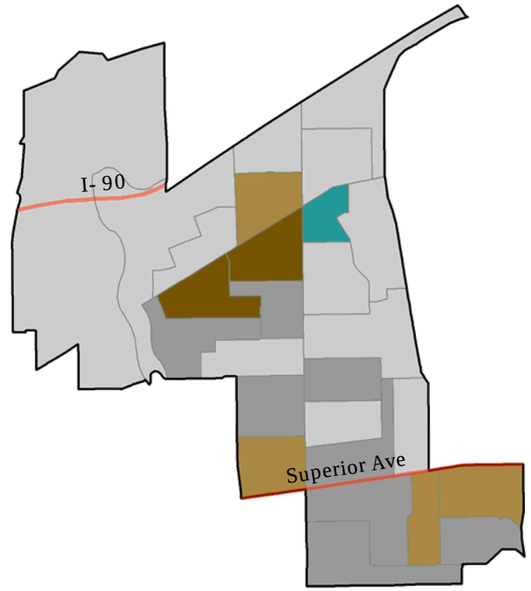
Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

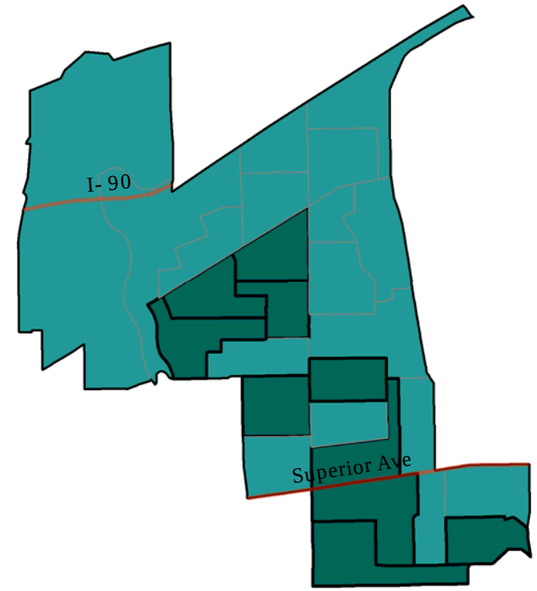
Map G-3: Glenville Buildings Built Before 1939



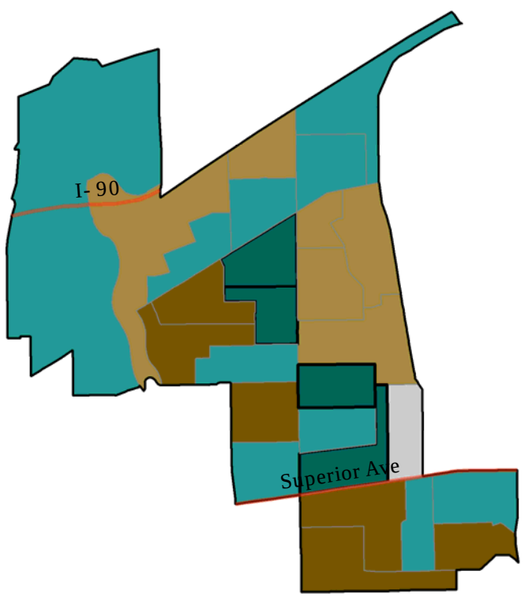
Percent Without High School Diploma



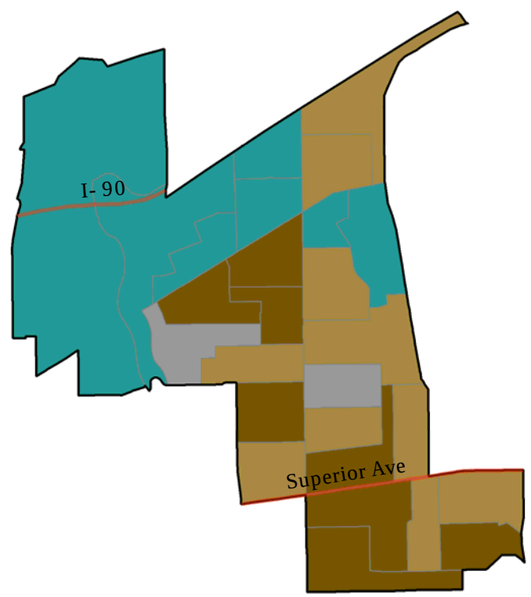
Percent Over the Age of 65



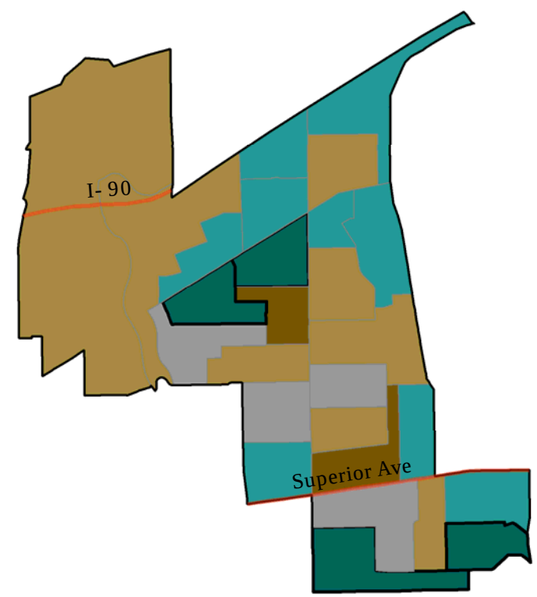
Percent Non-White



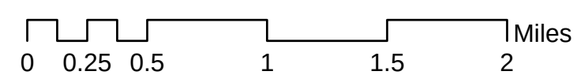
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Buildings Built
Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

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Projection:
NAD 1983, Ohio State Plane North

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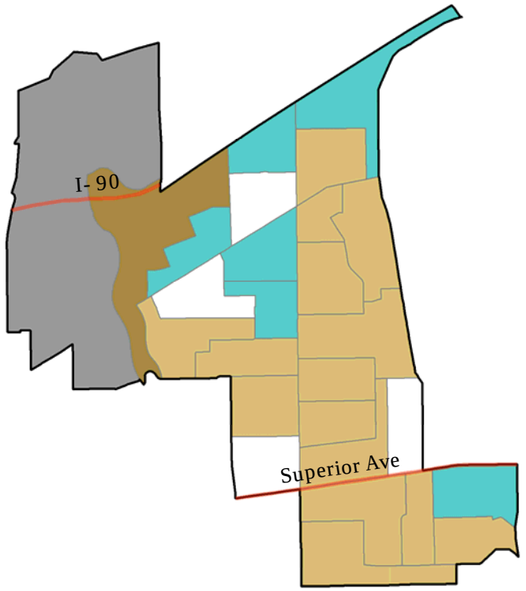
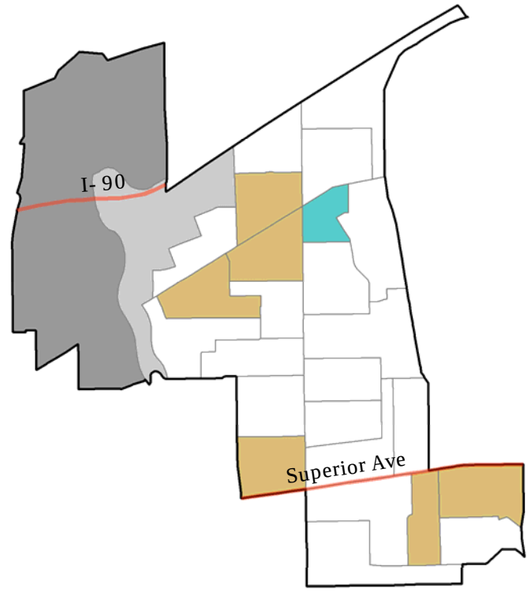
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

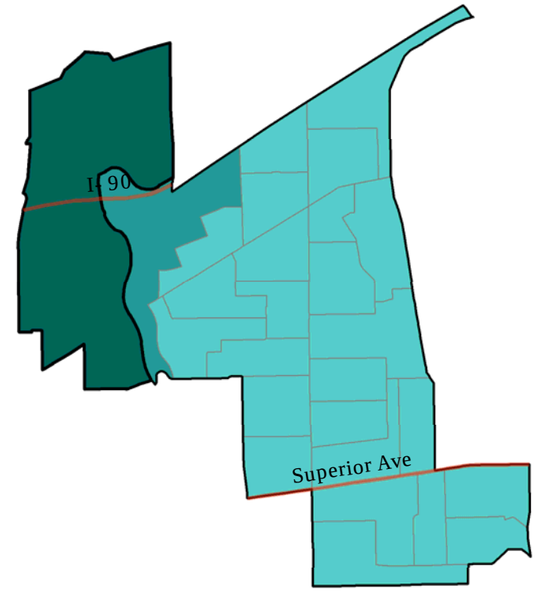
Map G-4: Glenville Flood Zones



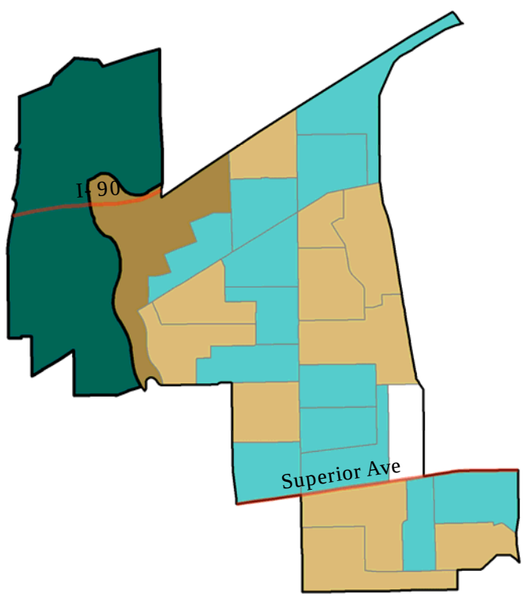
Percent Without High School Diploma



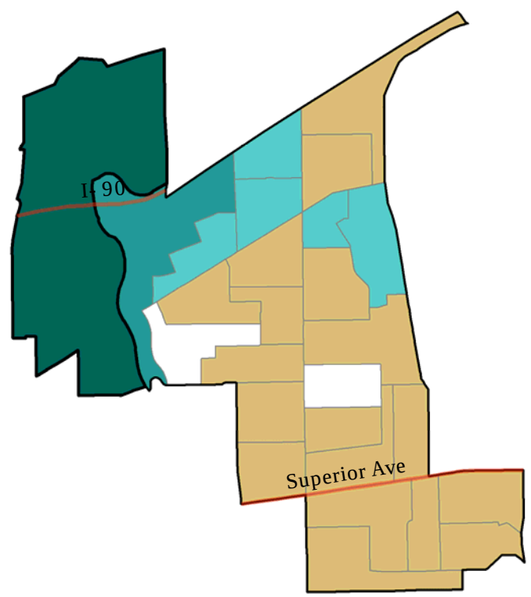
Percent Over the Age of 65



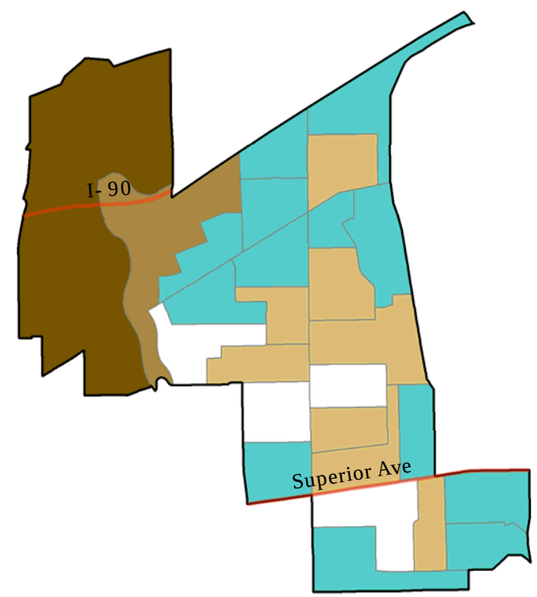
Percent Non-White



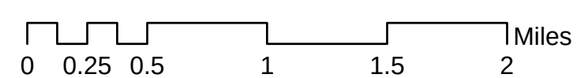
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Flood
Zones

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

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Projection:
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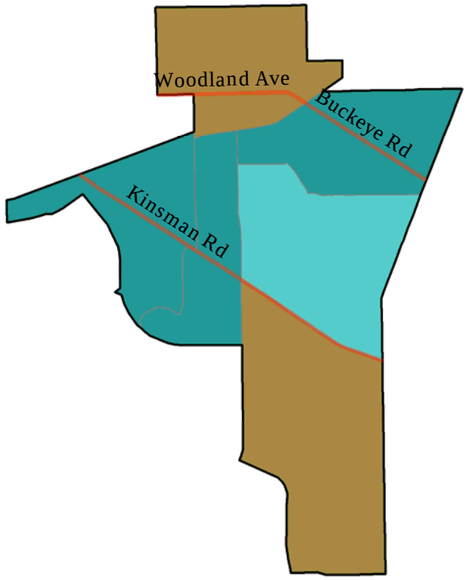
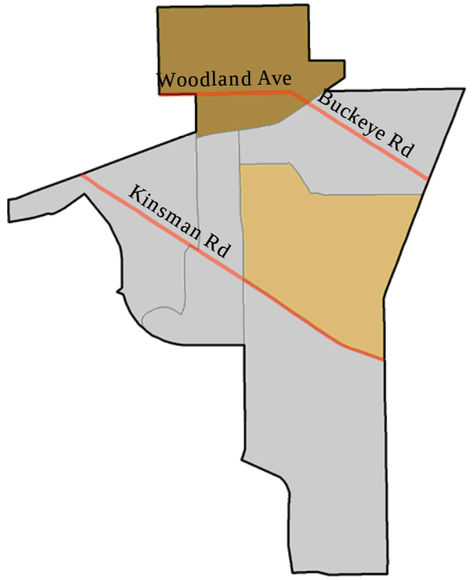
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

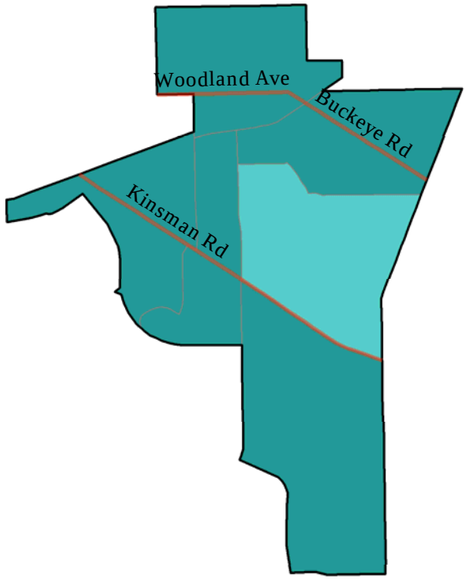
Map K-1: Kinsman Impervious Surfaces



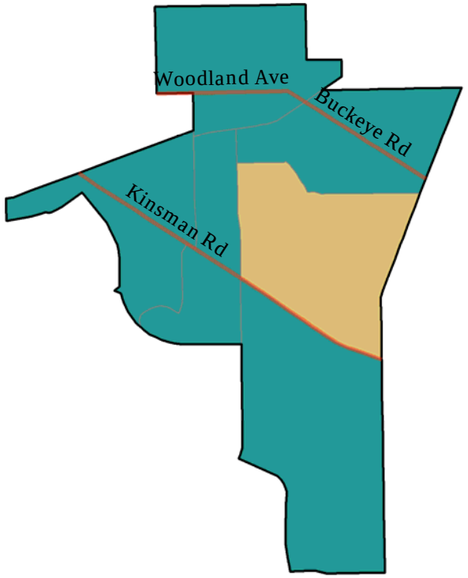
Percent Without High School Diploma



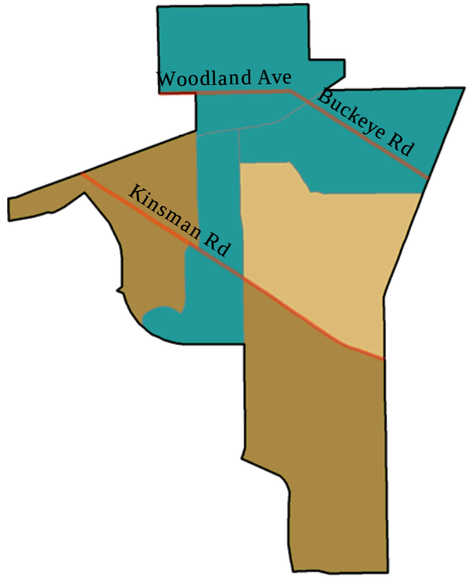
Percent Over the Age of 65



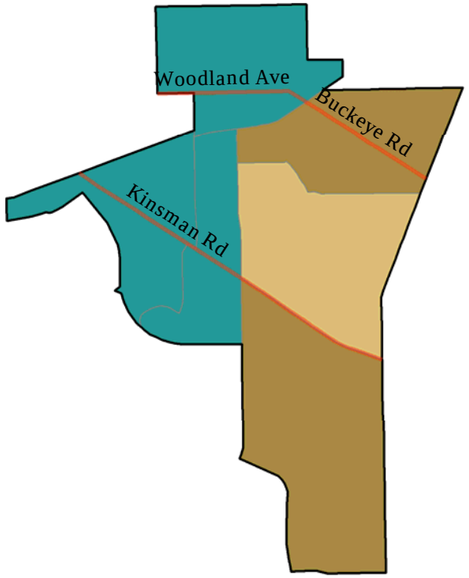
Percent Non-White



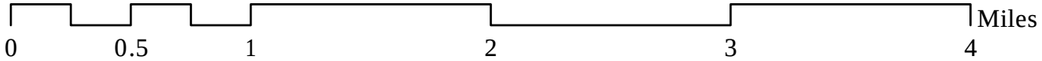
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Impervious
Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

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U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

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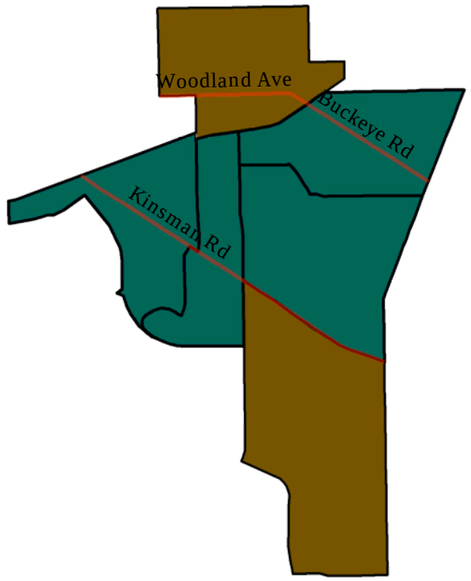
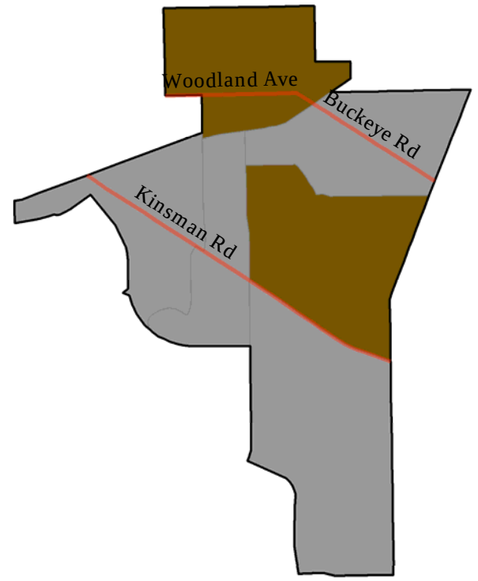
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

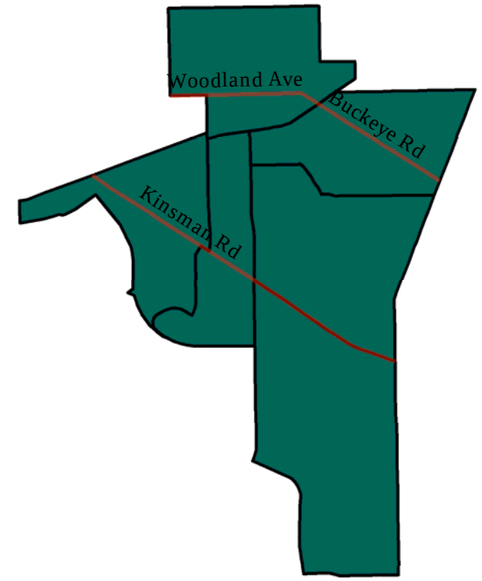
Map K-2: Kinsman Tree Canopy Coverage



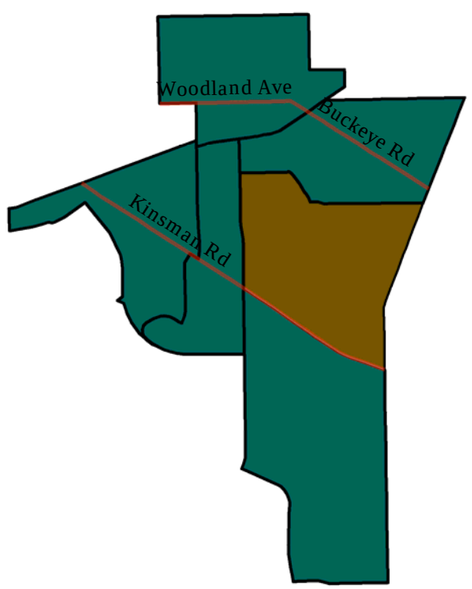
Percent Without High School Diploma



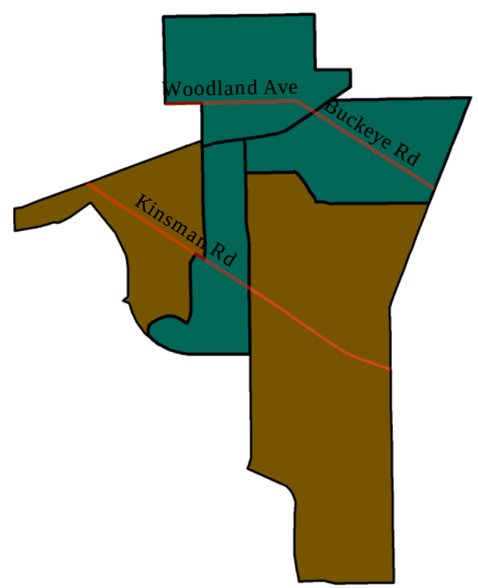
Percent Over the Age of 65



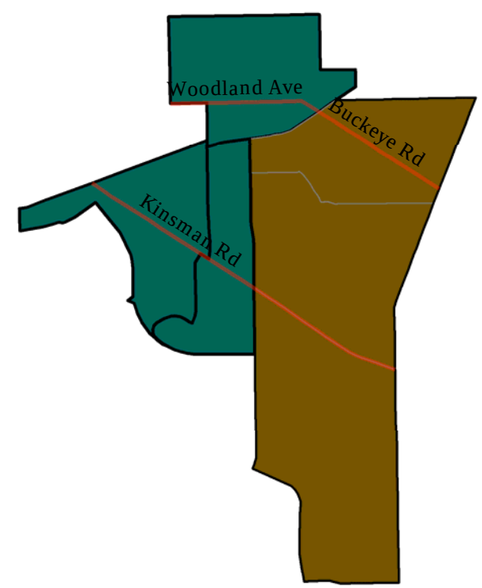
Percent Non-White



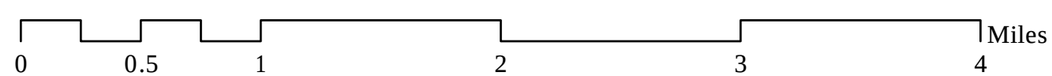
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Tree Canopy
Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:
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Projection:
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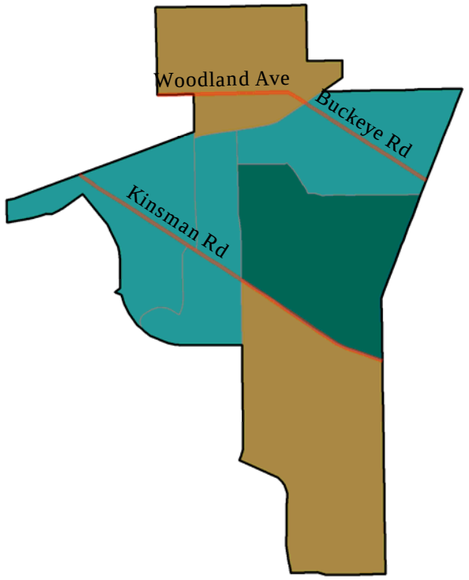
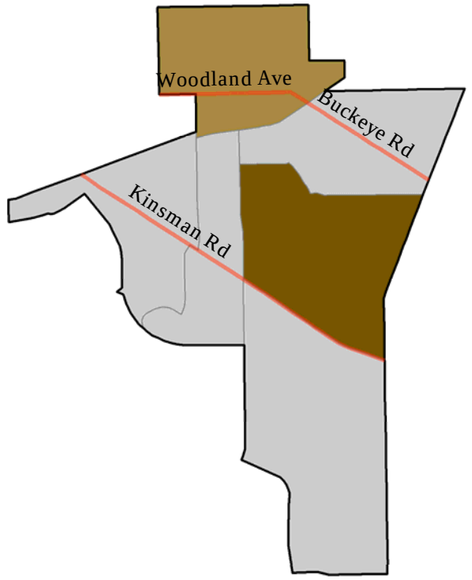
Maps Created:
Tuesday, June 23, 2015

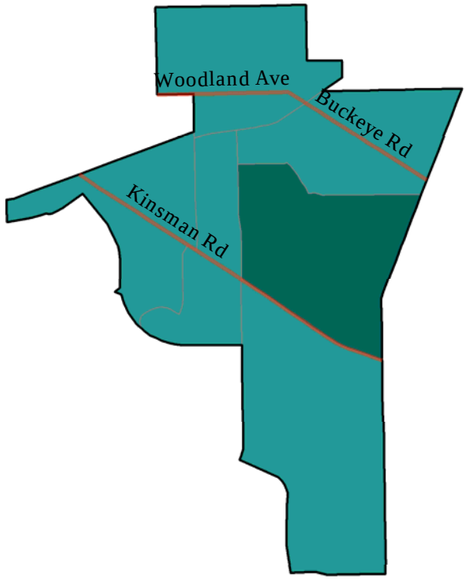
Map K-3: Kinsman Buildings Built Before 1939



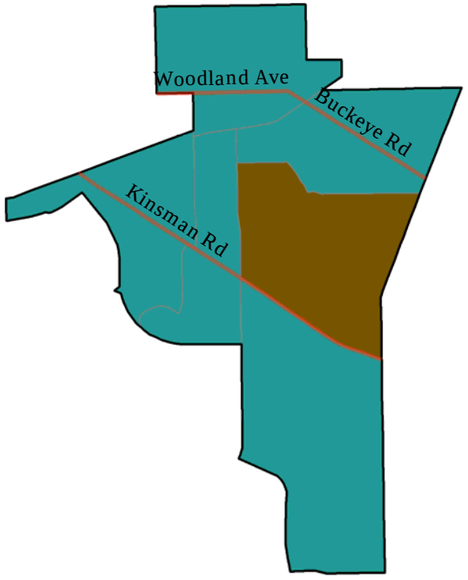
Percent Without High School Diploma



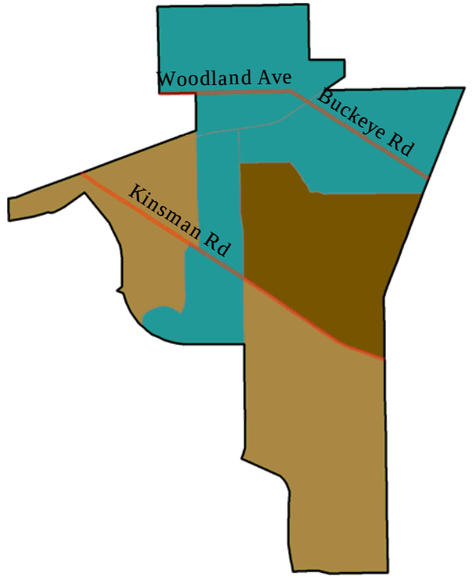
Percent Over the Age of 65



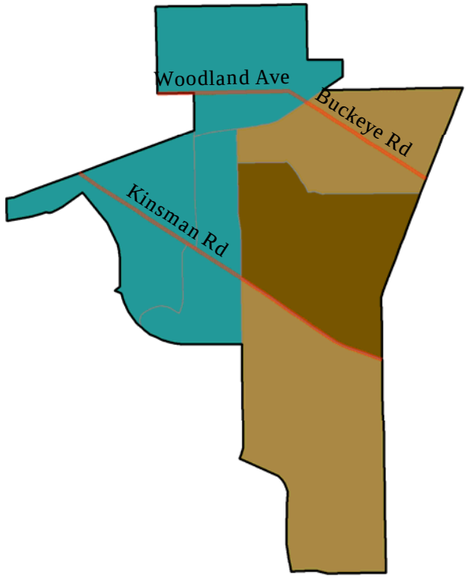
Percent Non-White



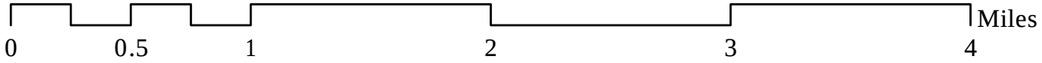
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels Below Each Map

Physical:
Buildings Built Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
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Projection:
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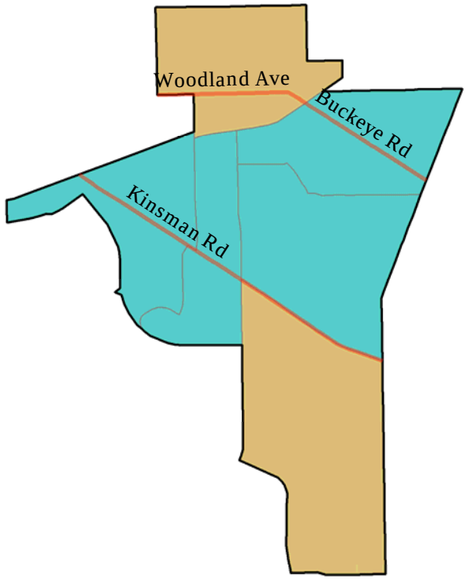
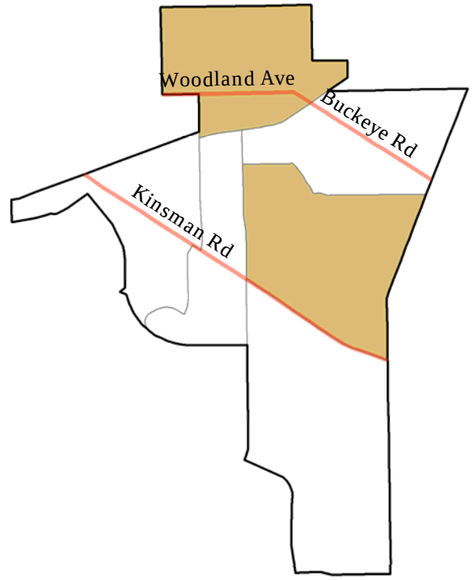
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

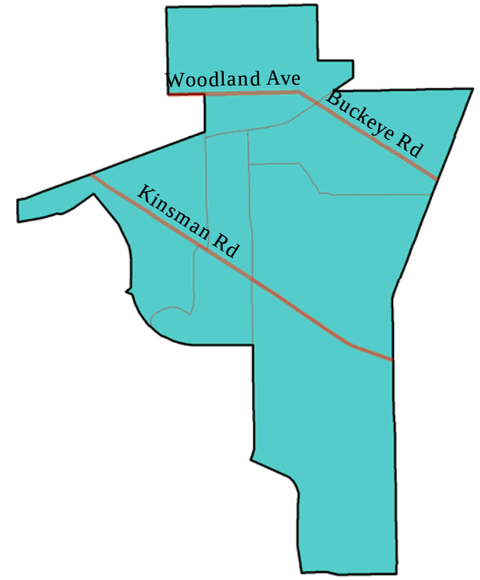
Map K-4: Kinsman Flood Zones



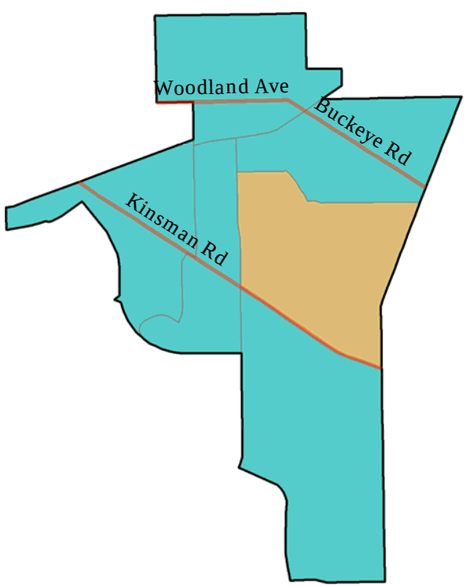
Percent Without High School Diploma



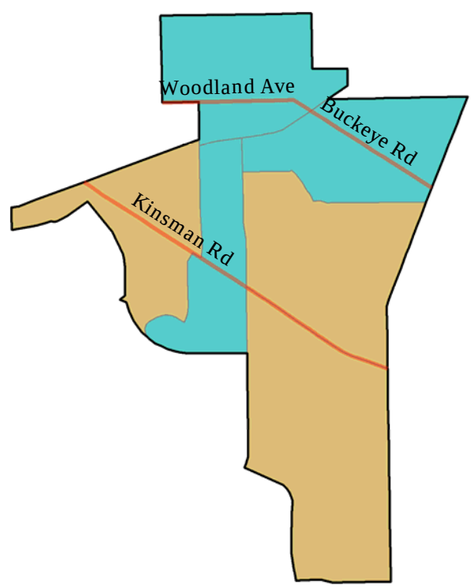
Percent Over the Age of 65



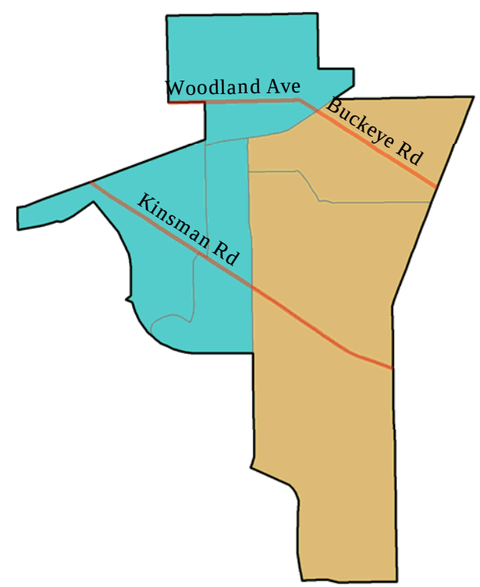
Percent Non-White



Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle

Legend:

Social:
See Labels
Below Each Map

Physical:
Flood
Zones

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

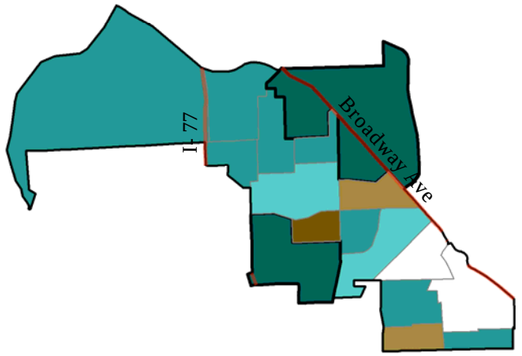
Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

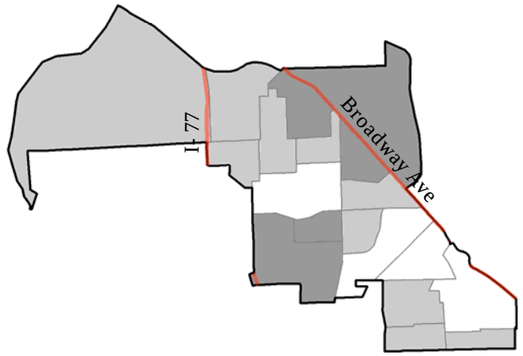
Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

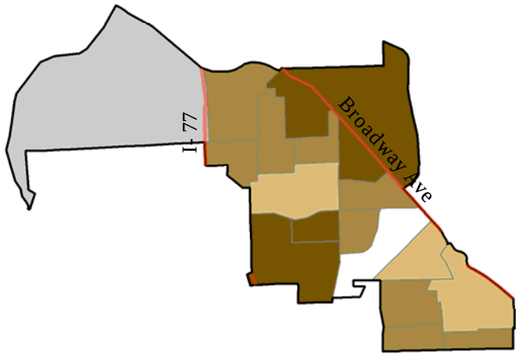
Map S-1: Slavic Village Impervious Surfaces



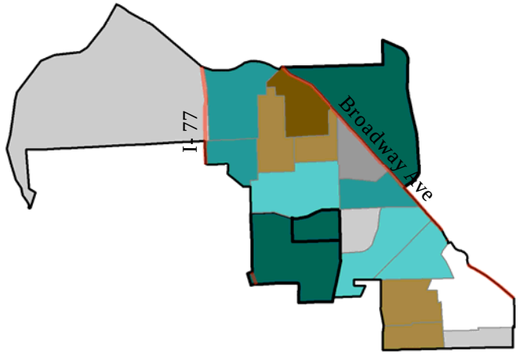
Percent Without High School Diploma



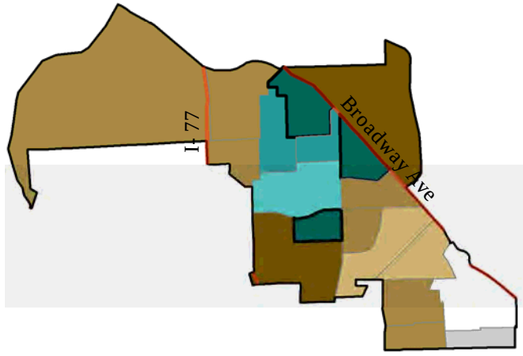
Percent Over the Age of 65



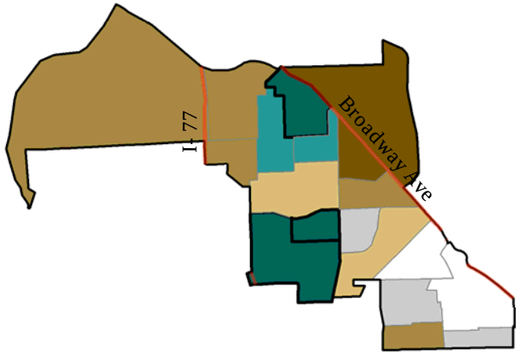
Percent Non-White



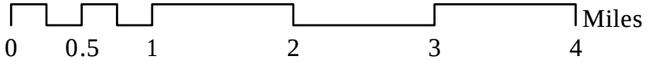
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Impervious
Surfaces

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
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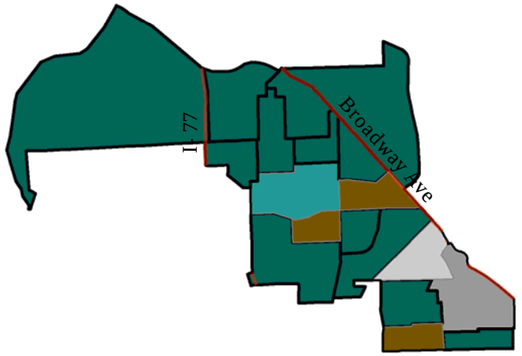
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

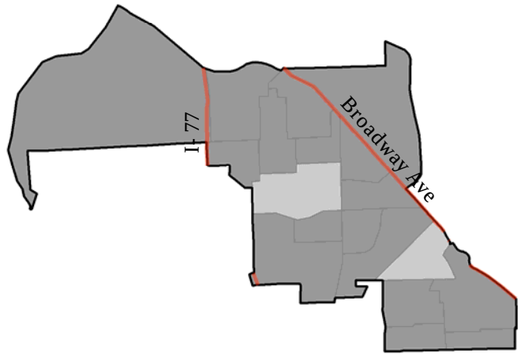
Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

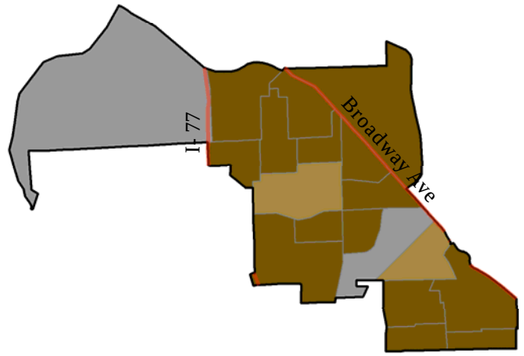
Map S-2: Slavic Village Tree Canopy Coverage



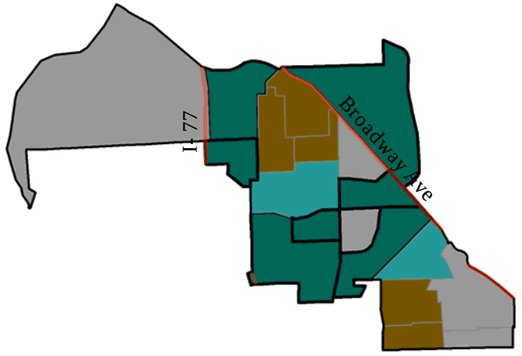
Percent Without High School Diploma



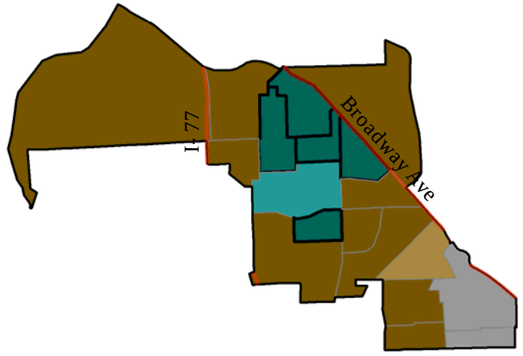
Percent Over the Age of 65



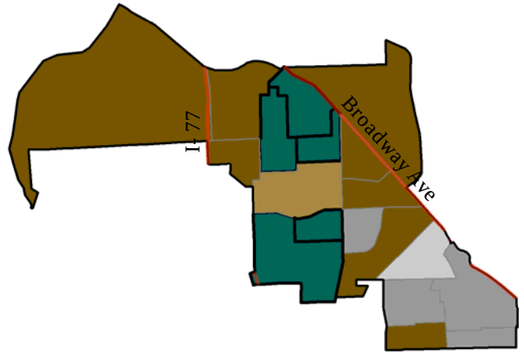
Percent Non-White



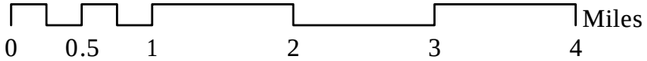
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Tree Canopy
Coverage

Low	1	High
	2	Medium
	3	Low
Medium	4	High
	5	Medium
	6	Low
High	7	High
	8	Medium
	9	Low

Note:
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Projection:
NAD 1983, Ohio State Plane North

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Mike Tuzzo and Nick Rajkovich
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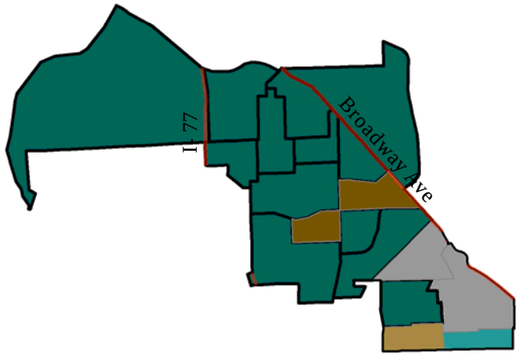
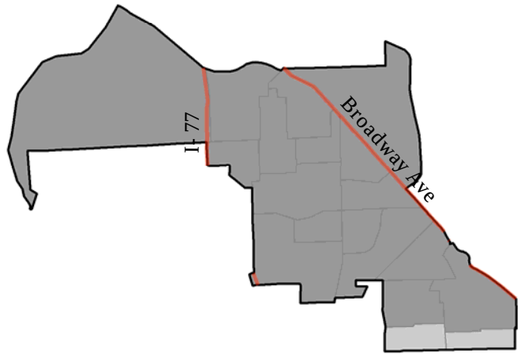
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

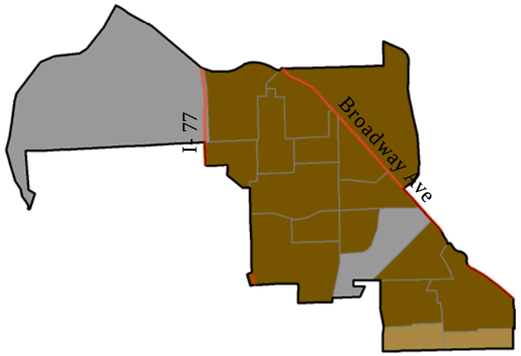
Map S-3: Slavic Village Buildings Built Before 1939



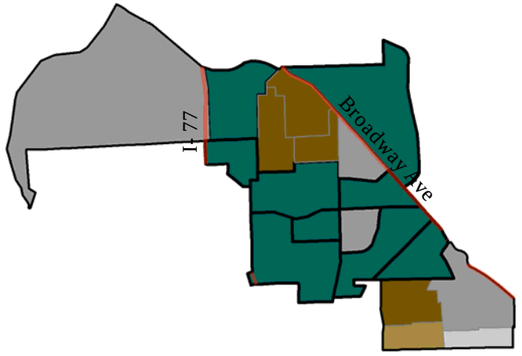
Percent Without High School Diploma



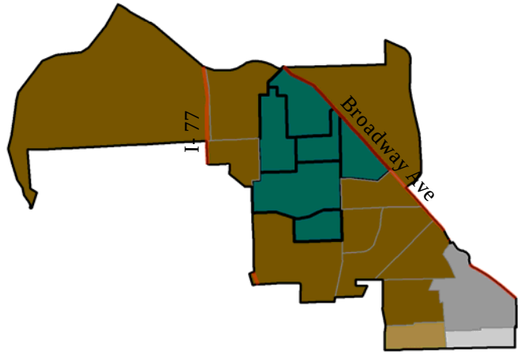
Percent Over the Age of 65



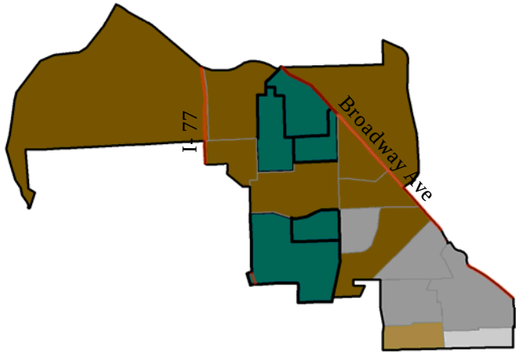
Percent Non-White



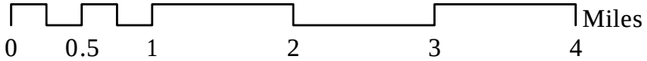
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Buildings Built
Before 1939

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

Data Source:
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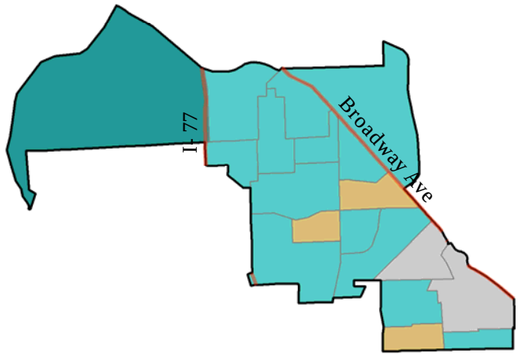
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

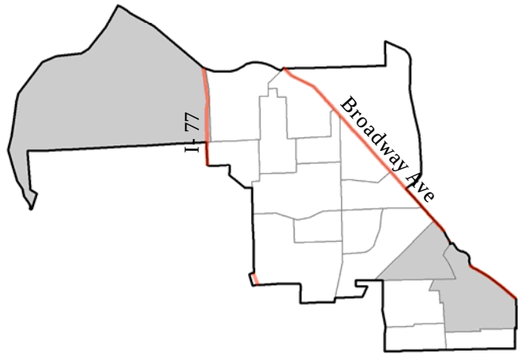
Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

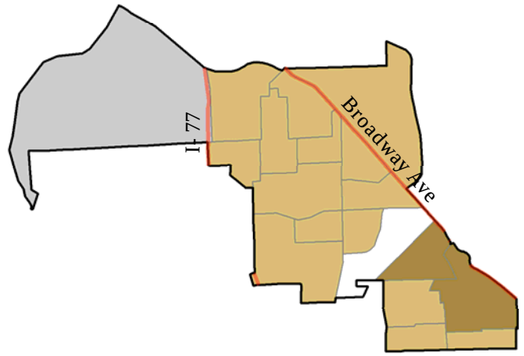
Map S-4: Slavic Village Flood Zones



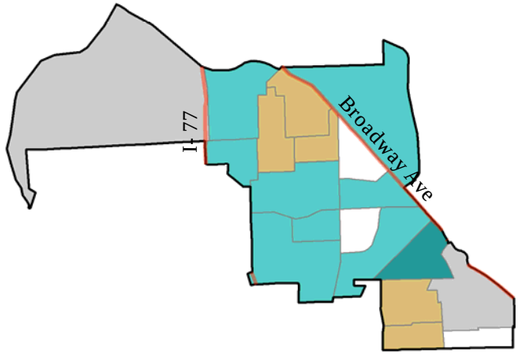
Percent Without High School Diploma



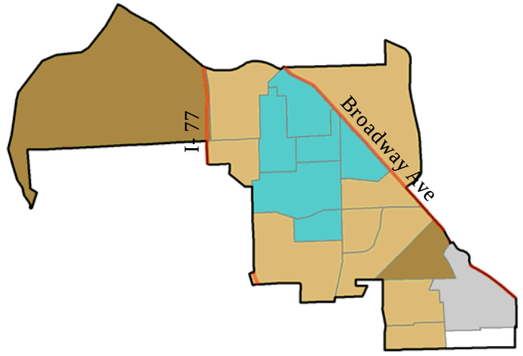
Percent Over the Age of 65



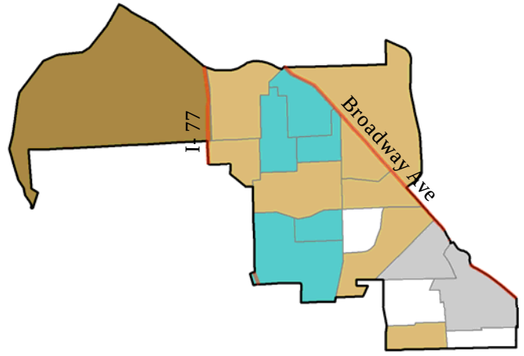
Percent Non-White



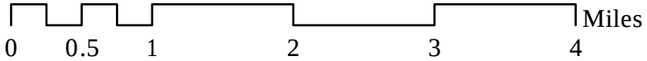
Percent Living Below Poverty Level



Percent Living in Rental Properties



Percent Without a Vehicle



Legend:

Social:
See Labels
Below Each Map

Physical:
Flood
Zones

Low	1	Low
	2	Medium
	3	High
Medium	4	Low
	5	Medium
	6	High
High	7	Low
	8	Medium
	9	High

Note:
Values labeled as "Low" include the lowest value up to and including the mean value. Values labeled as "Medium"are between the mean and one standard deviation above the mean. Values labeled as "High" include any value that is greater than one standard deviation above

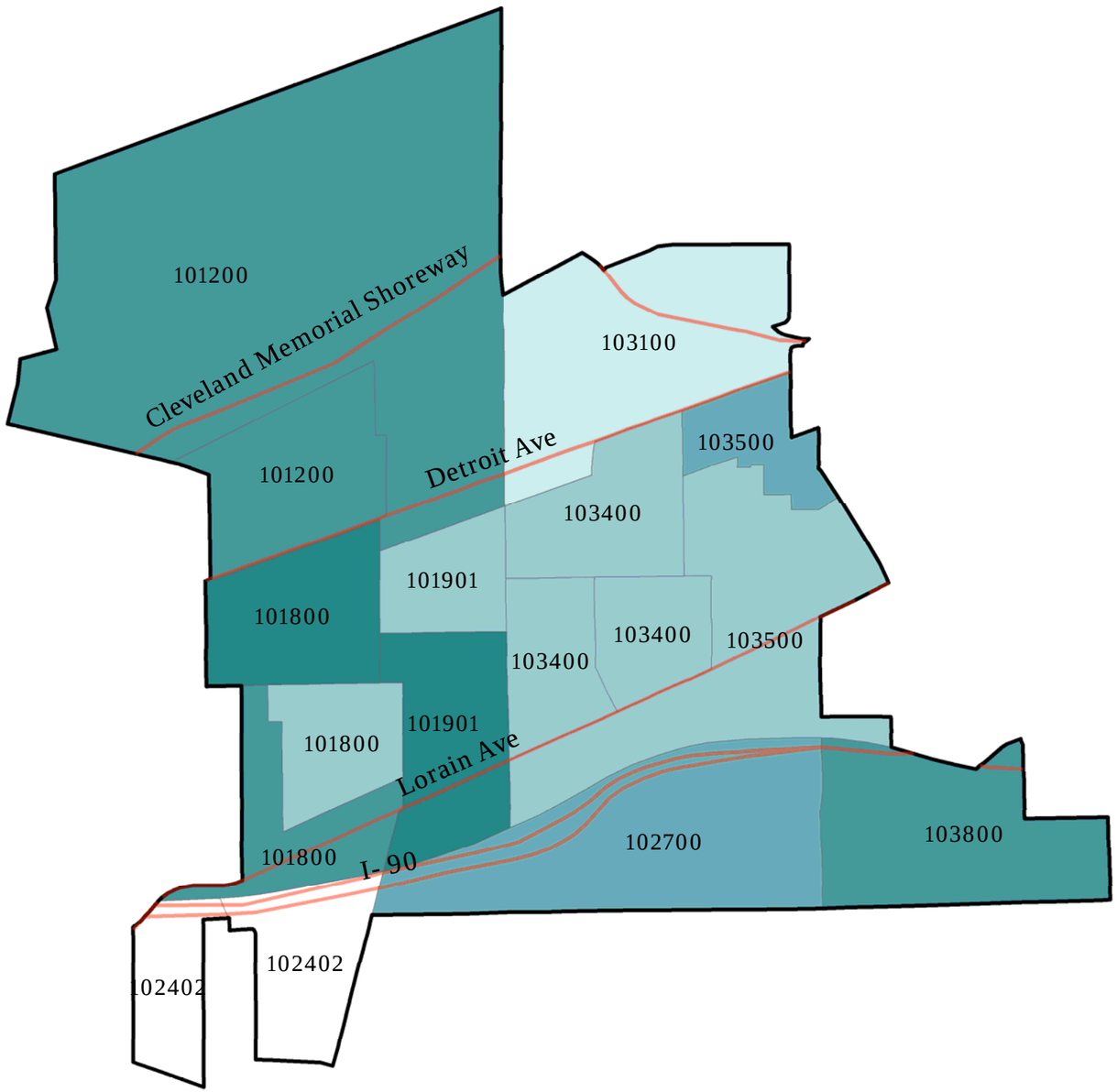
Data Source:
NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:
NAD 1983, Ohio State Plane North

Maps Produced By:
Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:
Tuesday, June 23, 2015

Map D-V: Detroit-Shoreway Vulnerability



Legend:

- Major Roads
- Detroit-Shoreway

Vulnerability

- 0 Least Vulnerable
- 3
- 4
- 6
- 8
- 9 Most Vulnerable

Note:
Vulnerability values for each block group are determined by the overall count of "High/High" values in the social and physical factor comparison. For example, a "High" value in the percent without a vehicle paired with a "High" value for impervious surfaces represents one vulnerability value.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Thursday, June 25, 2015

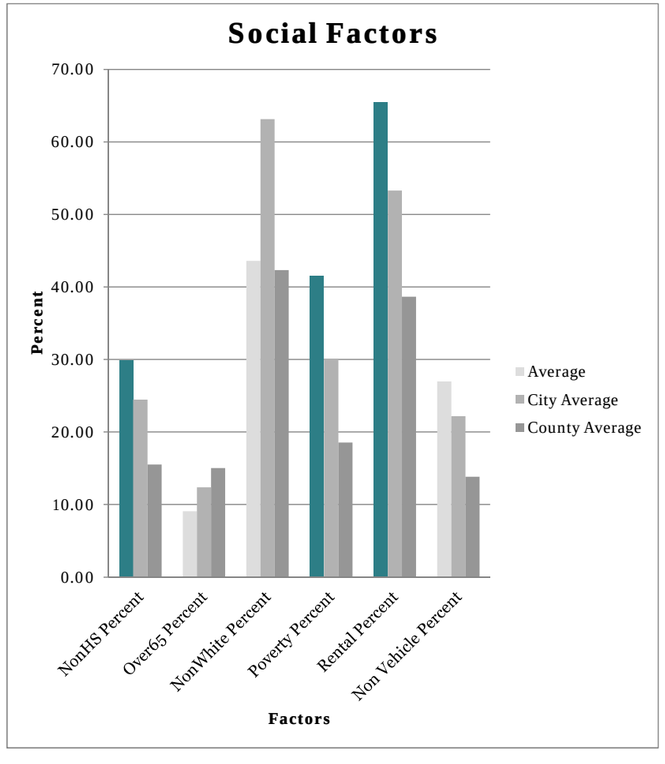
0 0.25 0.5 1 1.5 2 Miles

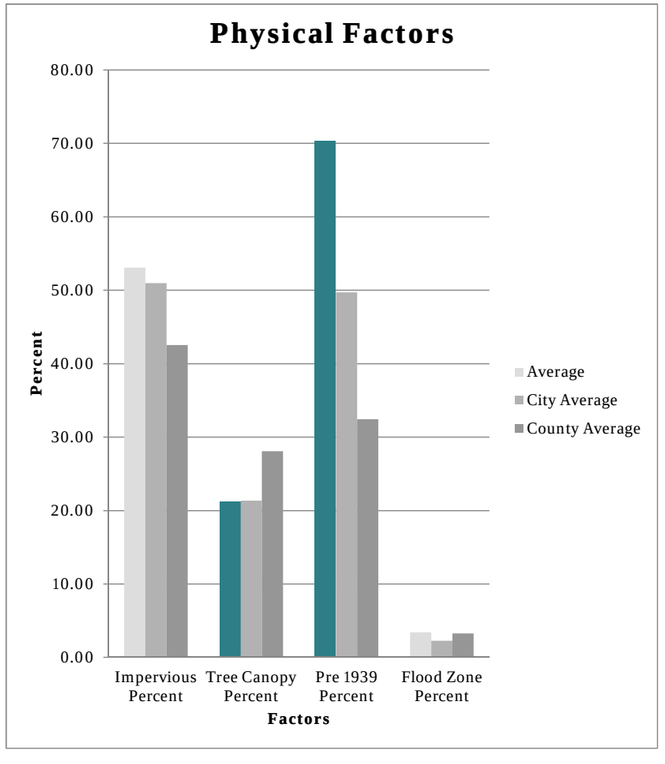
Detroit-Shoreway Social Data

GEOID	NonHS Percent	NonHS Number	Over65 Percent	Over65 Number	NonWhite Percent	NonWhite Number	Poverty Percent	Poverty Number	Rental Percent	Rental Number	Non Vehicle Percent	Non Vehicle Number
1012001	34.49	446	19.40	251	30.06	389	47.16	610	72.42	937	37.64	487
1012002	31.96	405	13.56	172	51.34	651	45.03	571	84.67	1074	47.68	605
1018001	31.12	335	19.07	205	48.19	518	43.75	470	70.48	758	21.72	233
1018002	37.24	322	6.12	53	46.88	406	42.47	368	68.65	595	32.38	280
1018003	38.40	384	7.49	75	48.55	486	58.30	584	59.48	595	21.66	217
1019011	30.90	231	7.21	54	36.98	277	46.26	346	61.46	460	7.46	56
1019012	25.44	240	7.53	71	55.04	519	47.90	452	66.03	623	60.90	574
1024022	12.33	98	6.03	48	41.21	328	28.61	228	61.75	492	11.90	95
1024023	17.18	185	6.79	73	42.51	457	16.36	176	52.96	569	10.66	115
1027004	53.57	524	6.64	65	40.04	392	50.61	495	65.29	639	15.61	153
1031001	14.38	152	6.55	69	40.89	431	19.45	205	66.88	705	10.23	108
1034001	35.10	412	6.99	82	47.91	562	48.85	573	63.74	748	24.63	289
1034002	11.50	94	7.98	65	48.10	392	41.06	335	59.50	485	33.33	272
1034003	36.94	289	11.00	86	42.07	329	37.97	297	63.67	498	22.16	173
1035001	37.54	563	6.94	104	41.89	628	46.15	692	62.37	935	24.54	368
1035002	13.24	64	7.68	37	35.06	169	43.43	209	69.40	335	38.91	188
1038001	45.86	484	7.48	79	44.22	467	41.79	441	64.11	677	37.11	392
Average	29.83		9.09		43.58		41.48		65.46		26.97	
City Average	24.48		12.38		63.15		30.11		53.28		22.19	
County Average	15.54		15.03		42.32		18.56		38.65		13.84	

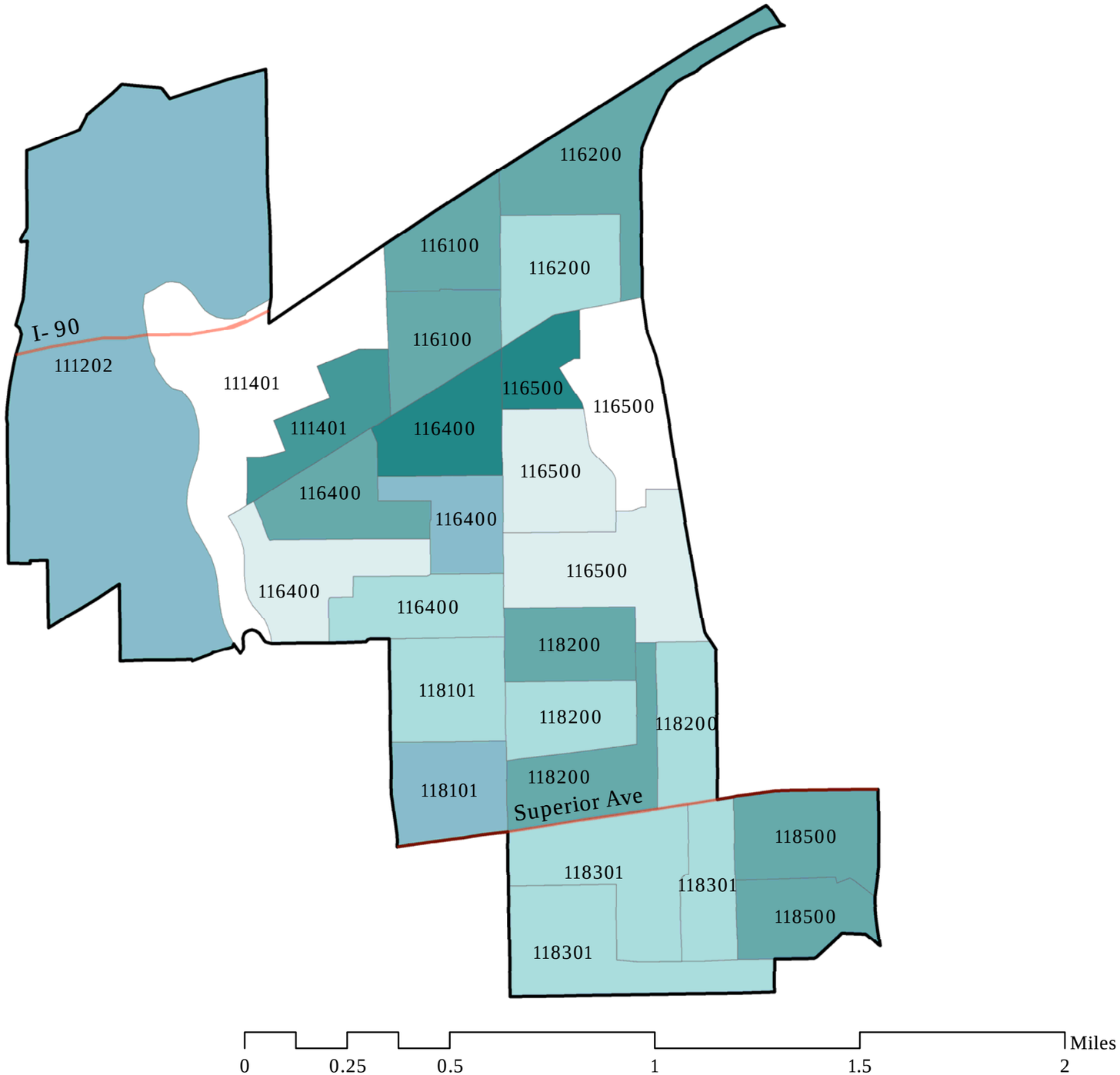
Detroit-Shoreway Physical Data

GEOID	Impervious Percent	Tree Canopy Percent	Pre 1939 Percent	Flood Zone Percent
1012001	40.00	18.00	59.71	57.00
1012002	67.00	16.00	49.62	0.00
1018001	64.00	16.00	78.01	0.00
1018002	54.00	21.00	77.25	0.00
1018003	46.00	25.00	72.85	0.00
1019011	56.00	23.00	86.46	0.00
1019012	58.00	20.00	62.16	0.00
1024022	56.00	20.00	74.53	0.00
1024023	48.00	24.00	70.53	0.00
1027004	51.00	14.00	69.30	0.00
1031001	58.00	16.00	68.94	1.00
1034001	54.00	25.00	73.38	0.00
1034002	52.00	25.00	67.87	0.00
1034003	50.00	27.00	67.15	0.00
1035001	43.00	22.00	72.13	0.00
1035002	52.00	27.00	73.21	0.00
1038001	53.00	22.00	72.66	0.00
Average	53.06	21.24	70.34	3.41
City Average	50.95	21.34	49.70	2.26
County Average	42.53	28.07	32.43	3.29





Map G-V: Glenville Vulnerability



Legend:

- Major Roads
- Glenville

Vulnerability

- 0 Least Vulnerable
- 1
- 2
- 3
- 4
- 5
- 8 Most Vulnerable

Note:

Vulnerability values for each block group are determined by the overall count of "High/High" values in the social and physical factor comparison. For example, a "High" value in the percent without a vehicle paired with a "High" value for impervious surfaces represents one vulnerability value.

Data Source:

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Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
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Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

Mike Tuzzo and Nick Rajkovich
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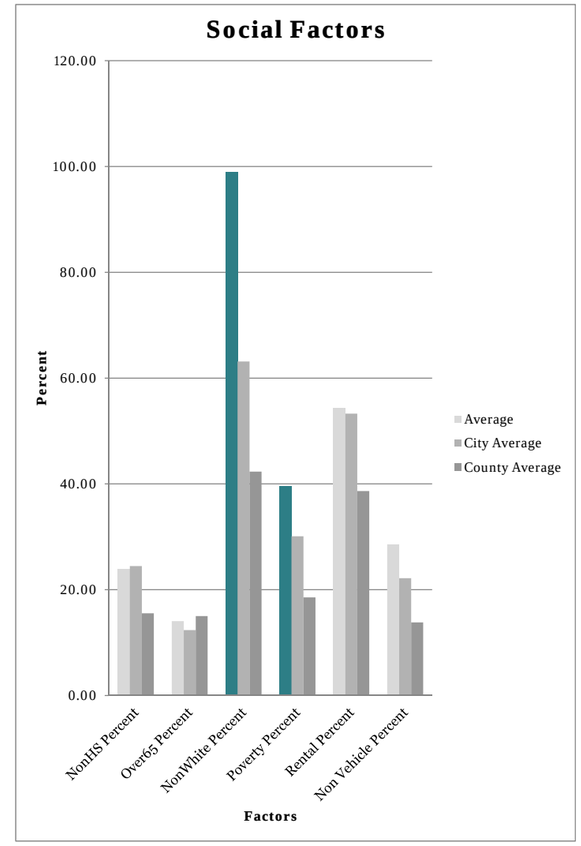
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

Thursday, June 25, 2015

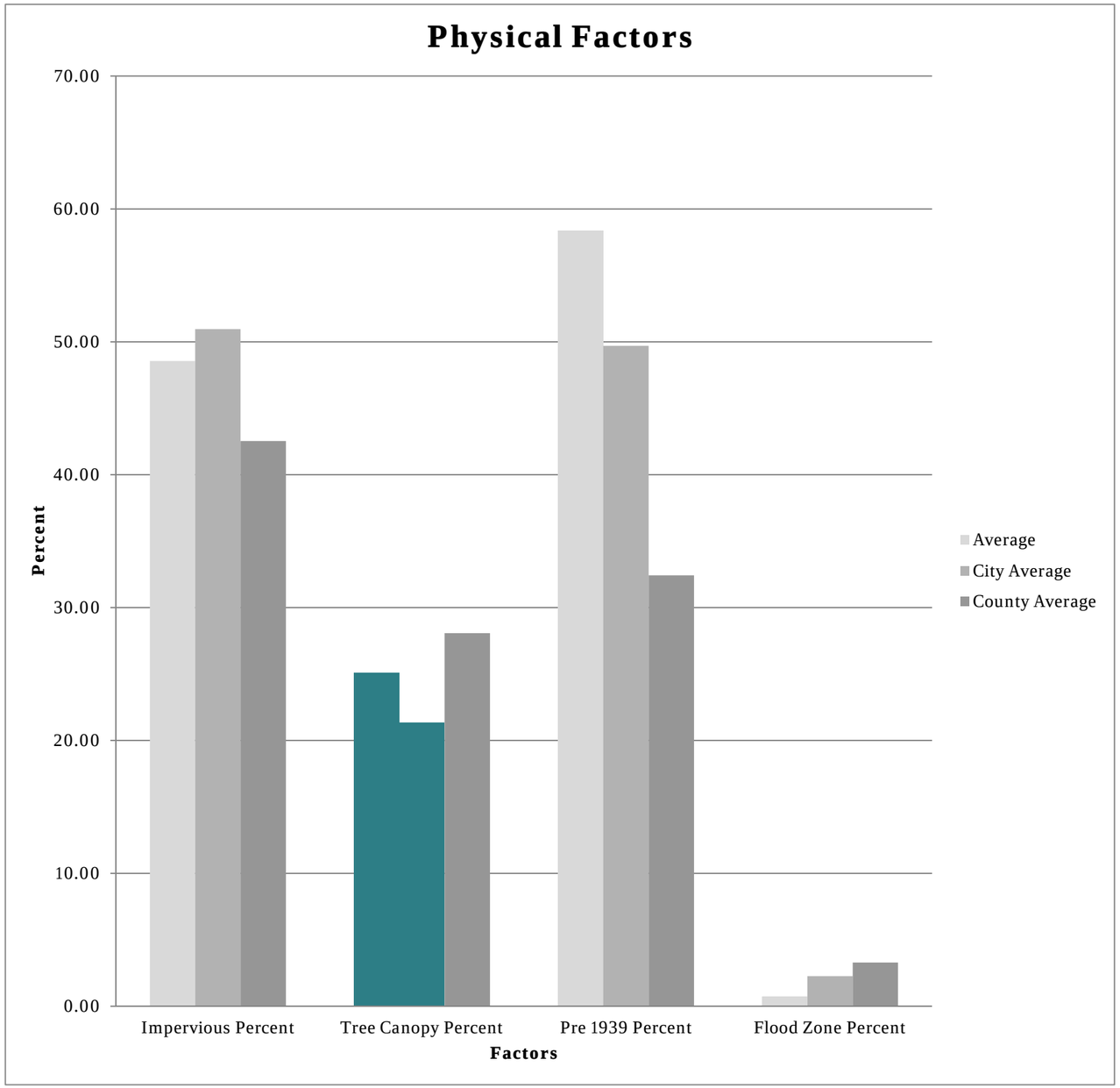
Glenville Social Data

GEOID	NonHS Percent	NonHS Number	Over65 Percent	Over65 Number	NonWhite Percent	NonWhite Number	Poverty Percent	Poverty Number	Rental Percent	Rental Number	Non Vehicle Percent	Non Vehicle Number
1112022	14.19	65	8.28	38	96.73	444	40.27	185	66.00	303	21.16	97
1114011	31.95	191	12.56	75	99.50	594	57.19	341	72.38	432	31.73	189
1114012	17.08	112	13.72	90	99.39	652	27.92	183	66.78	438	16.20	106
1161001	57.72	266	14.10	65	100.00	461	30.12	139	64.20	296	29.95	138
1161002	14.74	73	17.24	85	99.19	489	56.68	279	68.42	337	54.37	268
1162001	42.59	236	14.05	78	99.10	550	50.39	280	48.00	266	30.97	172
1162002	23.33	138	11.00	65	99.32	587	43.32	256	43.69	258	21.09	125
1164001	29.19	97	15.66	52	99.10	329	45.12	150	56.38	187	30.82	102
1164002	28.23	138	14.34	70	99.59	486	65.38	319	51.93	253	26.95	132
1164003	16.74	145	11.56	100	99.77	863	54.76	474	62.18	538	24.22	210
1164004	24.88	176	14.43	102	99.29	702	24.76	175	23.97	169	10.71	76
1164005	12.39	74	18.73	112	99.50	595	35.45	212	54.84	328	55.15	330
1165001	25.89	122	12.92	61	97.67	461	27.43	129	65.22	308	44.65	211
1165002	25.94	240	12.55	116	99.68	921	34.41	318	60.78	562	26.05	241
1165003	21.54	158	13.51	99	99.59	730	22.12	162	42.24	310	22.40	164
1165004	26.12	121	27.37	127	99.78	463	28.75	133	84.31	391	57.84	268
1181012	26.85	264	10.47	103	99.49	979	27.24	268	62.03	610	12.76	126
1181013	12.77	72	16.05	91	97.00	550	45.25	257	55.04	312	30.85	175
1182001	13.52	87	12.50	80	99.37	636	17.97	115	53.69	344	29.82	191
1182002	18.95	103	10.85	59	99.63	542	56.08	305	46.67	254	22.47	122
1182003	20.78	102	11.38	56	98.37	484	44.58	219	49.09	242	23.53	116
1182004	24.09	102	13.18	56	99.76	424	50.81	216	30.32	129	0.00	0
1183012	16.15	71	15.56	68	97.25	425	41.11	180	49.76	217	21.71	95
1183013	19.10	131	14.29	98	99.85	685	26.85	184	48.50	333	13.40	92
1183014	22.91	178	13.27	103	94.85	736	35.60	276	39.05	303	29.10	226
1185001	32.94	175	17.89	95	99.44	528	51.17	272	53.00	281	39.90	212
1185002	23.90	111	12.31	57	100.00	463	27.92	129	51.37	238	43.56	202
Average	23.87		14.07		98.97		39.58		54.44		28.57	
City Average	24.48		12.38		63.15		30.11		53.28		22.19	
County Average	15.54		15.03		42.32		18.56		38.65		13.84	

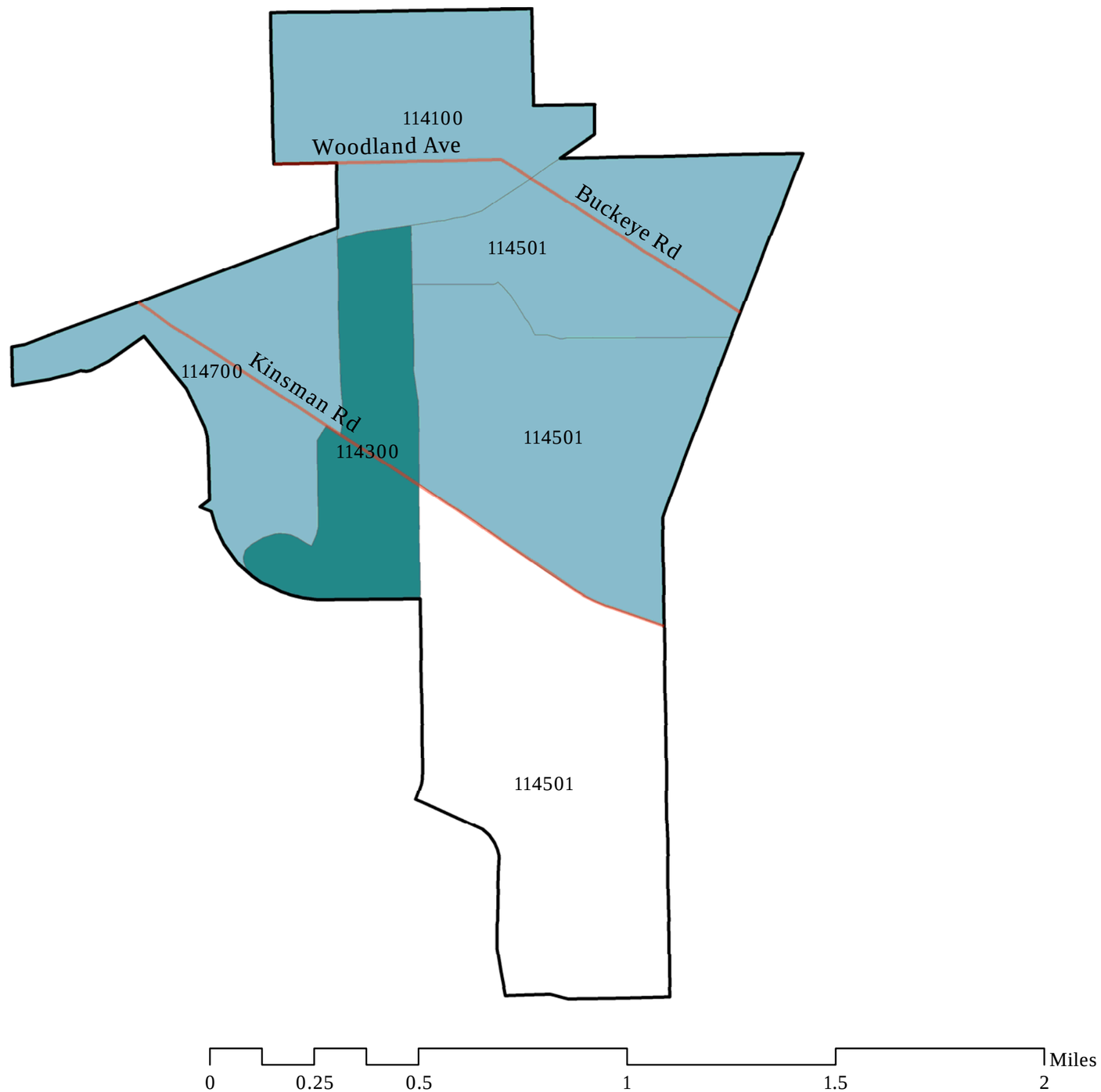


Glenville Physical Data

GEOID	Impervious Percent	Tree Canopy Percent	Pre 1939 Percent	Flood Zone Percent
1112022	36.00	29.00	43.30	15.00
1114011	54.00	23.00	40.00	0.00
1114012	36.00	35.00	50.87	5.00
1161001	53.00	20.00	40.59	0.00
1161002	50.00	27.00	59.92	0.00
1162001	48.00	23.00	54.11	0.00
1162002	53.00	17.00	50.70	0.00
1164001	56.00	20.00	61.51	0.00
1164002	44.00	30.00	72.70	0.00
1164003	48.00	25.00	54.96	0.00
1164004	42.00	35.00	80.20	0.00
1164005	54.00	25.00	74.61	0.00
1165001	46.00	29.00	58.30	0.00
1165002	49.00	23.00	50.69	0.00
1165003	48.00	26.00	51.78	0.00
1165004	63.00	17.00	40.52	0.00
1181012	53.00	22.00	69.71	0.00
1181013	49.00	24.00	59.40	0.00
1182001	50.00	24.00	49.34	0.00
1182002	48.00	26.00	67.59	0.00
1182003	49.00	24.00	57.14	0.00
1182004	46.00	26.00	71.90	0.00
1183012	44.00	27.00	57.48	0.00
1183013	52.00	23.00	68.04	0.00
1183014	46.00	28.00	70.18	0.00
1185001	50.00	22.00	52.10	0.00
1185002	44.00	27.00	67.51	0.00
Average	48.56	25.07	58.34	0.74
City Average	50.95	21.34	49.70	2.26
County Average	42.53	28.07	32.43	3.29



Map K-V: Kinsman Vulnerability



Legend:

- Major Roads
- Kinsman

Vulnerability

- 2 Least Vulnerable
- 4
- 5 Most Vulnerable

Note:
Vulnerability values for each block group are determined by the overall count of "High/High" values in the social and physical factor comparison. For example, a "High" value in the percent without a vehicle paired with a "High" value for impervious surfaces represents one vulnerability value.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative (http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
Kristen Zeiber and Terry Schwarz
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

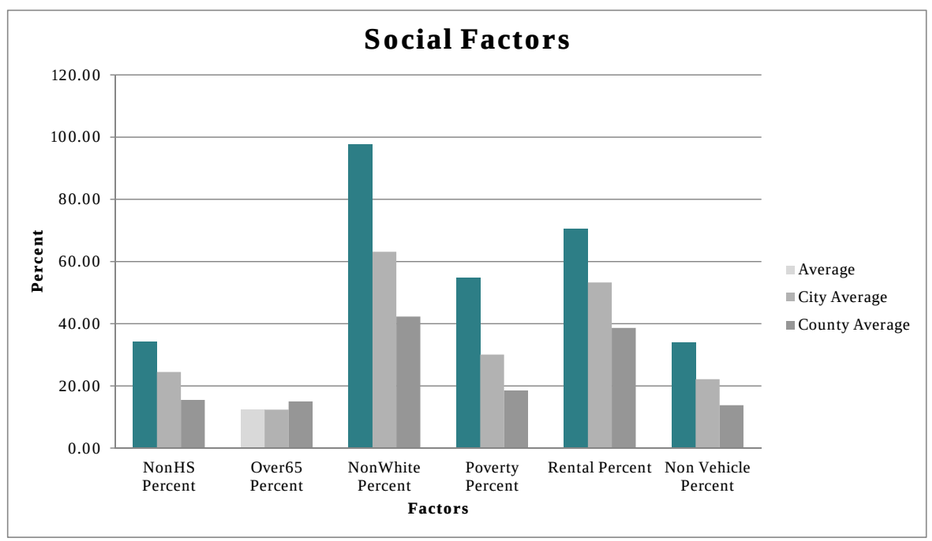
Thursday, June 25, 2015

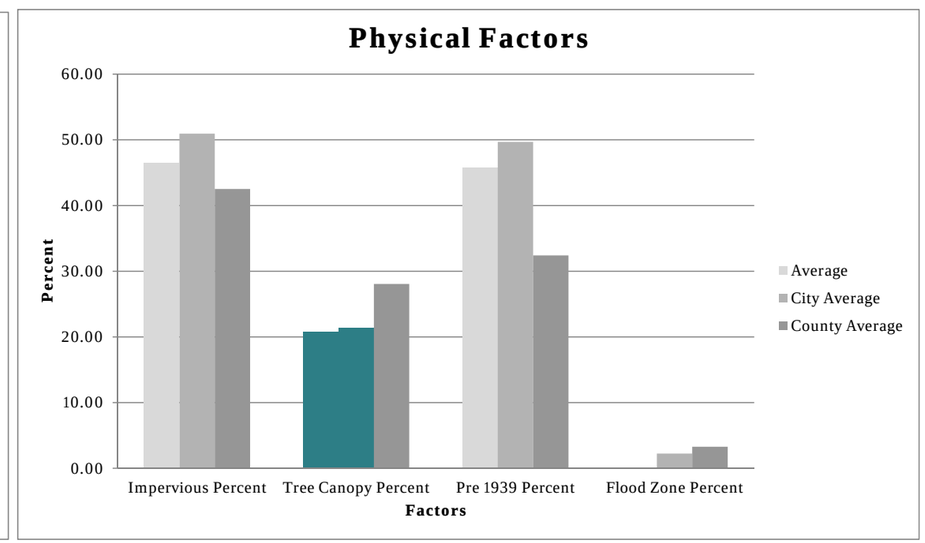
Kinsman Social Data

GEOID	NonHS Percent	NonHS Number	Over65 Percent	Over65 Number	NonWhite Percent	NonWhite Number	Poverty Percent	Poverty Number	Rental Percent	Rental Number	Non Vehicle Percent	Non Vehicle Number
1141001	25.13	282	17.84	200	99.55	1116	56.93	638	80.64	904	44.57	500
1143001	46.50	896	2.96	57	99.48	1917	81.15	1564	92.58	1784	38.08	734
1145011	32.48	173	10.90	58	95.68	509	59.24	315	64.09	341	19.72	105
1145012	43.34	124	16.84	48	96.14	274	26.42	75	62.41	178	25.15	72
1145013	27.69	153	11.05	61	95.29	526	67.48	372	59.92	331	23.90	132
1147001	29.86	72	14.17	34	100.00	240	37.23	89	63.00	151	51.88	125
Average	34.17		12.29		97.69		54.74		70.44		33.88	
City Average	24.48		12.38		63.15		30.11		53.28		22.19	
County Average	15.54		15.03		42.32		18.56		38.65		13.84	

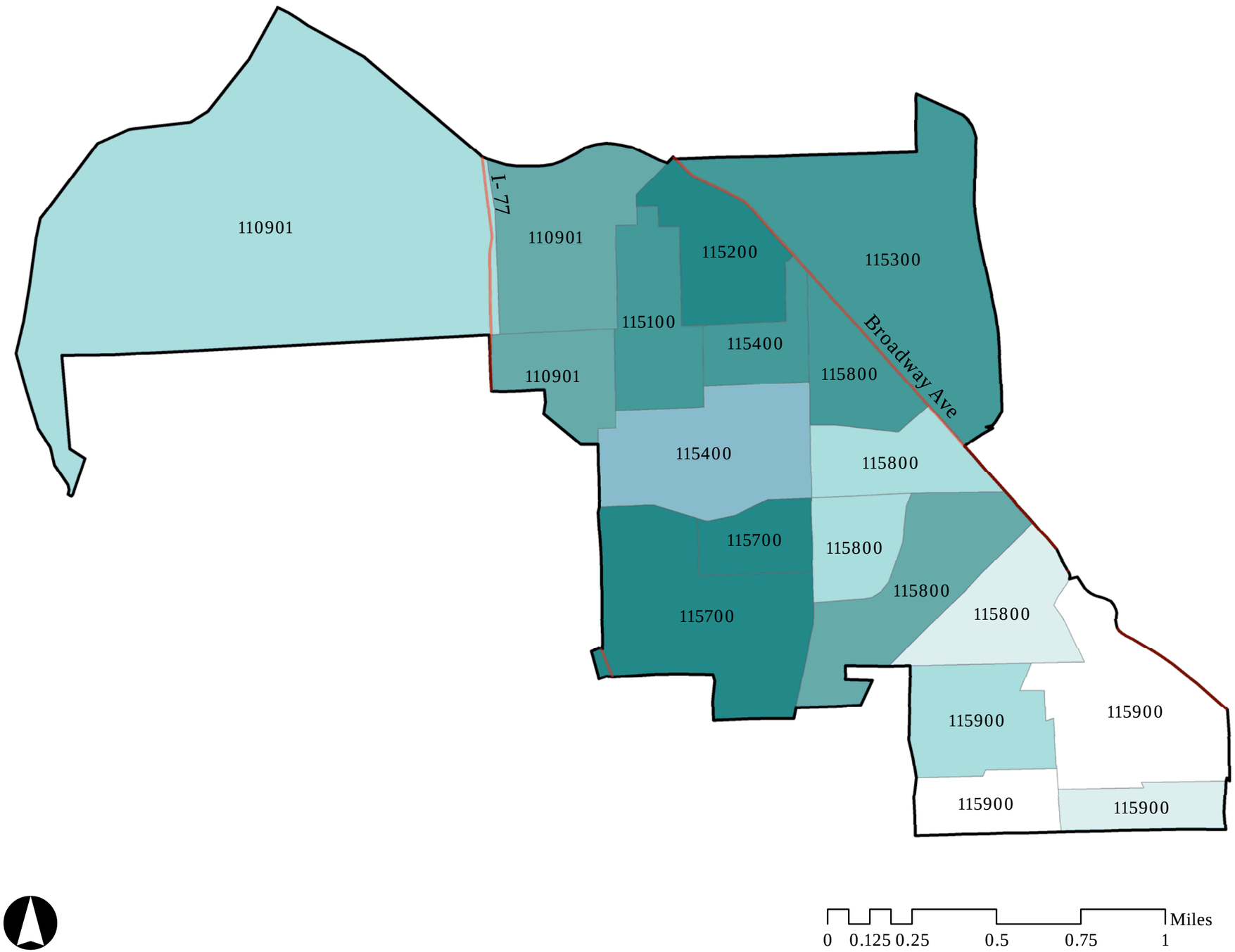
Kinsman Physical Data

GEOID	Impervious Percent	Tree Canopy Percent	Pre 1939 Percent	Flood Zone Percent
1141001	47.00	21.00	47.29	0.00
1143001	47.00	19.00	32.85	0.00
1145011	48.00	21.00	58.79	0.00
1145012	37.00	24.00	66.06	0.00
1145013	52.00	15.00	32.71	0.00
1147001	48.00	25.00	36.94	0.00
Average	46.50	20.83	45.77	0.00
City Average	50.95	21.34	49.70	2.26
County Average	42.53	28.07	32.43	3.29





Map S-V: Slavic Village Vulnerability



Legend:

- Major Roads
- Slavic Village

Vulnerability

- 0 Least Vulnerable
- 1
- 2
- 3
- 4
- 6
- 9 Most Vulnerable

Note:

Vulnerability values for each block group are determined by the overall count of "High/High" values in the social and physical factor comparison. For example, a "High" value in the percent without a vehicle paired with a "High" value for impervious surfaces represents one vulnerability value.

Data Source:

NEO CANDO,
Northeast Ohio Data Collaborative
(http://neocando.case.edu/neocando/),
U.S. Census,
Cuyahoga County GIS Department,
FEMA Flood Map Service Center

Projection:

NAD 1983, Ohio State Plane North

Maps Produced By:

Mike Tuzzo and Nick Rajkovich
(University at Buffalo)
and Kristen Zeiber
(Cleveland Urban Design Collaborative)
Contact: ResilientCleveland@gmail.com

Maps Created:

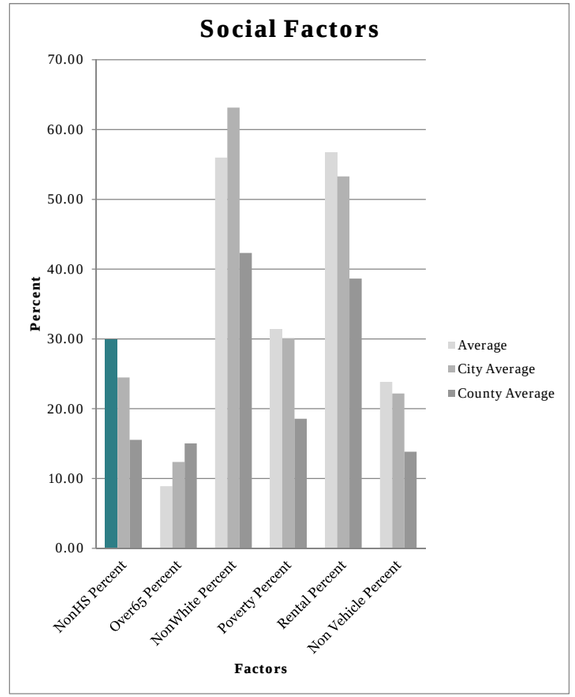
Thursday, June 25, 2015

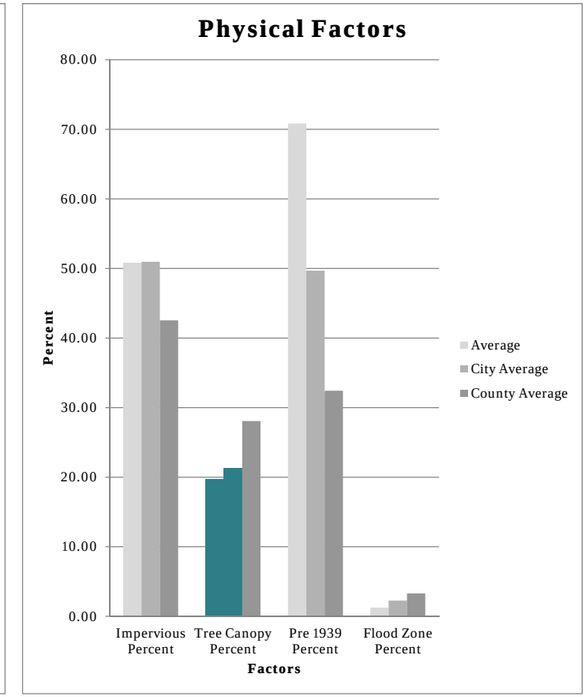
Slavic Village Social Data

GEOID	NonHS Percent	NonHS Number	Over65 Percent	Over65 Number	NonWhite Percent	NonWhite Number	Poverty Percent	Poverty Number	Rental Percent	Rental Number	Non Vehicle Percent	Non Vehicle Number
1109011	36.95	339	12.53	115	37.15	341	13.11	120	40.62	373	21.37	196
1109012	28.52	225	10.27	81	45.25	357	42.10	332	52.68	416	25.34	200
1109013	32.30	451	7.24	101	52.97	739	37.13	518	58.82	821	25.97	362
1151001	35.91	478	8.72	116	57.78	769	35.58	474	72.17	961	42.93	571
1152001	29.80	283	10.42	99	55.58	528	25.66	244	67.39	640	39.81	378
1153001	44.79	420	5.66	53	73.21	686	46.45	435	63.56	596	20.99	197
1154001	33.12	279	9.75	82	68.61	577	29.87	251	72.43	609	34.33	289
1154002	28.20	404	8.09	116	51.53	739	41.21	591	67.10	962	20.09	288
1157001	24.41	168	9.75	67	60.84	418	41.78	287	65.08	447	48.12	331
1157002	35.35	258	9.19	67	46.78	341	54.50	397	56.68	413	31.87	232
1158001	29.14	184	6.49	41	69.78	441	14.09	89	71.31	451	28.05	177
1158002	27.36	189	9.97	69	53.18	368	53.23	368	56.64	392	23.63	164
1158003	33.71	208	8.27	51	56.08	346	3.23	20	55.79	344	8.09	50
1158004	37.38	218	10.81	63	38.08	222	39.52	230	50.00	292	28.52	166
1158005	11.88	83	6.13	43	67.38	473	48.06	337	60.64	426	13.54	95
1159001	13.08	158	8.09	98	58.71	711	7.68	93	31.45	381	0.00	0
1159002	32.64	174	11.24	60	47.19	252	1.43	8	36.57	195	0.00	0
1159003	28.72	343	6.62	79	67.81	809	32.28	385	54.00	644	13.42	160
1159004	24.20	177	9.69	71	55.66	408	28.63	210	45.03	330	26.98	198
Average	29.87		8.89		55.98		31.34		56.73		23.84	
City Average	24.48		12.38		63.15		30.11		53.28		22.19	
County Average	15.54		15.03		42.32		18.56		38.65		13.84	

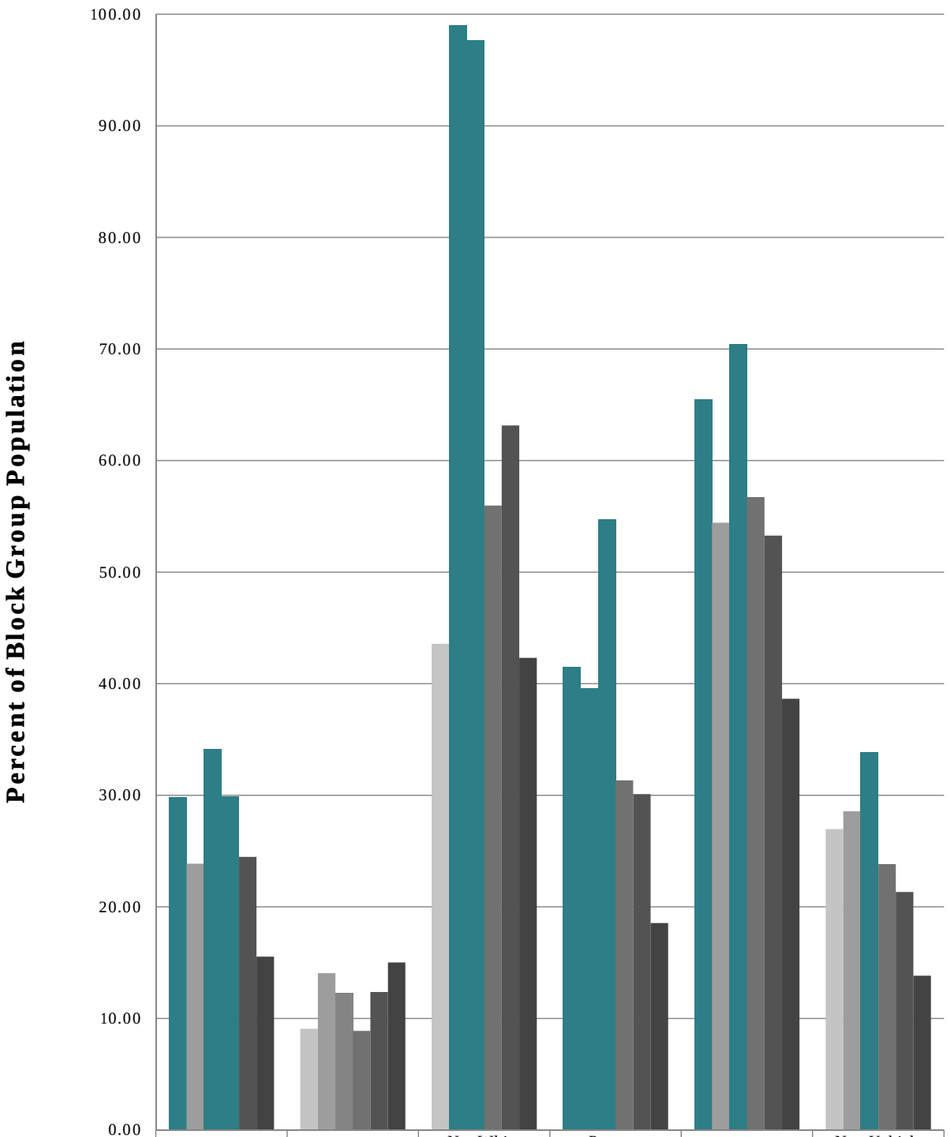
Slavic Village Physical Data

GEOID	Impervious Percent	Tree Canopy Percent	Pre 1939 Percent	Flood Zone Percent
1109011	52.00	7.00	71.84	7.00
1109012	50.00	26.00	88.62	2.00
1109013	44.00	19.00	77.84	0.00
1151001	54.00	21.00	80.74	0.00
1152001	58.00	17.00	66.67	0.00
1153001	61.00	12.00	64.67	0.00
1154001	54.00	23.00	71.76	0.00
1154002	41.00	29.00	78.39	0.00
1157001	60.00	19.00	68.54	0.00
1157002	64.00	11.00	85.00	0.00
1158001	58.00	18.00	68.21	0.00
1158002	55.00	19.00	76.96	0.00
1158003	51.00	25.00	67.73	0.00
1158004	34.00	24.00	71.66	2.00
1158005	37.00	28.00	65.55	5.00
1159001	42.00	23.00	60.21	7.00
1159002	46.00	17.00	57.58	0.00
1159003	49.00	19.00	73.67	1.00
1159004	54.00	17.00	50.27	0.00
Average	50.74	19.68	70.84	1.26
City Average	50.95	21.34	49.70	2.26
County Average	42.53	28.07	32.43	3.29



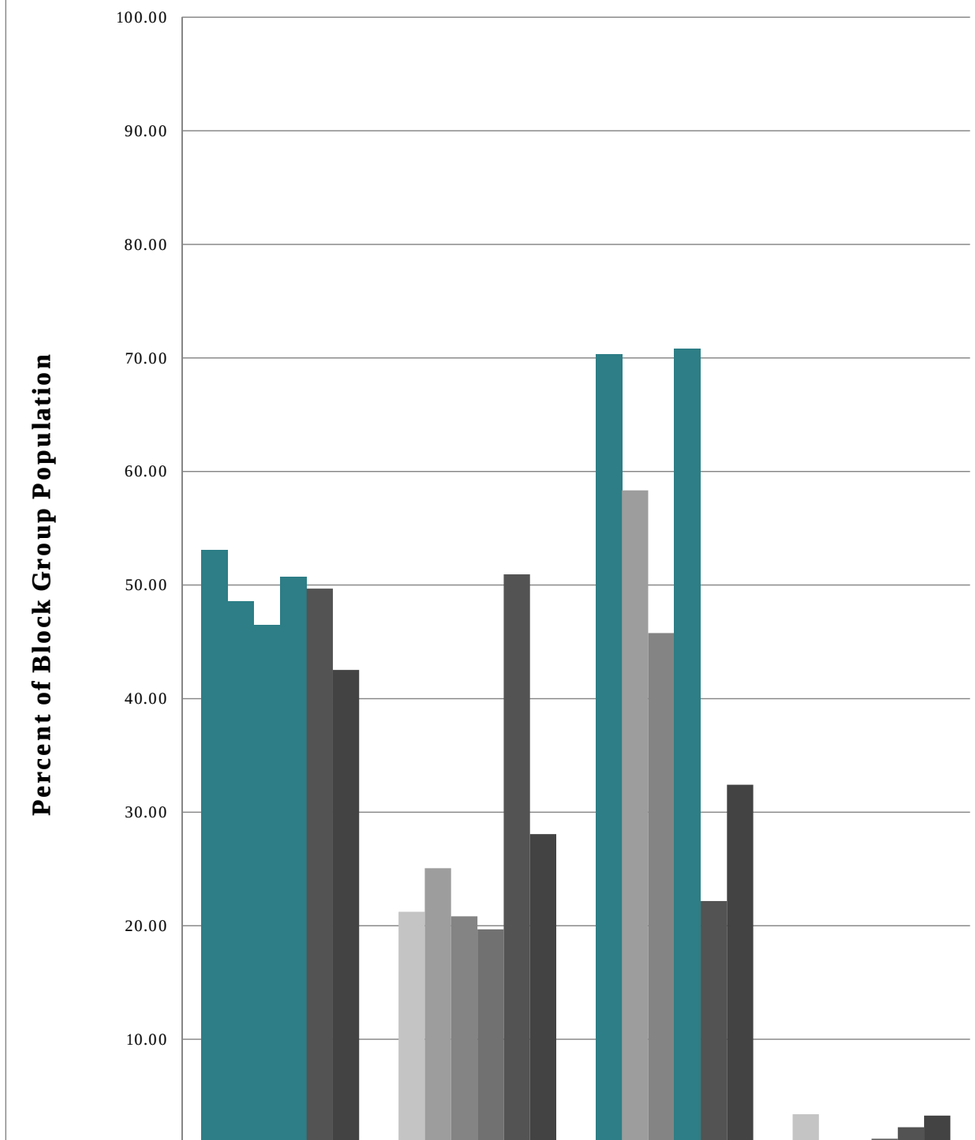


Social Factor Averages



	NonHS Percent	Over65 Percent	NonWhite Percent	Poverty Percent	Rental Percent	Non Vehicle Percent
Detroit-Shoreway	29.83	9.09	43.58	41.48	65.46	26.97
Glenville	23.87	14.07	98.97	39.58	54.44	28.57
Kinsman	34.17	12.29	97.69	54.74	70.44	33.88
Slavic Village	29.87	8.89	55.98	31.34	56.73	23.84
Cleveland Avg	24.48	12.38	63.15	30.11	53.28	21.34
County Average	15.54	15.03	42.32	18.56	38.65	13.84

Physical Factor Averages



	Impervious Percent	Tree Canopy Percent	Pre 1939 Percent	Flood Zone Percent
Detroit-Shoreway	53.06	21.24	70.34	3.41
Glenville	48.56	25.07	58.34	0.74
Kinsman	46.50	20.83	45.77	0.00
Slavic Village	50.74	19.68	70.84	1.26
Cleveland Avg	49.70	50.95	22.19	2.26
County Average	42.53	28.07	32.43	3.29

Appendix F:

An Assessment of the Impacts of Extreme Temperature on Mortality in Cuyahoga County

Prepared by:

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Introduction:

Research assessing the impacts of extreme temperatures upon human health has shown considerable spatial variability, and that negative health impacts across a number of causes are observable. The assessment of these impacts is complicated by several factors: the seasonality or long-term changes in human mortality and morbidity can be confounding factors.

Delayed effects are another key uncertainty. For heat, typically the most intense effects on human health are acute, with increases in negative health outcomes most notable within 48 hours of the event. Further, there have been numerous observations of mortality displacement, as it has been observed that mortality falls below expected levels soon after a heat wave, suggesting a portion of those who died in a heat wave would have died soon thereafter. In the case of cold, conversely, typically the most negative impacts are not immediately observed, but rather are observed several days to two weeks later, most notably with increases in respiratory diseases.

Methods:

To analyze the impacts of extreme temperatures on health impacts in Cleveland, a long-term mortality data set was acquired from the National Center for Health Statistics for the period 1975-2010. As the data are aggregated to the county level, all of Cuyahoga County is collectively studied. Meteorological data are obtained for Cleveland-Hopkins Airport (CLE) to represent environmental exposure.

Mortality totals are available as a daily total, and several subsets of mortality data in addition to the total were analyzed. Subsets were created for cause of death (respiratory (ICD: J00-99), cardiovascular (ICD10: I00-99), and all other causes); age (0-64, 65-74, 75 and older), race (black, white), and sex (male, female).

For each subset of analysis, a distributed-lag model was used to assess the cumulative impact of weather on health outcome, using the *dlnm* package in statistical software package R. The model used in this research is:

$$\text{Log}\ (deaths) = intercept + weather + \text{ns}\ (year) + \text{ns}\ (day) + DOW.$$

Outcome is the daily count of deaths assuming a Poisson distribution of counts; *ns (year)* is a natural spline (4 df) fit to the years of study, to account for long-term changes in mortality; *ns (day)* is a natural spline (3 df) fit to the days of the year, to account for seasonal variability in mortality; and *DOW* is series of dummy variables representing day of week. *Weather* refers to the 5PM apparent temperature, which is a combined measure of temperature, humidity, and wind, similar to the heat index or wind chill.

In all analyses, relative risks (RR) are calculated to assess vulnerability. The effects of weather are assessed as zero-day, as well as cumulative 14-day lags, with the lags are constrained to fit a natural spline with 5 df. In all cases, the RR are calculated relative to a baseline 5PM apparent temperature of 75°F, which is the value at which overall mortality is least. RR graphics are presented on the following pages, with the zero-day and 14-day cumulative lag on the same page for each different subset. Note that to enable interpretability, the y-axis is different in each plot.

Results:

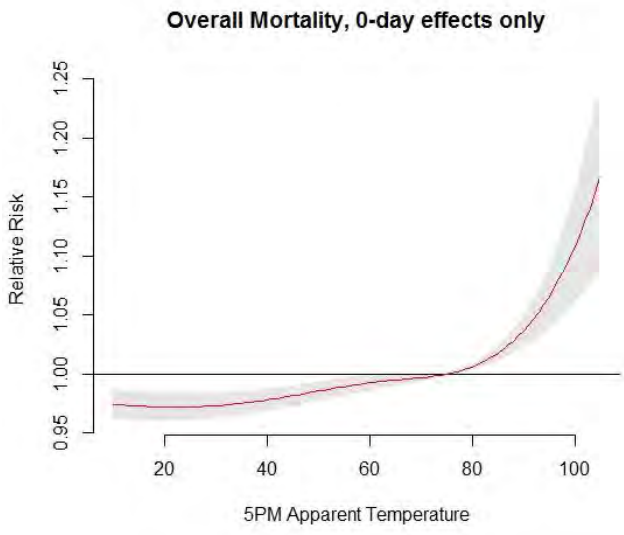
For heat, across all subsets, a clear difference is observed between the zero-day and 14-day cumulative lag graphs. For 0-day impacts, meaning, the weather-health impacts that are observed on the day of the particular weather conditions only, a clear heat signal is seen across overall mortality (RR=1.16 at 105°F) as well as most subsets.

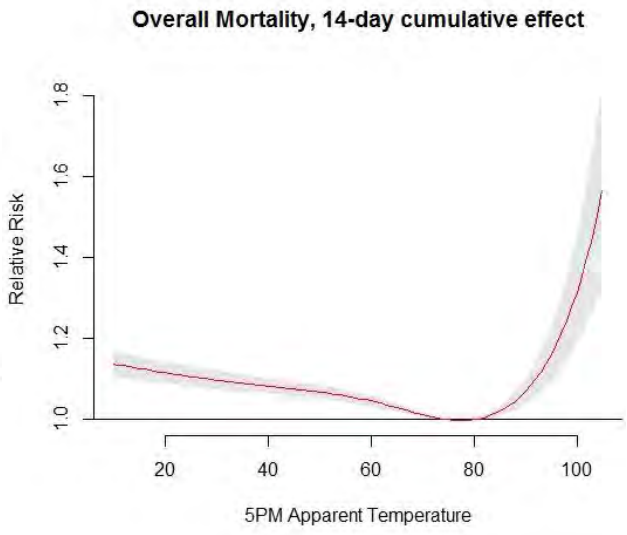
The only subsets for which increases are not statistically significant are respiratory mortality, other-cause mortality, and for those ages 0-64 and 65-75. *This suggests that heat's immediate impacts are most observable in cardiovascular-related mortality and those 75 and older, regardless of sex or race. Within these categories, there is a sharper increase in black mortality (RR=1.22 at 105°F) than white (1.15), and slightly higher for men (1.17) than women (1.15).*

Comparing the results to the 14-day cumulative results, in which the impacts are assessed in aggregate, a generally similar pattern is observed, although results are more intense and broader. Statistically significant results are observed with all subsets except for other-cause mortality; the relative risk is greatest for cardiovascular mortality (2.30 at 105°F) and respiratory (3.00). A greater risk is observed for blacks (1.70) than whites (1.55), while across age and sex differences are minimal.

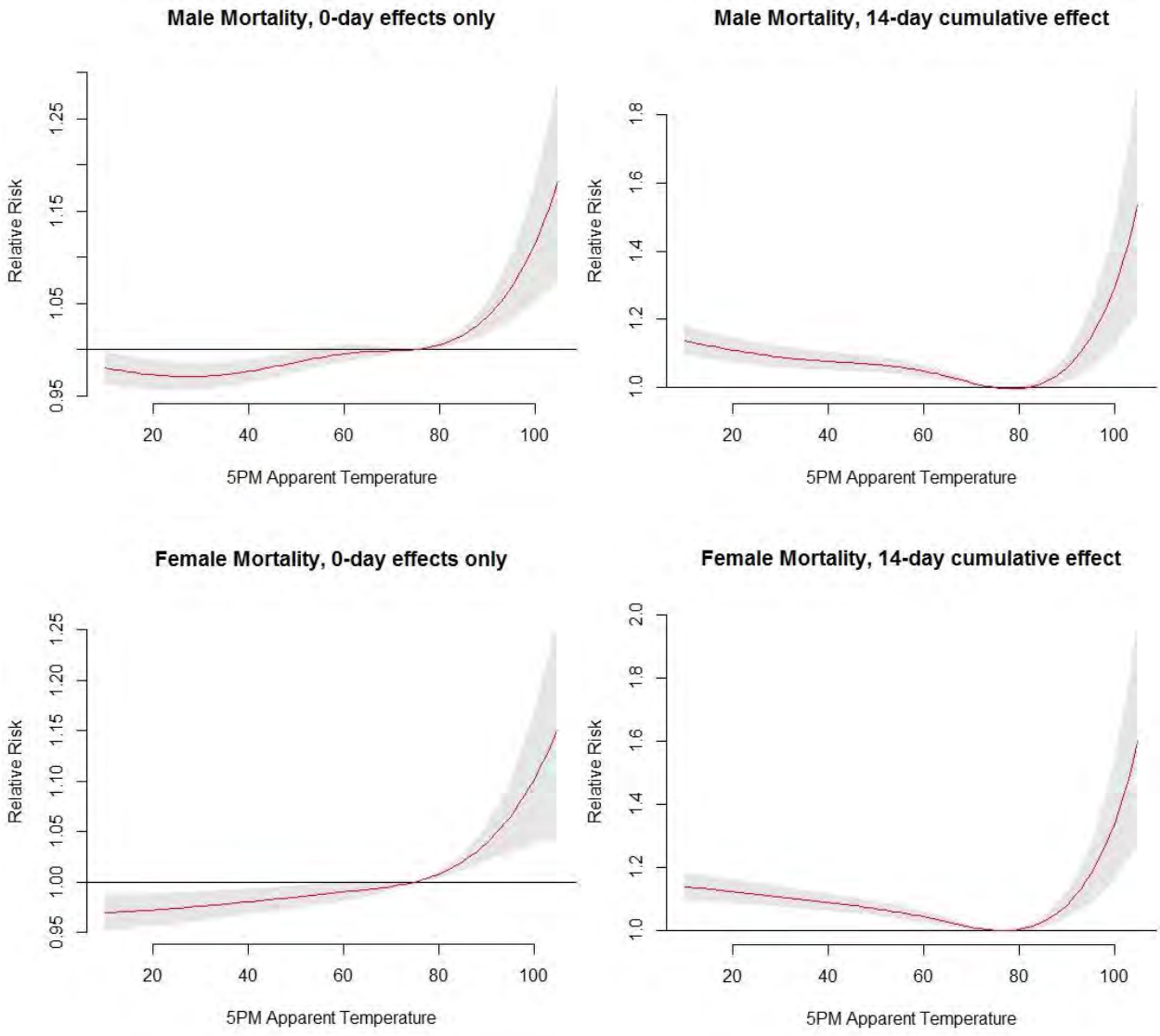
For cold, more mixed results emerge. There are no 0-day statistically significant increases in mortality observed across the subsets studied, with some subsets suggesting statistically significant decreases in mortality (albeit weak ones) at very cold temperatures. For 14-day cumulative results, statistically significant increases in mortality are observed in overall mortality (RR=1.15 at 5°F) all subsets. Overall increases in mortality are generally weaker than for heat, and broadly similar across subsets. Blacks and whites, and males and females, are equally affected (1.15); and cardiovascular and respiratory mortality (1.20) are both greater than other-cause (1.10). Those 75 and older are more affected (1.19) than those younger (1.10).

Overall Mortality, 0-day and 14-day Effects:

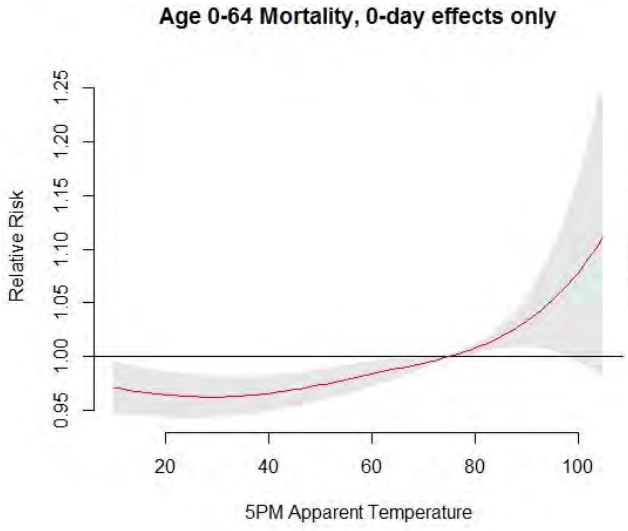


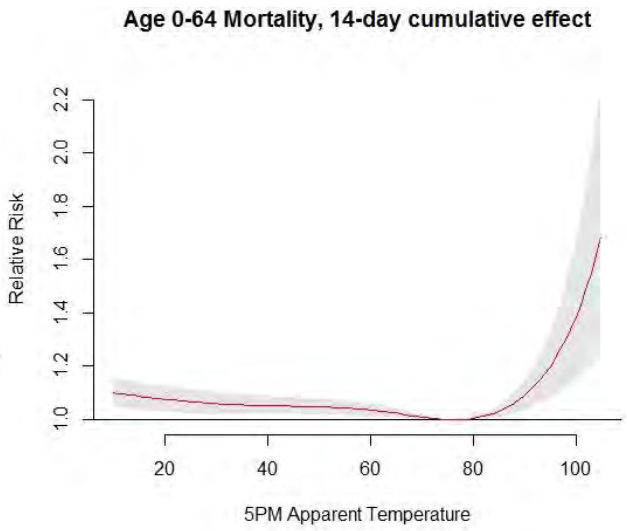


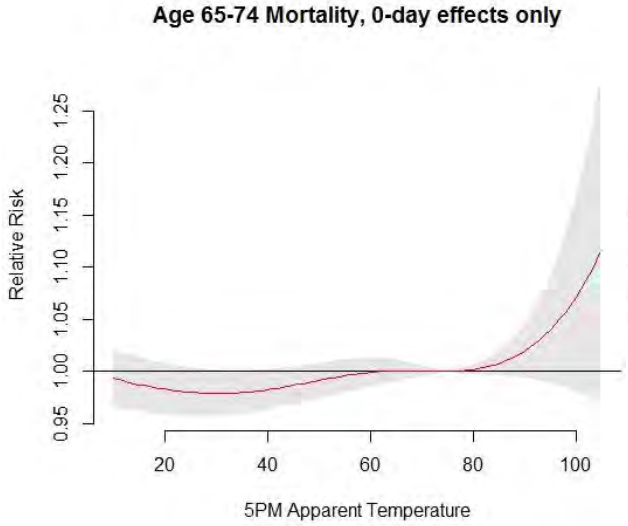
Overall Mortality by Sex, 0-day and 14-day Effects:

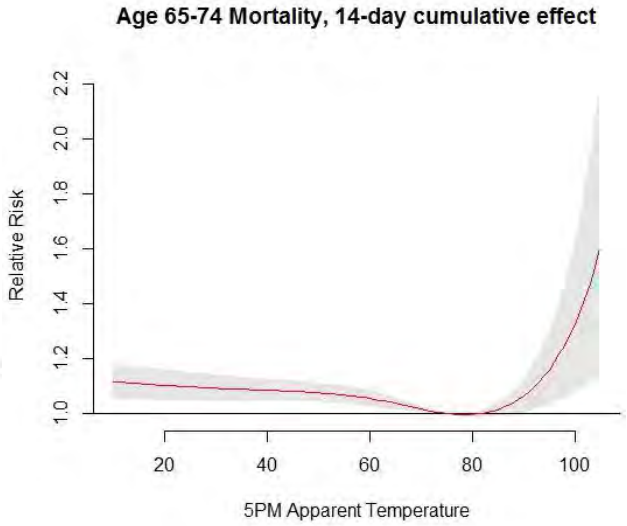


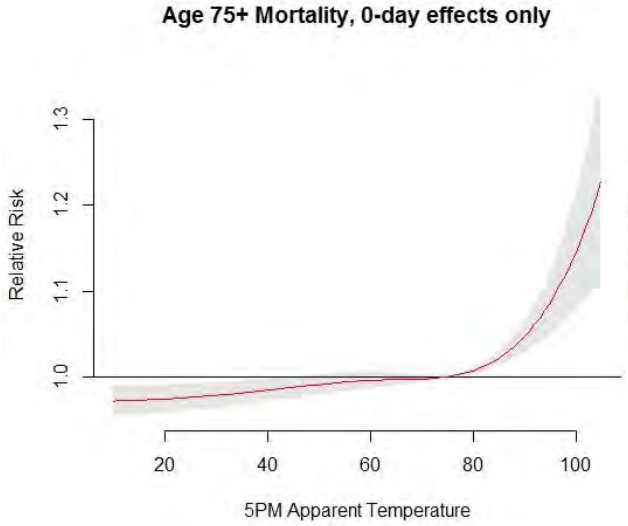
Overall Mortality by Age, 0-day and 14-day Effects:

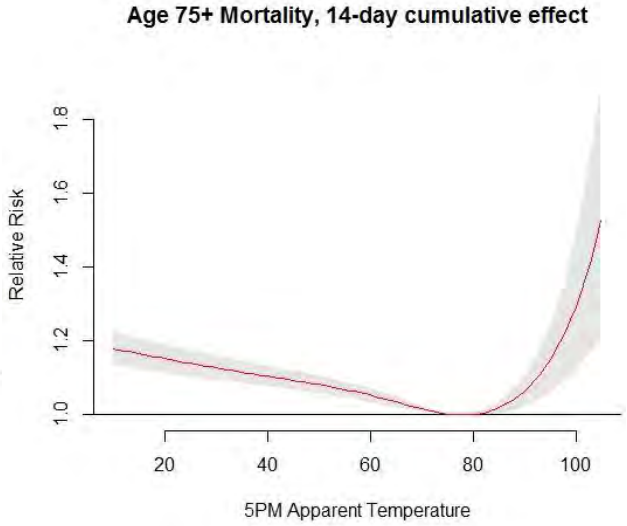












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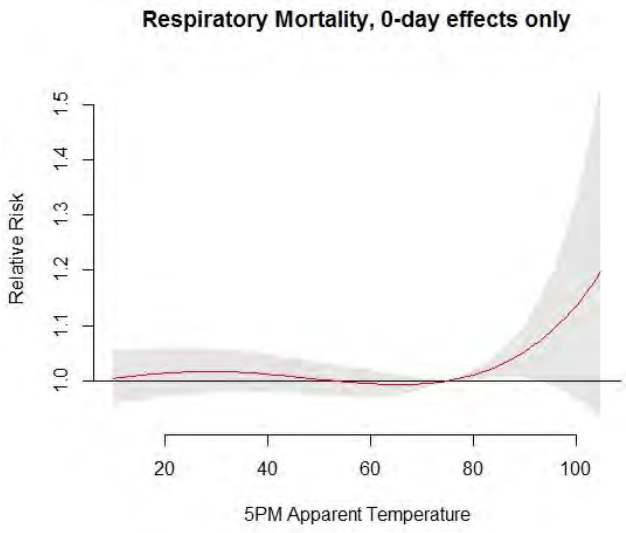

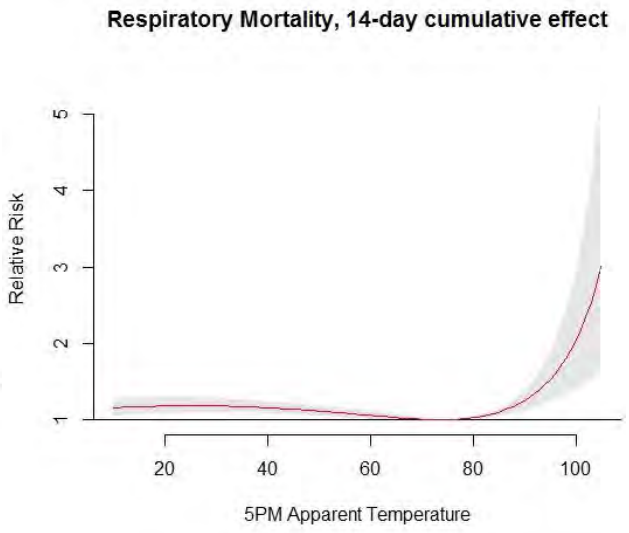

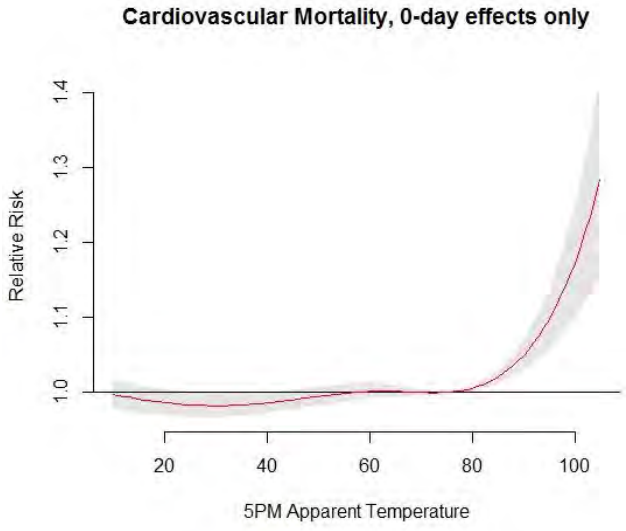

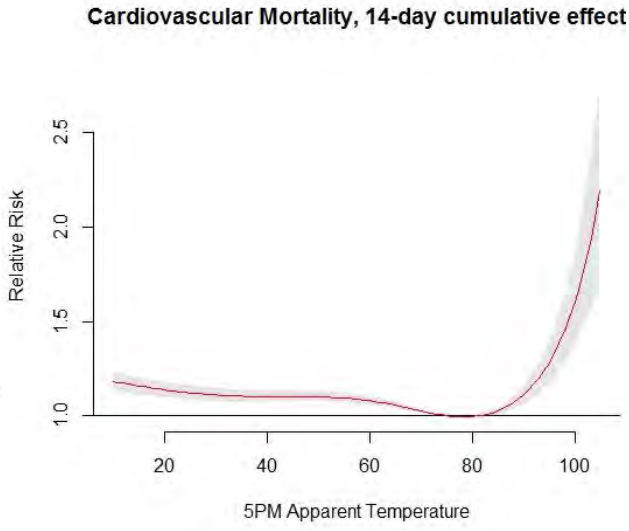

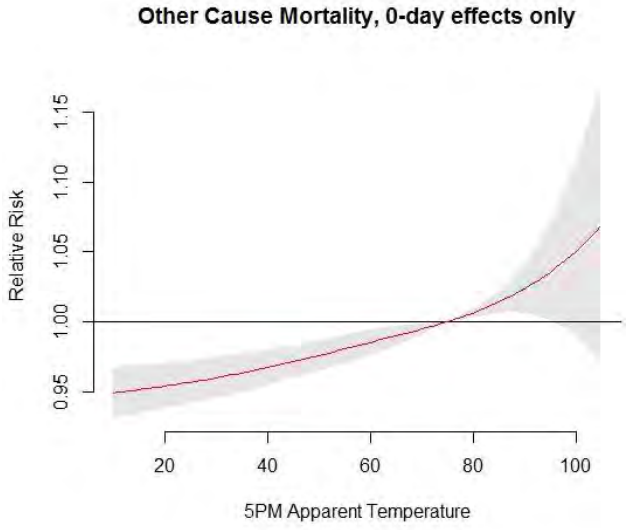

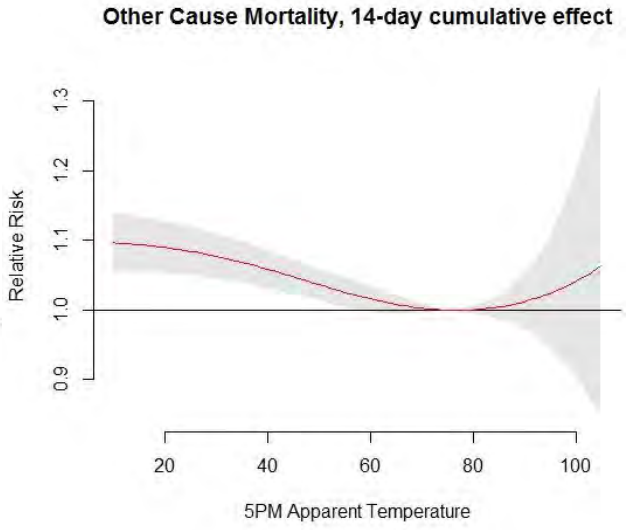

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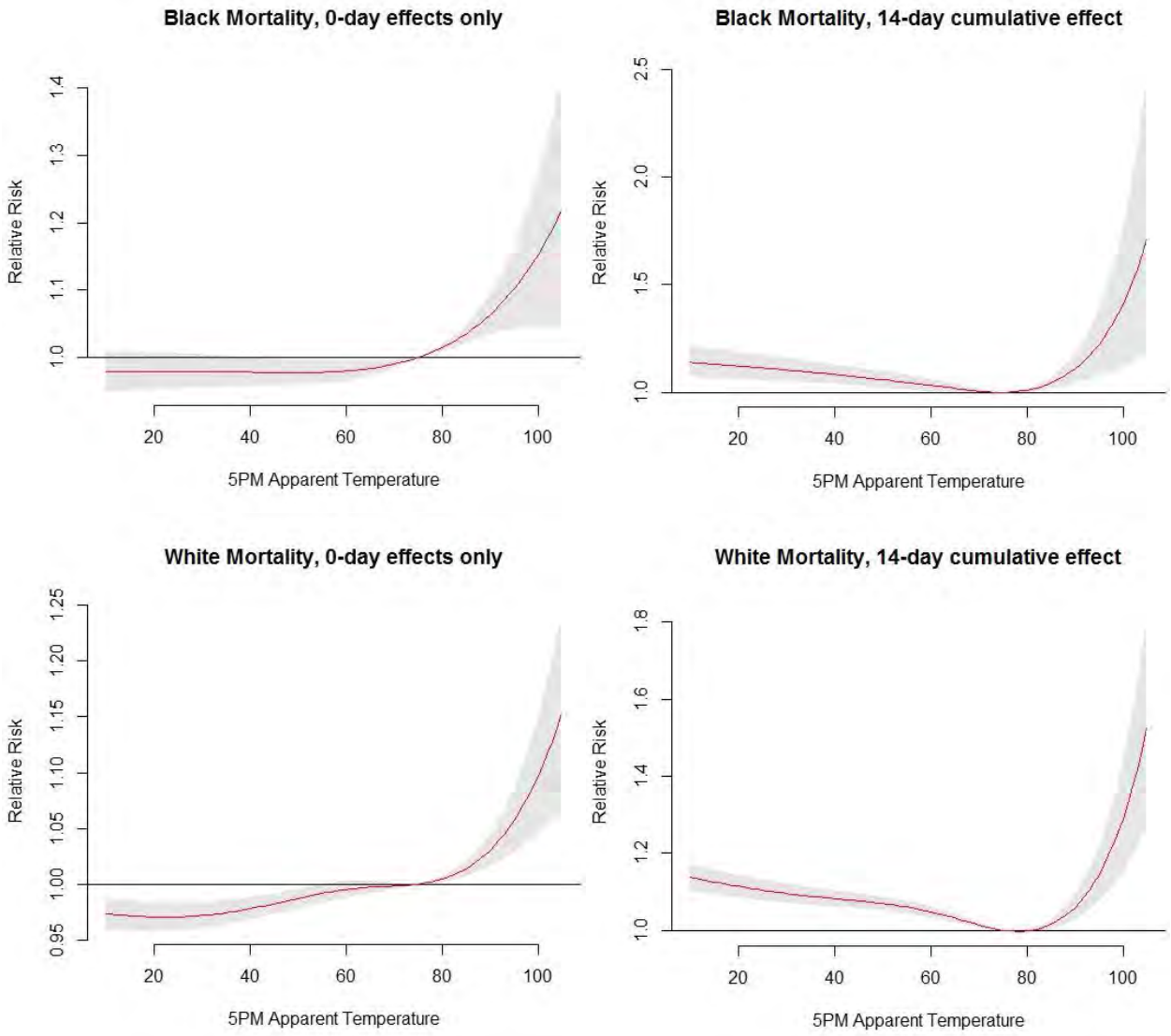

Appendix G:

Urban Heat Island Effect and Land Cover Analysis

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Summary of Recommendations

Urban heat island (UHI) effect is the most documented phenomenon for climate change. It refers to the development of higher urban temperatures of an urban area compared to the temperatures of surrounding suburban or rural areas. Impervious surfaces, loss of vegetation, land use, and the built environment that are major sources of anthropogenic heat create such differences.

There is a significant variation in UHI intensities (maximum of 47.79ºF during winter, 37.58ºF during spring, 26.33ºF, and 32.67ºF during fall) among Cleveland neighborhoods: Slavic Village, Kinsman, Glenville, and Detroit Shoreway. The average daily temperature at Hopkins Airport data is used as a reference case during 2012 which is recorded as the hottest year in the region. These study areas are identified as the most susceptible neighborhoods to changing climate per Cleveland Climate Action Plan.

The land cover analysis of above neighborhoods shows a very high percentage of impervious surfaces that includes sidewalks, driveways, parking lots, roads/rail roads, and building roofs: Slavic Village (52%), Kinsman (42%), Glenville (49%), and Detroit Shoreway (55%). The average tree canopy cover ranges from 22% in Detroit Shoreway to 33% in Glenville neighborhood.

Based on UHI and land cover analysis following adaptation and mitigation strategies for climate resiliency are suggested. These strategies are applicable at policy as well as community project scale for all study areas. Such strategies are particularly geared towards energy efficiency in buildings, increasing urban tree canopy, and increase pervious water retaining paving.

Energy Efficient Buildings

- Make buildings airtight
- Increase envelope insulation, especially attic insulations in residential buildings
- Replace existing windows with energy efficient operable windows
- Increase roof albedo values or develop green roof strategies

Increase Urban Tree Canopy

- Increase tree canopy cover by increasing urban street tree density and biodiversity. A new policy level programs like planting a tree program similar to weatherization program can be promoted
- Plant shade trees on the west and southwest windows and walls
- Plant solar friendly deciduous trees to shade the east and an open understory to promote penetration of cool breeze
- Plant evergreen windbreaks to the northwest and west for protection from winter winds
- Promote green infrastructure strategies like rain water garden, bio swales, etc. and engage community members by providing necessary training and educations
- Maintain existing street trees by providing required training and education
- Propose new neighborhood parks, urban forests as well as urban agriculture on vacant parcels

Pervious pavers for sidewalks

- Replace impervious surfaces by permeable paving or green space

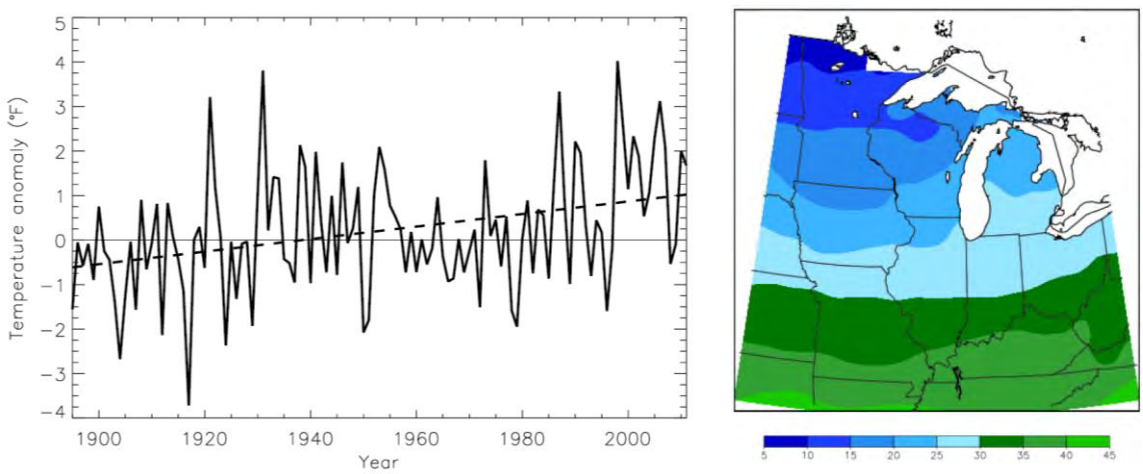
Urban Park and Forestry

- Initiate planting tree towards long-term urban forestry project

1.0 Climate Change in the Midwest Region

Historical Trends: During 1901-2005, Midwest region witnessed an increase of 0.14^{0}F per decade (Figure 1(a)). The temperature increase in the last 35 years is relatively higher with an increase of 0.49^{0}F per decade from 1979-2005(Kunkel et al. 2013). The International Panel on Climate Change (IPCC) reported the warmest 12 years on the record from 1995-2006. Since then additional warm years have occurred, including 2012, which was the warmest year on record in Cleveland.

The changes in temperature varies from North (cold) to South (warm) (Figure 1 (b)) and it is affected by lakes which keep lake cities cooler during summer and warmer during winter. However, the "lake effect" causes heavy snow in lake cities. In addition to lakes, local features, like built environment, vegetation, plays an important role in creating local climates that can vary among lake cities.



(a) (b)

Figure 1: (a) Temperature anomaly for the Midwest region (b) Average Temperature (^{0}F): December 1 to February 29 during 1981-82 to 2009-10 *(Source: (Kunkel et al. 2013))*

Future Projections: The North American Regional Climate Change Assessment Program (NARCCAP) predicts annual average temperature increase of 4 to 5 ^{0}F across the Midwest in this century. Three scenarios for time period 2021-2050, 2041-2070, and 2070-2099 are presented. The temperature change in winter is expected to range from 4.0 to 6.0 ^{0}F, 3.0 to 4.5 ^{0}F in spring, 4-6 ^{0}F in summer, and 4.5 to 5.5 ^{0}F in fall. These temperature trends are statistically significant (at the 95% level) and were estimated based on annual average temperature of 1971-2000 for high emission scenario.

The future warming trend in the Midwest is illustrated in the Figure 2 and it indicates that summers in these states will feel progressively more like summers currently experiences by the states to the Southwest under both higher and lower future emissions scenarios.

The multi-model means and standard deviations of simulated annual mean change indicates extended periods of extreme heat event and its increased likelihood of such occurrences (Table 1). Increased cooling degree days puts burden on existing infrastructure/utilities and results in increased greenhouse gas emissions. The heating energy needs are reduced and growing degree days are increased.

Temperature Variable	NARCCAP Mean	NARCCAP Standard Deviation	Daily_CMIP3 Mean
Freeze-free period	+24 days	5 days	+25 days
#days $T_{max} > 90°F$	+19 days	5 days	+26 days
#days $T_{max} > 95°F$	+15 days	6 days	+13 days
#days $T_{max} > 100°F$	+11 days	5 days	+4 days
#days $T_{min} < 32°F$	-22 days	4 days	-27 days
#days $T_{min} < 10°F$	-16 days	5 days	-13 days
#days $T_{min} < 0°F$	-10 days	5 days	-7 days
Consecutive #days > 95°F	+85%	37%	+232%
Consecutive #days > 100°F	+106%	50%	+562%
Heating degree days	-15%	2%	-17%
Cooling degree days	+66%	18%	+75%
Growing degree days (base 50°F)	+32%	5%	+33%

Table 1: Predicted temperature variables from NARCAP simulations for the Midwest region. *(Source: (Kunkel et al. 2013))*

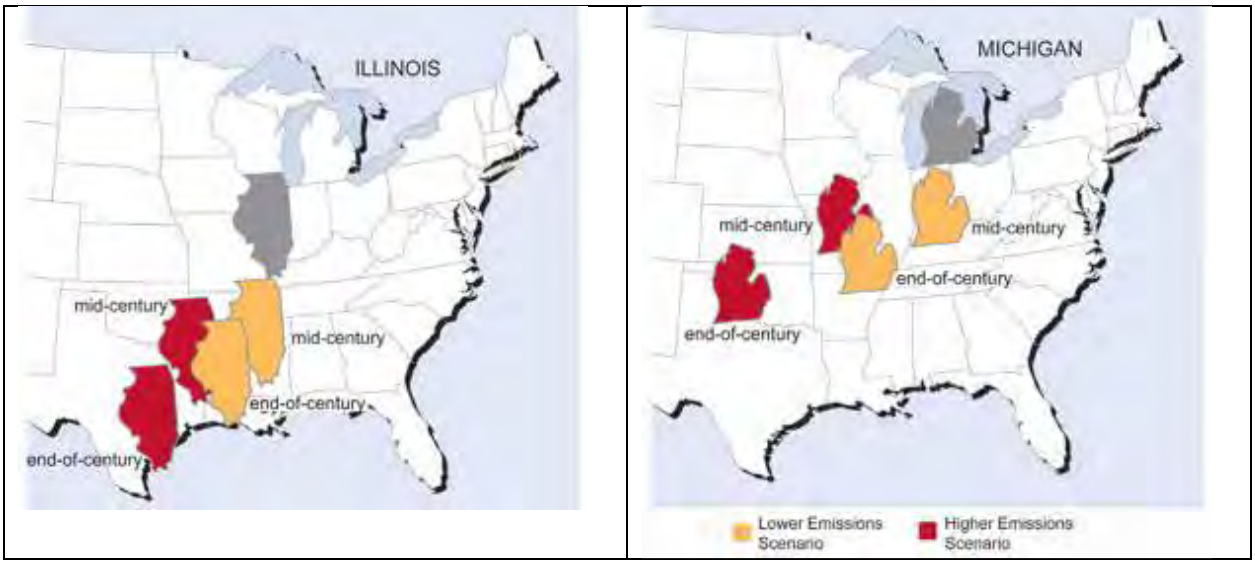


Figure 2: Migrating temperatures *(source: (Hayhoe et al.))*

Potential Impacts: The climate change related extreme events that makes communities vulnerable includes heat waves, resulting in excess urban mortality (O'Neill 2005) and affecting infrastructure and built environments. For example: the 1995 heat wave in Chicago, IL is the most deadly U.S. heat wave in decades and resulted in 700 fatalities. Maximum daily temperatures were equal to or greater than 90^0F and greater than 100^0F at the peak of the heat wave. Even more importantly, there was no relief in night, as nighttime minimum temperatures were over 80F during the hottest days. Heat waves also cause major power outage because of increased demand for power outstripping the infrastructure capacity, contributing to health issues and also disrupting economic activities.

Adaptation and Mitigation Strategies: In response to the 1995 heat wave, the City of Chicago put together an extreme weather operations plans that included mitigation steps for the city to take during heat waves. These were implemented during a 1999 heat wave that was nearly as hot as the 1995 event, but fatalities were far less numerous. The city has also put together an ambitious Climate Action Plan (Hayhoe and Wuebbles 1998) that outlines both adaptation and

mitigation strategies. Even though uncertainties around climate change persisted, the adaptation and mitigation initiatives focused on improving green infrastructure and replacing impervious surfaces as building energy efficiency continued to penetrate the market.

City of Cleveland

Major urban centers, including Cleveland, are more sensitive to some weather and climate events due to specific characteristics of the urban environment such as building density, land use, urban sprawl, and proximity to the Lake Erie. Extreme temperatures can have larger impacts on human health, particularly in the urban core where the heat absorbed by the urban surfaces (concrete, asphalt, etc.) elevates summer afternoon temperature and lessens the cooling rate at night. During the winter, cities such as Cleveland are susceptible to lake-enhanced snowfall. Extreme rainfall can cause host problems, including storm water overflows, flooding of home and roadways, and contamination of municipal water supplies. Climate extremes combined with the urban pollution sources can create air quality conditions that are detrimental to human health. Therefore, this study focused on neighborhoods that are most vulnerable to climate changes

2.0 Heat Island Effect

Heat island is the most documented phenomenon of climate change. Heat island refers to the development of higher urban temperatures of an urban area compared to the temperature of surrounding suburban and rural areas. The phenomenon is related to positive thermal balance created in the urban environment because of the increased heat gains like the high absorption of solar radiation and the anthropogenic heat, and the decreased thermal losses. The intensity of urban heat island may exceed several degrees over regional and temporal variability. The phenomenon is observed in specific areas of the cities presenting varying Land Use and Land Cover (LULC) including high density, and low environmental quality and results in a serious reduction of ambient thermal comfort levels and poor indoor thermal conditions.

Summertime UHI considerably increases the energy demand of a city and as a consequence of this energy increase, wide spread power outage may occur due to the increase of the air conditioning system usage. Low-income urban dwellers those who cannot afford air conditioners are more susceptible to the heat related illnesses, indoors as well as outdoors.

For this purpose, this study looked at weather data during the hottest year of Cleveland. The weather stations are located at the airport: Burke, Hopkins, and Cuyahoga County Airport. The Burke Airport is closer to the Lake Erie and it is a representative of weather conditions of Detroit Shoreway and the Cuyahoga County Regional Airport weather data is a representative of Glenville neighborhood. Not all study areas have National Climatic Data Center monitored weather stations nearby. In such cases, weather data available from the nearest Weather Underground network is used. A weather station located between Slavic Village and Kinsman is representing both these neighborhoods.

In order to estimate variations in temperature of these study areas, the Hopkins Airport is considered suitable baseline condition. Similar baseline conditions have been adopted for the Chicago metropolitan area (Coseo and Larsen 2014) where Midway Airport is used as a baseline condition to analyze UHI in selected urban neighborhoods. In order to get comparable data from weather stations, this study looked at 2012 weather data to demonstrate a snapshot of the warmest year.

There is a significant change in average daily temperatures among four locations in the Cleveland area (Figure 3). Slavic Village, Kinsman, and Glenville locations are warmer throughout the year (maximum up to 88-89ºF) in comparison to Hopkins airport location (74ºF) and Detroit Shoreway (78ºF). The average daily temperature (73ºF) of these locations during the summer months is 10ºF higher than Detroit Shoreway and Hopkins airport location (63ºF). Winter is 12-13ºF warmer at Slavic Village, Kinsman, and Glenville compared to the airport location. Following the similar trend, spring temperature at these locations is higher than 10ºF with reference to the airport. Winter months considered for this study are January, February, and March; Spring months are April, May, and June; Summer months are July, August, and September; and Fall season is represented by October, November, and December.

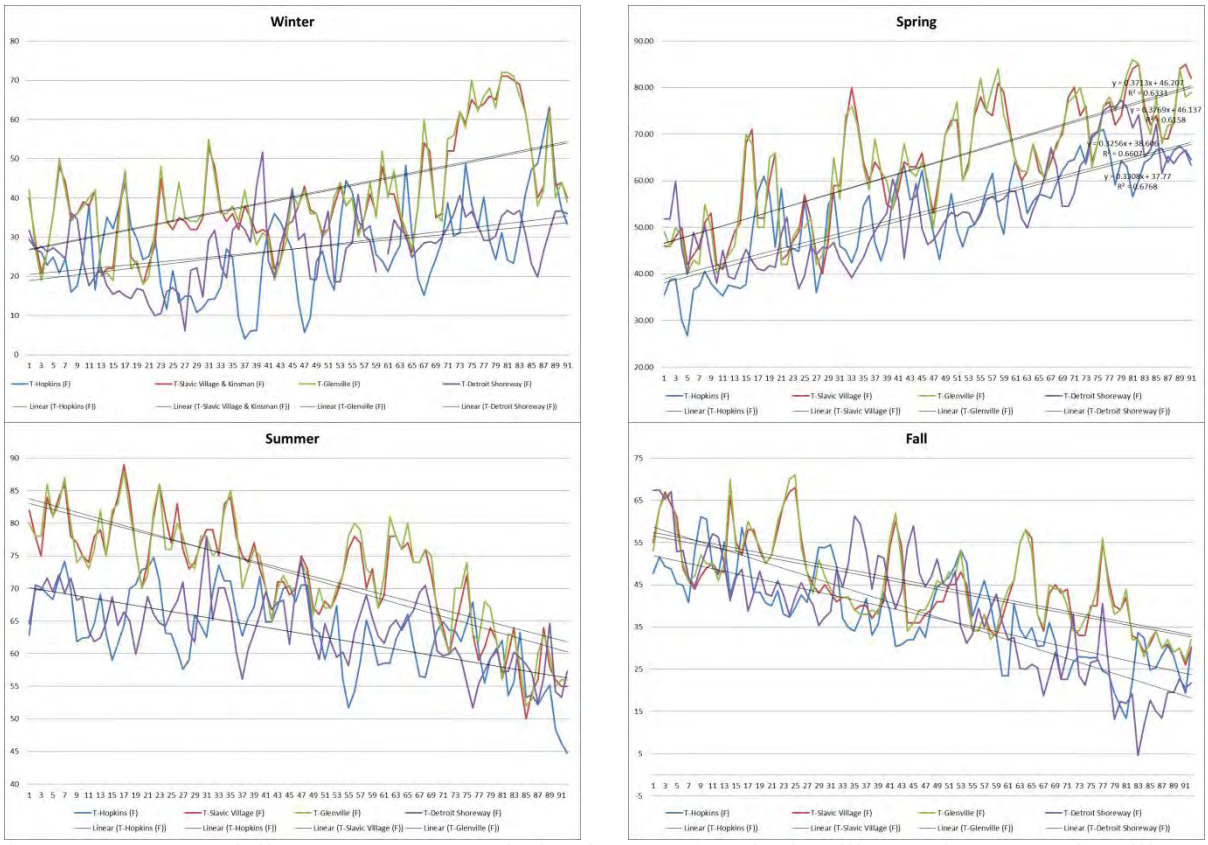


Figure 3: Average daily temperature variation in 2012 for Slavic Village, Kinsman, Glenville, and Detroit Shoreway

Seasonal UHI

Variations in UHI are significant in study areas when average daily temperature is compared with Hopkins Airport as a baseline condition. The maximum UHI intensity of 47.79ºF is observed during winter whereas summer shows minimal UHI intensity of 26.33ºF. Spring and fall UHI intensities are 37.58ºF and 32.67ºF respectively. The maximum daily temperature in these summer and spring seasons reached around 90ºF and UHI intensities during these seasons are particularly critical from health as well as energy perspective. High UHI intensities and large impervious surfaces can further increase such intensities on locations with less vegetation and shade. Therefore, following section looks into the land cover in study areas that may exacerbate such conditions and suggest possible adaptation and mitigation strategies.

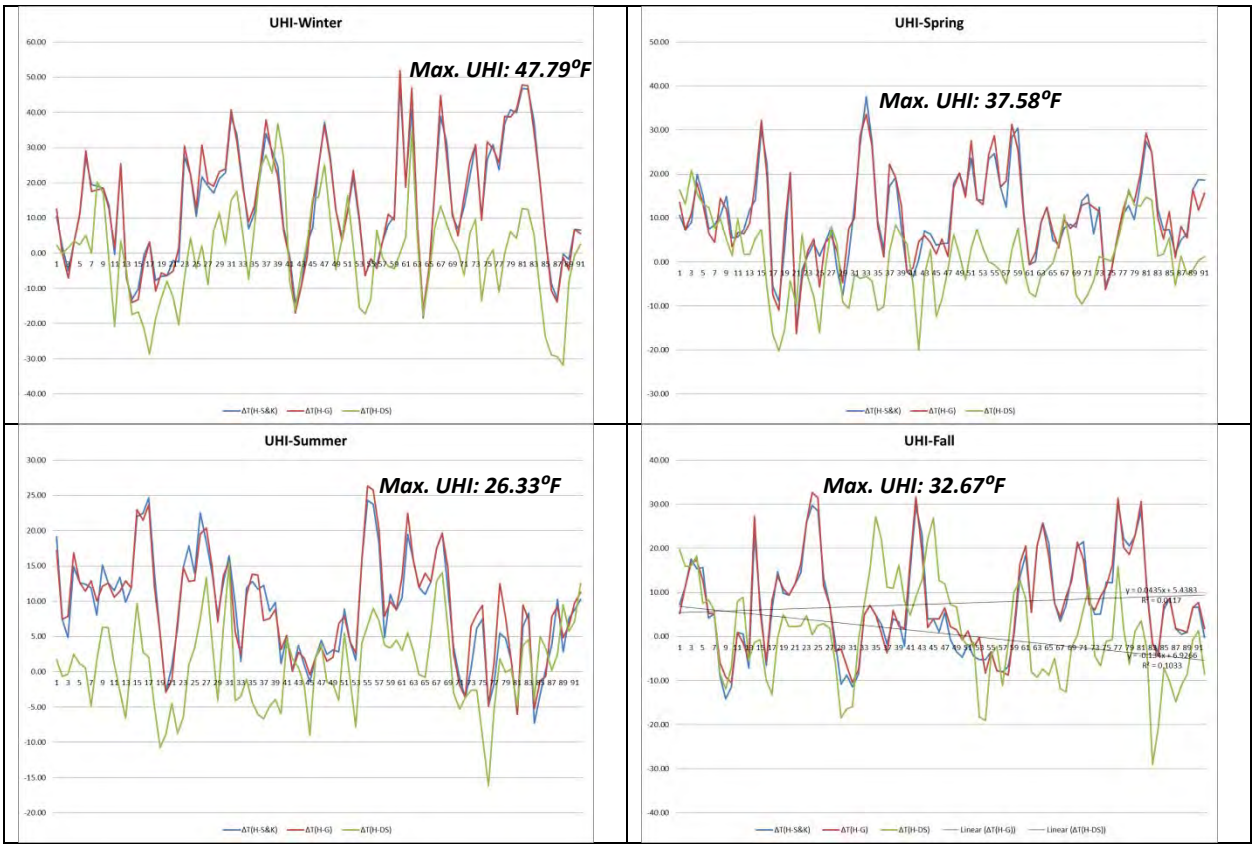


Figure 4: Seasonal UHI Variations with reference to the Hopkins International Airport (S&K: Slavic Village and Kinsman, G: Glenville, DS: Detroit Shoreway, and H: Hopkins Airport)

3.0 Land Cover Analysis

The Cuyahoga Country Planning Division completed an existing land use land cover analysis however it does not provide finer resolution at the neighborhood level. This study fills in such a gap by realizing and completing a need for detailed analysis. The primary source for the detailed land cover analysis is the state-of-the-art i-Tree program provided by the USDA Forest Service and it utilizes NOAA satellite imagery available from Google Maps. These images used for the study were captured in 2012 and it overlaps with the weather data used for UHI analysis.

In order to accurately identify land cover in a relatively larger area, each study area (Slavic Village, Kinsman, Glenville, and Detroit Shoreway) is divided in to small zones, 25-30 zones per study area (Figure 5). This facilitated selection of maximum points (100 per zone) for analysis using i-Tree program. In all, over 2500-3500 points were selected for each study area that increased the accuracy of land cover analysis as suggested by the program manual. Figure 5 shows a sample zoning approach adopted for all study areas.

The average tree canopy cover in all study areas is 27%, impervious surface area is 49%, and the grass/shrubs and bare soil area is 26%. Figure 6 shows the tree canopy cover ranges from 23-33% in the study area. Glenville (33%) shows the highest tree canopy cover whereas Detroit Shoreway (23%) shows minimum tree canopy cover. The impervious surfaces include Sidewalks, Driveways, Parking Lots, Roads/Rail Roads, and Building Roofs and their percentage is quite high in all study areas: Slavic Village (52%), Kinsman (42%), Glenville (49%), and Detroit

Shoreway (55%). Further current grass/shrub (19%) and bare soil (7%) accounts for almost quarter of the land cover.

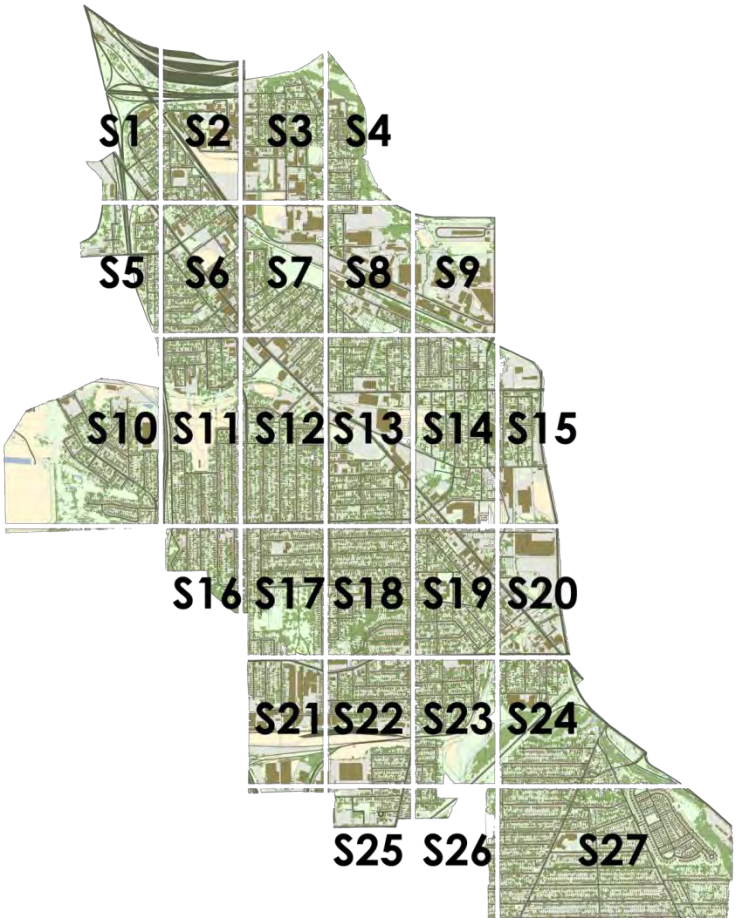
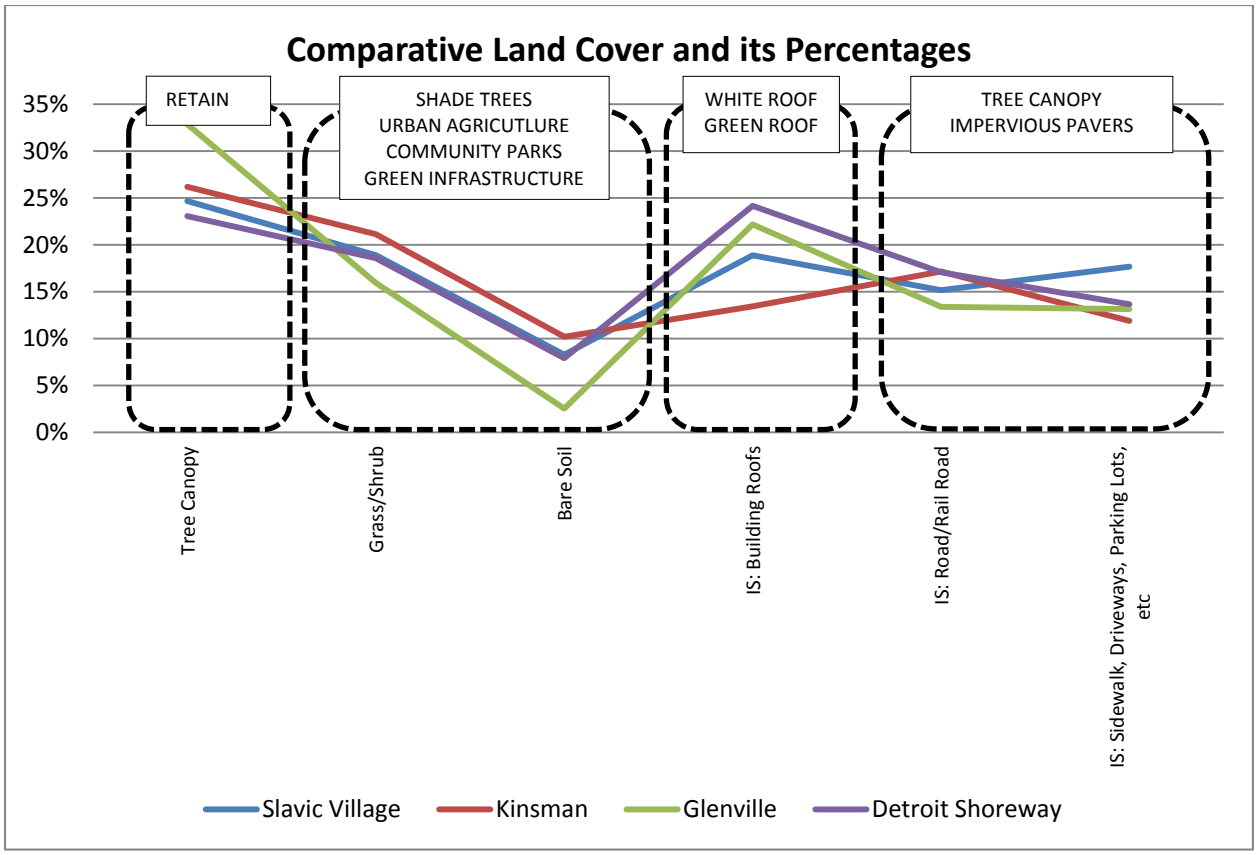


Figure 5: Zoning adopted for Land cover analysis for all study areas was analyzed using i-Tree program and it allowed for more accurate land cover analysis opportunities

Adaptation and Mitigation Strategies for UHI

Figure 6 shows the existing land cover categories (tree canopy, grass/shrubs, bare soil, and impervious surfaces) and it also illustrates the most appropriate strategies for existing land cover. All the study areas can benefit from few common strategies. For example: the most important step is to retain existing trees in the study area. Areas covered by grass/shrubs and bare soil provide opportunity for increasing tree density and canopy cover, urban agriculture, as well as implementing green infrastructure strategies depending upon its location in the neighborhood. Existing residential buildings roofs can be painted white whereas large industrial roofs are potential candidates for green roofs as well other green infrastructure strategies.

These study areas provide opportunities to promote a policy level strategy for adaption and mitigation of climate change like increase water retaining permeable paving and urban tree canopy layer. By providing training and education, community dwellers can be engaged in successful implementation of such policies. The replacement of impervious surfaces can also be integrated with green urban design strategies based on neighborhood specific projects where community dwellers are actively engaged.



*IS represents Impervious Surfaces and it is categorized as 1) Building Roofs, 2) Roads/Rail Roads, and 3) Sidewalks, Driveways, Parking Lots etc.
** Tree canopy cover presented in this graph does not distinguish vegetation type

Figure 6: Land cover analysis and potential climate resilient strategies

This analysis included available vacant land parcels under land cover category grass/shrub and bare soil. Such vacant parcels as well as available land on occupied parcel provide multiple opportunities to improve climate resiliency. For example: growing shade trees can cool buildings on occupied parcel and prevents heat absorption by impervious surfaces. This is important for reducing summertime cooling needs and outdoor thermally comfortable conditions. During winter time, strategically located deciduous trees can block winter breeze. Existing vacant land parcels provides opportunities for implementing green infrastructure that can improve tree canopy cover as well as provide storm water benefits.

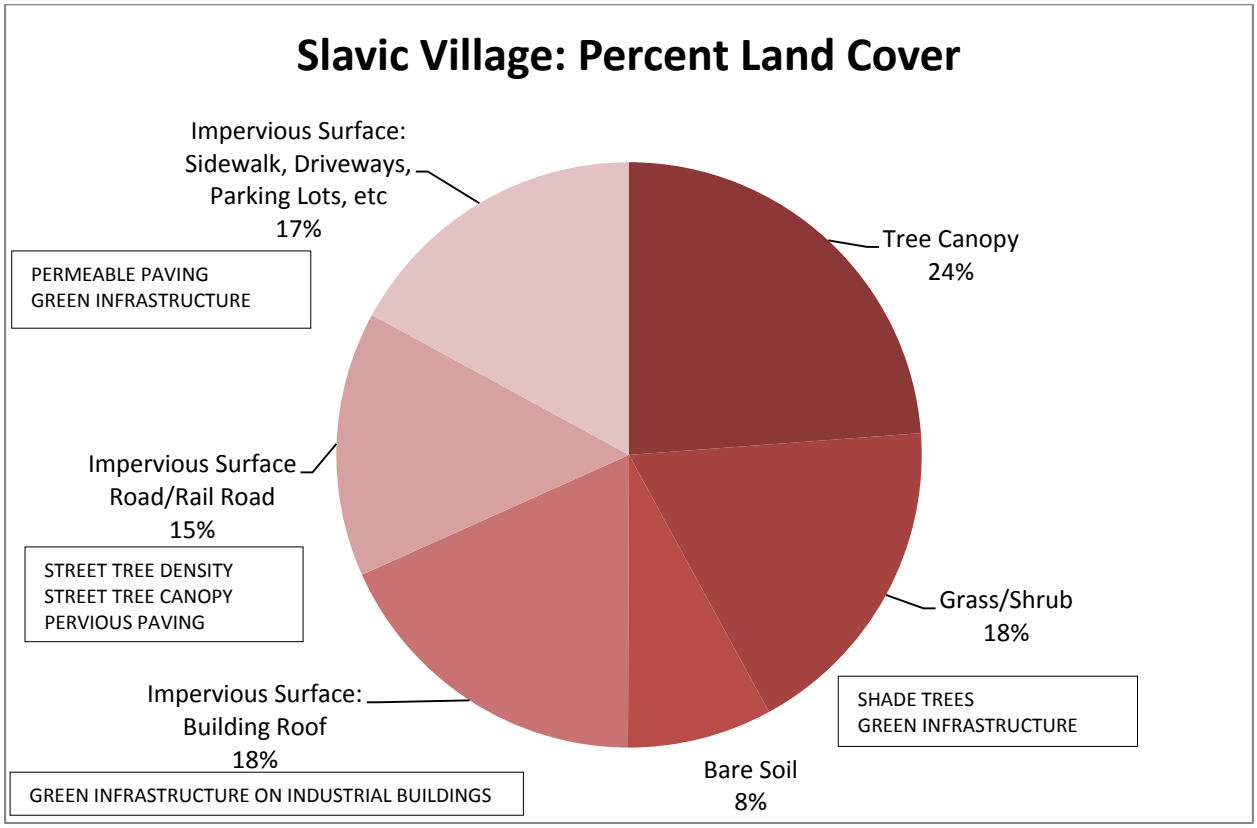
Since many environmental functions are related to leaf surface areas (eg. reduction in air temperature, air pollution, volatile organic emissions, carbon dioxide sequestrations), understanding the leaf-area contribution of various species is important to urban-forest researchers, managers, and planners. Further analysis of leaf areas and plant species and its applications at smaller scale will be helpful. In addition, the relationship between UHI and land cover can be further analyzed.

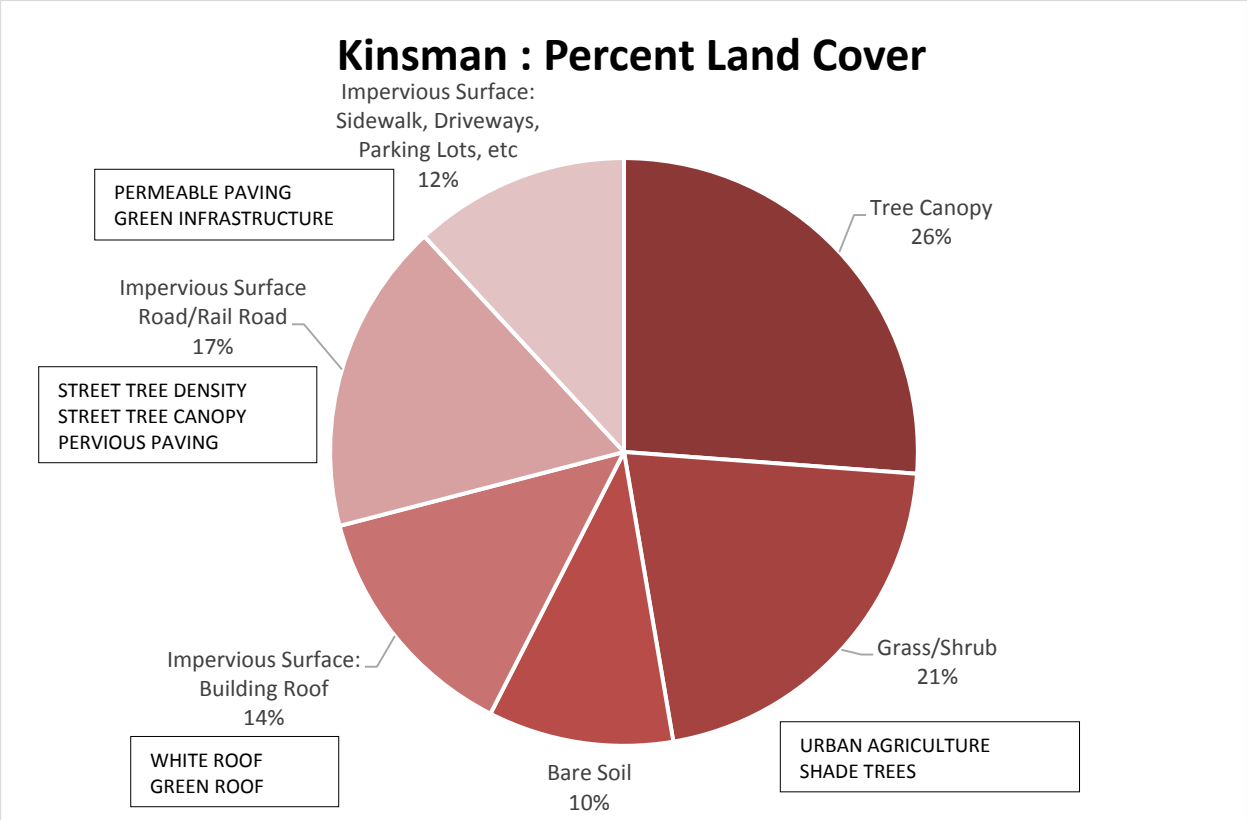
4.0 Applications for Study Areas

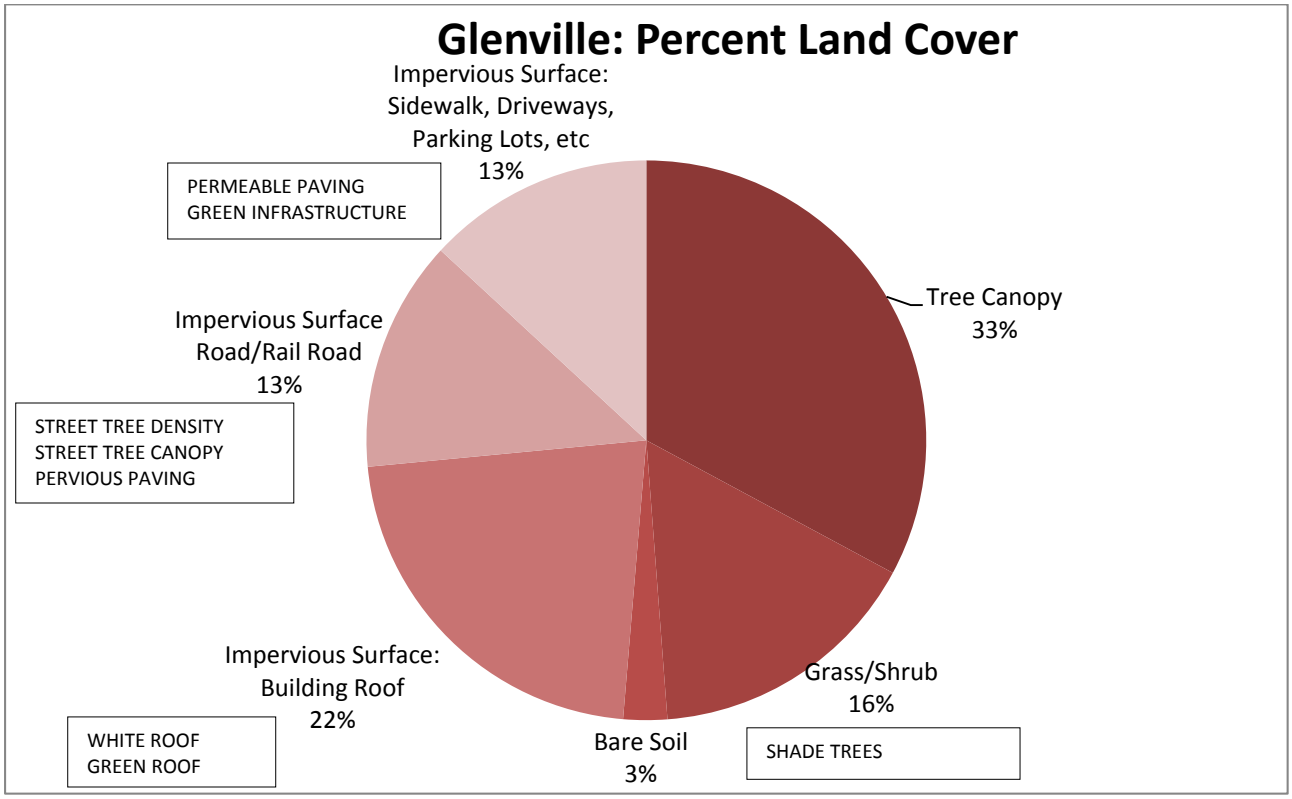
One of the major questions for this project is to identify appropriate use of vacant land parcels for developing climate resilient strategies. This section provides potential answers based on existing literature and its suitability for the study area.

Strategizing urban greening efforts

Greening efforts should be concentrated on various land uses (like industrial, warehouse, as well as residential) where current vegetation cover is minimal. There are multiple urban greening approaches suitable for each land uses. For example, large industrial and warehouse land uses in the Slavic Village provide opportunities for green roofs (Lin et al. 2013, Castleton et al. 2010) and large parking lots on these land uses are suitable for implementing green infrastructure for surrounding health and safety (Kondo et al. 2015). Land use dedicated to transportation, available in all study areas, provides an opportunity to increase street tree density and its canopy cover (Janhäll 2015). Use of local plant species (Sæbø 2012) that have high leaf area density will offer improved environmental (Panda, Amatya, and Hoogenboom 2014), ecological (McPherson et al. 1994), as well as social benefits (Bruton and Floyd 2014). Such urban greening efforts not only contribute towards healthy ecosystems but offers economic and social benefits as well (2009). In residential areas, parcel level vegetation strategies can provide maximum benefits to residents by offering reduced heat island effect, air pollution, thermal comfort, and energy efficiency in addition to health benefits (South et al. 2015).




Kinsman : Percent Land Cover
Impervious Surface: Sidewalk, Driveways, Parking Lots, etc 12%
PERMEABLE PAVING
GREEN INFRASTRUCTURE
Tree Canopy 26%
Impervious Surface Road/Rail Road 17%
STREET TREE DENSITY
STREET TREE CANOPY
PERVIOUS PAVING
Grass/Shrub 21%
Impervious Surface: Building Roof 14%
WHITE ROOF
GREEN ROOF
Bare Soil 10%
URBAN AGRICULTURE
SHADE TREES


Glenville: Percent Land Cover
Impervious Surface: Sidewalk, Driveways, Parking Lots, etc 13%
PERMEABLE PAVING
GREEN INFRASTRUCTURE
Tree Canopy 33%
Impervious Surface Road/Rail Road 13%
STREET TREE DENSITY
STREET TREE CANOPY
PERVIOUS PAVING
Impervious Surface: Building Roof 22%
Grass/Shrub 16%
WHITE ROOF
GREEN ROOF
Bare Soil 3%
SHADE TREES

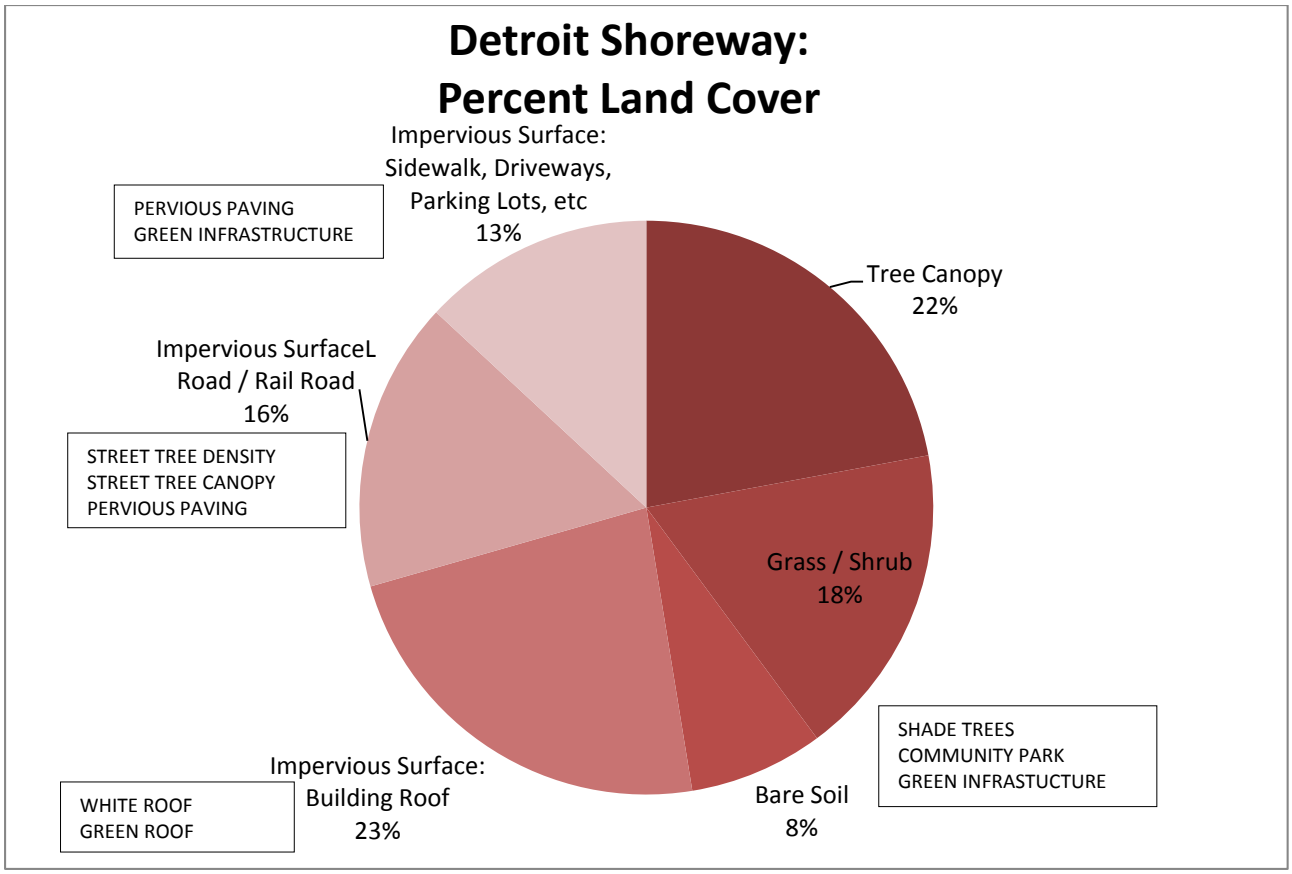


Figure 7: Land Cover and Potential Climate Resilient Strategies for study areas

Effect of Urban Trees on Wind and Air Temperature: By transporting water, blocking winds, shading surfaces, and modifying the storage and exchanges of hear among urban surfaces, trees affect local climate and consequently energy use in buildings, human thermal comfort, and air quality. Accurate estimation of the effect of urban trees on local wind speeds and air temperature at the height of people and residential buildings have been estimated in observational studies and by simulation models to explore the complexity of the multiple surfaces in urban areas. A study conducted in Chicago reported air temperature at below-canopy sites remained within 3.6^0 F of the temperature at the same height at the airport (McPherson et al. 1994). This study also reported higher air temperature in residential neighborhoods with less (10 percent) vegetation cover resulted in increased anthropogenic heat by paved surfaces.

While urban forest ecosystem study of Chicago provides closest reference for this project, there exists additional evidences on urban greening to cool towns and cities (Bowler et al. 2010) that reported cooling effects of ground and roof vegetation, urban trees and forests, and parks and green areas. Figure 8 shows a summary of various studies that compared air temperature differences between built up area and various greening strategies in a day. The average temperature reduction in the day is 0.94◦C (95% CI = 0.71–1.16), based on 26 effect sizes from 16 studies. Analysis on the subset of data measured at night (22:00–06:00) based on 12 effect sizes from 7 studies found a similar average temperature reduction of 1.15◦C (95% CI = 0.86–1.45). This result could be indicative of an extension of the park's cooling effect into its surroundings, which would reduce the temperature difference. Also, the results of these studies show that larger parks were either more likely to be cooler or that the cooling effect was greater.

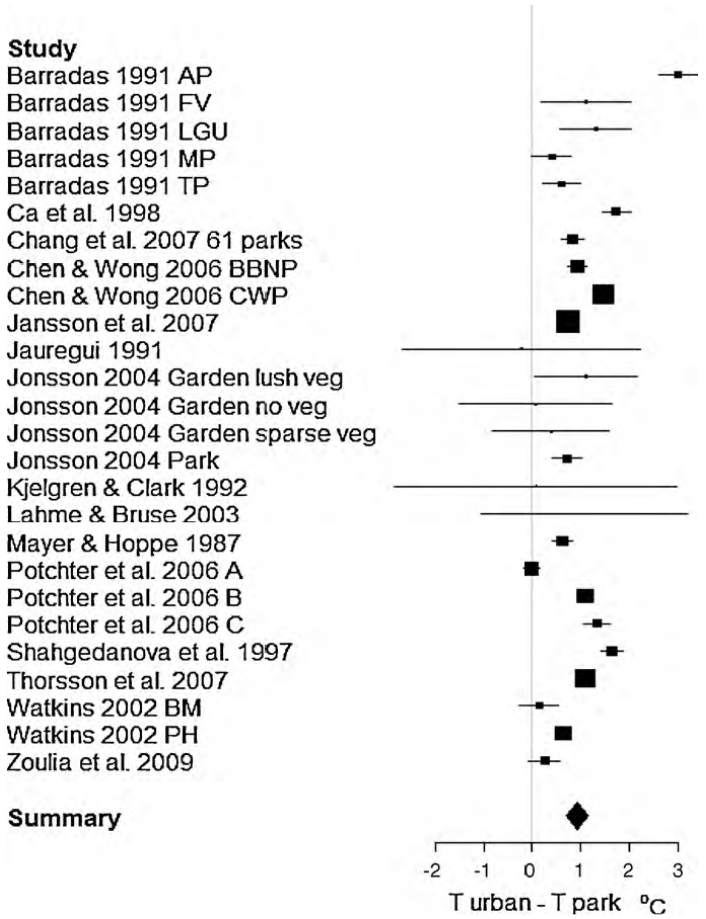


Figure 8: Black squares represent the average temperature difference between a built-up area and a park or green area in the day (the effect size; Turban –Tpark ◦C). The horizontal bars are the 95% confidence intervals for each effect size. The vertical axis line represents the line of no temperature difference; positive effect sizes indicate that the park was cooler. The average effect size ("Summary" shown as a diamond symbol) was calculated as a weighted average. The size of black squares reflects the "weight" given to each study (see Section 3) and was based on the inverse of the variance. *(source: (Bowler et al. 2010))*

Local-scale Energy and Water Exchanges: The complex mix of anthropogenic surfaces (like buildings, roads) and natural surfaces (like trees. Grass) in urban areas affects how energy and water are partitioned and cycles through the urban systems. The replacement of natural surfaces with anthropogenic surfaces alters the thermal and moisture properties of the area, thereby modifying the local atmosphere and generating an "urban climate" that is commonly characterized by increase air temperatures and poor air quality.

Potential Building Energy Savings from Urban Trees: Trees can reduce building energy use by lowering summertime temperature, shading buildings during the summer, and blocking the winter winds. However, trees also can increase building energy use by having their branches shade building during the winter, and an increase or decreased energy use by blocking summertime breezes. The energy-saving potential of trees in Chicago (McPherson et al. 1994) reported that increasing tree cover by 10 percent (or about 3 trees located in optimal energy-conserving locations per building, as shown in Figure 9) could reduce total heating and cooling energy use by 5 to 10 percent. On a per-tree basis of this mass planting, annual heating energy use can be reduced by about 1.3 percent, cooling energy use by about 7 percent, and peak cooling

demand by about 6 percent. Benefit-cost ratios of 1.40 for trees planted around typical two-story buildings and 1.96 for trees near energy-efficient wood frame buildings indicate that a utility-sponsored share tree program could be cost effective for both existing and new construction

Street trees can be a major source of building shade. Shade from a large tree located on west side of a typical brick residence can reduce the annual use of air-conditioning energy by 2 to 7 percent and peak cooling demand by 2 to 6 percent. Street trees that shade the east side of buildings can produce similar cooling savings, have a negligible effect of peak cooling demand, and can slightly increase heating costs. Shade from large trees to the south increase heating costs more than they decrease cooling costs.

Planting "solar friendly" trees to the south and east can minimize the energy penalty associated with blocking irradiance during the heating seasons. Features of energy-efficient residential landscape includes 1) shade trees, shrubs, and vines located for shade on the west and southwest windows and walls; 2) solar friendly deciduous trees to shade the east and an open understory to promote penetration of cool breeze; 3) evergreen windbreaks to the northwest and west for protection from winter winds; and 4) shade on air conditioners where feasible. Further, location specific design guidelines and recommendations on tree species for energy-efficient landscapes are suggested as future works.

Figure 9: Energy-efficient residential landscape design with east and west shade as well as wind protection to the west and northwest (source: Sand and Huelman, 1983)

Benefits and Costs of Urban Tree Planting and Care:

A benefits-cost ratio analysis for various greening strategies e.g. parcel to urban forest scale shows that small scale interventions like a yard-tree plantation strategies can have incremental impact in the beginning however it can catch up with larger scale urban parks that have higher impact in the early in the implementation stages. This analysis values the role small scale as well as large scale tree planting strategies.

5.0 Conclusions:

Various microclimatic conditions, UHI, exist within Cleveland neighborhoods. The observed maximum UHI intensity in based on average daily temperature of 2012 is 47.79^0 F in winter, 37.58^0 F in spring, 26.33^0 F in summer, and 32.67^0 F in fall. The UHI intensities are high during spring and summer months when average daily temperature is also high compared to other seasons.

The average tree canopy cover in all study areas is 27%, impervious surface area is 49%, and the grass/shrubs and bare soil area is 26%. The tree canopy cover ranges from 23-33% in the study area. Glenville (33%) shows the highest tree canopy cover whereas Detroit Shoreway (23%) shows minimum tree canopy cover. The impervious surfaces include Sidewalks, Driveways, Parking Lots, Roads/Rail Roads, and Building Roofs and their percentage is high in all study areas: Slavic Village (52%), Kinsman (42%), Glenville (49%), and Detroit Shoreway (55%). Further current grass/shrub (19%) and bare soil (7%) accounts for almost quarter of the land cover.

Based on the literature cited in this study, two most effective strategies to improve climate resiliency for the selected neighborhoods is; increasing tree density and canopy cover and replacing impervious surfaces by water retaining pervious surfaces. Both these strategies have a potential to be implemented as a policy as well as develop community engagement projects at parcel and urban scale alike.

Future scope of this study includes evaluate project specific adaptation and mitigation strategies to figure out most effective strategies for climate resiliency for studied neighborhood based on its energy, environmental, economic, as well as health and social relevance.

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Appendix H:

Overlay of Climate Change Actions and Climate Impacts

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1. Introduction

Projected climate change impacts are expected to differ across the United States. While increased temperatures will impact all regions of the country, other climatic variables such as precipitation and extreme weather events will differ. Strategic climate change measures are required from state and local governments to reinforce a community's resilience to adverse climate change impacts.

Cleveland has placed focus and resources towards climate change mitigation and adaptation efforts through multiple actions plans and policy recommendations. These include the Cleveland Climate Action Plan and the Re-imagining a More Sustainable Cleveland Plan. Actions in both plans fall generally under similar focus areas, and the scope of these efforts address ten categories of climate impacts which are described in greater detail in Appendix C:

1- Increase temperatures
2- Changes in Precipitations
3- Extreme weather events
4- Public Health
5- Water Quality
6- Food Systems
7- Forests and Land Cover
8- Energy and Industry
9- Transportation Systems
10- Fish and Wildlife

The following document attempts to correlate the expected benefits and effects of these strategies in relation to the ten climate impacts presented in the literature review. This may help policy makers to prioritize the numerous mitigation and adaptation actions with regard to available financial and human resources, time, and desired outcomes.

2. Overlay of Cleveland Climate Action Plan (CAP) and climate impacts

Table 1 illustrates the various impacts of the Cleveland CAP proposed strategies on the numerous components of climate change that extend beyond decreasing greenhouse gases emissions. It is important to note, that besides the direct benefits of climate change policies, there are also co-benefits of climate change actions, which arise from the synergies of the various actions and policies. Identifying the potential benefits and co-benefits of climate change actions helps policy makers prioritize mitigation and adaptation strategies when resources are limited; however this requires a more precise analysis and assessment of the potential impacts. Therefore, the data in the table indicates only the direct benefits of climate actions.

Actions within the CAP are categorized into six different focus areas, each with a set of specific strategies. The focus areas include energy efficiency and green building, advanced and renewable energy, sustainable mobility, waste reduction and resource conservation, land use and clean water and community engagement and public health. Though the table attempts to simplify the complex interrelations between actions and benefits, it implies that certain actions result in a wide range of benefits. This helps at selecting actions that may be more promising than others.

The goal to lessen the pressures on energy demands and energy generation is at the center of most mitigation strategies in the CAP. In addition, it is clear from the table that the management

of the public health and energy and industry climate impacts require policies with input from various sectors of the government benefited by collaborations with local communities. This emphasizes the need for an integrated and multidisciplinary approach to tackling climate change and its adverse effects.

Energy efficiency and green buildings & advanced and renewable energy: The most promising actions are based on increasing energy efficiency and adapting advanced and renewable energy, by reducing energy demand and waste, accelerating renewable energy use, reducing vehicle emissions, and improving transportation options. Moreover, such strategies have a vast amount of co-benefits including improved water and air quality, stable temperatures, and reduce risks to public health.

Sustainable mobility: Improved air quality, reduced fuel consumption and vehicle miles traveled are the main objectives of sustainable mobility. The CAP strategies actions target climate impacts on public health and energy and industry; by cutting transport emissions it reduces the effects of traffic pollution on health. In addition to these benefits, green streets actions add co-benefits that include increased land cover, decreasing temperatures, providing more comfortable outdoor spaces, and managing stormwater runoff.

Waste reduction and resource conservation: Actions that promote the reduction, reuse and recycling of waste generated by Cleveland residents are important for controlling and reducing GHG emissions, extracting energy from organic wastes, extending the productivity of landfills and reducing disposal costs. A coordinated approach to waste management efforts targets the climate's impacts on public health, water quality, food systems, and energy production.

Land use and clean water: At a first glance, climate change actions within the land use and clean water focus area result in a more diverse set of benefits in comparison to the other focus areas. Land use and clear water issues intersect between climate change adaptation and mitigation efforts(City of Cleveland Office of Sustainability 2013). The actions included in the CAP address almost all components of climate impacts including water quality, temperature and precipitation patterns, public health, and energy.

Community engagement and public health: Actions targeting community engagements and public health can be characterized as having indirect benefits that result from the synergies of the actions of this category and the actions of the other focus areas.

Table 1: Overlay of Cleveland Climate Action Plan and Climate Impacts

Focus Area	Objective	#	Actions[1]	Mitigation (M) and/or Adaptation (A)[2]	Climate Impacts[3]									
					Increased Temperatures	Changes in Precipitation Patterns	Extreme Weather Events	Public Health	Water Quality	Food Systems	Forests and Land Cover	Energy and Industry	Transportation Systems	Fish and Wildlife
Energy efficiency and green building	Retrofit and renovate existing buildings	1	Retrofit residential buildings	MA	●		●	●				●		
		2	Retrofit commercial & industrial buildings	M	●		●	●				●		
	Make green building the standard for all new construction	3	Exceed existing building codes	MA	●		●	●				●		
	Implement neighborhood-level solutions	4	Make utility data easily accessible	M				●	●			●		
		5	Expand smart grid	M			●	●	●			●		
		6	Expand energy & green building challenges	M				●				●		
		7	Green Cleveland's existing schools	MA	●			●				●		
Advanced and renewable energy	Accelerate renewable energy use by Cleveland's residents and small businesses	8	Install renewable energy at homes & businesses	MA			●	●				●		
		9	Incorporate renewable energy into municipal aggregation	M			●	●	●			●		
	Use local projects to help meet or exceed the utility renewable energy standards	10	Install renewable energy projects on vacant land	M			●	●			●	●		
		11	Develop an offshore wind farm	M								●		
		12	Meet energy efficiency & renewable energy standards	M				●				●		
	Implement advanced energy technologies	13	Accelerate conversion of organic waste to energy	M					●			●		
		14	Create low-carbon district heating & cooling systems	M				●	●			●		
		15	Support businesses to reduce industrial emissions	M	●			●				●		
Sustainable Mobility	Reduce congestion and vehicle emissions	16	Drive more efficient vehicles	M				●				●	●	
		17	Encourage anti-idling citywide	M				●				●	●	
		18	Expand carpooling & car sharing	M				●				●	●	
		19	Increase the use of public transit	M			●	●				●	●	
	Create Complete and Green Streets	20	Make biking & walking easier & safer	M			●	●				●	●	
		21	Create complete & green streets	MA	●	●		●	●		●	●	●	
Waste reduction and resource conservation	Significantly reduce the amount of waste sent to landfills	22	Encourage waste reduction by residents & businesses	M				●	●	●		●		
		23	Increase deconstruction & recycling of demolished buildings	M								●		
		24	Develop an integrated waste management plan for Cleveland	M				●	●	●		●		
Land use and clean water	Encourage vibrant downtown and neighborhoods	25	Green Cleveland's codes to encourage sustainable development	MA	●	●		●	●		●	●	●	●
		26	Rightsize the City's infrastructure	MA	●	●		●	●			●	●	
	Restore and regenerate the natural environment	27	Develop & implement an urban tree plan	MA	●	●	●	●	●		●	●		●
		28	Scale up the local food system	MA	●	●	●	●	●	●		●	●	
		29	Implement green infrastructure to capture storm water	MA	●	●	●	●	●		●	●		
		30	Increase water conservation & efficiency	MA		●		●	●			●		●
Community engagement and public health	Organizations, neighborhoods, and individuals become climate leaders	31	Promote businesses striving to meet energy & carbon goals	M			●	●	●			●		
		32	Recognize neighborhood capacity to take climate action	MA	●	●	●	●	●	●	●	●	●	●
	Improve public health and resiliency to climate change impacts	33	Build resiliency against the impacts of climate change	A	●	●	●	●	●	●	●	●	●	●

Notes:

1. Actions are from the *Cleveland Climate Action Plan: Building Thriving and Healthy Neighborhoods* (City of Cleveland Office of Sustainability 2013).
2. Mitigation is defined as actions that reduce GHG emissions and help to slow climate change. Adaptation is defined as actions that help human society and natural systems prepare for and become less vulnerable to a changing environment (U.S. Environmental Protection Agency 2013).
3. Climate impacts are adapted from the *Synthesis of the Third National Climate Assessment for the Great Lakes Region* (Baule, Gibbons et al. 2014), and Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment (Winkler, Andresen et al. 2014).

3. Overlay of Re-imagining a More Sustainable Cleveland and climate impacts

By examining where the actions and impacts overlap, Table 2 indicates that Re-imagining plan places emphasis on strategies that address climate change impacts on public health and water quality. While it is hard to pinpoint the co-benefits of each policy, the table indicated multiple benefits from all the 26 strategies, in particular the strategies targeting green infrastructure and urban agriculture. There are no clear direct benefits of the policies in relation to extreme weather events, however, it is expected that the benefits gained from reducing energy use, temperature and precipitation patterns would have an indirect impact on extreme weather events.

Actions within the Re-imagining plan are categorized into five different focus areas, each with a set of specific actions and strategies. The focus areas include land use, data, green infrastructure, urban agriculture, and energy generation.

Land use: Land use acquisition mechanisms and the implementation of methods to streamline the disposition of properties do not directly target climate impacts; however they aid in improving governmental process when it comes to the land use decision making and management of properties. The land reutilizations strategies task force targets climate impacts on temperature, public health and water quality, while the use of hydrological and soil data for land use and storm water management strategies is related to precipitation patterns, public health, water quality and land cover.

Data: Geocoding vacant land and parcel-based mapping of environmental contaminations aid in the management of vacant lands, with the latter targeting temperatures, public health, water quality and fish and wildlife climate impacts. Mapping and documentation of lead contaminated sites, wetland criteria and drainage patterns, soil properties and existing vegetative covers targets multiple climate impacts, more specifically public health, water quality and land cover.

Green infrastructure: The expansion of a green space network, restoring ecosystems, and the remediation of sites riddled with contamination provide the city with new recreation resources, management of storm water runoffs, and overall ecosystem restoration. Such actions can improve air and water quality and increase biodiversity. Ultimately a healthy ecosystem offers environmental benefits and improves the quality of life of residents by limiting the impact of climate change on public health.

Urban agriculture: Utilizing vacant land as productive landscapes that generate economic return benefits communities on various levels. Access to affordable produce through community gardens, market gardens, and commercial agricultures on larger areas of vacancy in the city adds to the potential economic development. Overall, improving the agriculture production of vacant lands directly affects the extent of climate impacts on temperature, water quality, food systems, and public health.

Energy generation: Solar, wind, geo-thermal and biofuel technologies can be used in vacant lands for energy generation, while more research is required to determine the most feasible option for Cleveland's dispersed vacant land, such polices provide incentives for generating and using alternative energy at local levels. In addition to energy conservation and optimization, these policies have a direct correlation to the climate impacts on energy and industry and public health. While multiple co-benefits are expected, identifying them is based on a more defined set of policies within this focus area.

Table 2: Overlay of Re-Imagining a More Sustainable Cleveland and climate impacts

Focus Area	#	Actions[1]	Climate Impacts[2]: Increased Temperatures	Changes in Precipitation Patterns	Extreme Weather Events	Public Health	Water Quality	Food Systems	Forests and Land Cover	Energy and Industry	Transportation Systems	Fish and Wildlife
Land Use	1	establish a task force for new vacant land reutilization strategies	●			●	●					
	2	Adopt land use decision-making mechanism										
	3	Streamline the disposition of properties in the city's land bank										
	4	Encourage use of hydrological data and soil characteristics for land use and storm water management strategies		●		●	●		●			
Data	5	Develop methods to classify and geo-code vacant land										
	6	Develop detailed parcel-based mapping of environmental contaminations	●			●	●					●
	7	Parcel-level mapping on sites where children have high blood-lead levels & connect to building demolition decision making				●				●		
	8	Map and document wetland criteria and drainage patterns		●		●	●					
	9	Map and document soil properties		●		●	●		●			
	10	Delineate areas of existing vegetative cover by using aerial photos	●						●			
Green Infrastructure	11	Expand green space and land preservation areas in the 2020 land use plan	●			●	●		●	●		
	12	Identify city-wide green infrastructure initiative	●			●	●			●	●	
	13	Adopt design guidelines for ecosystem preservation in riparian and headwaters areas					●		●			●
	14	Enhance, preserve and create wetland systems					●					
	15	Encourage or mandate use of bioswales and pervious paving	●	●		●	●					
	16	Encourage rain gardens on residential properties	●			●	●					●
	17	Link green infrastructure projects to the Cleveland Carbon Fund	●	●								
Urban Agriculture	18	Prioritize agricultural land uses and create land use category for urban agriculture	●			●		●	●	●		
	19	Establish a minimum half a mile radius between residents and community or market gardeners				●		●		●	●	
	20	Integrate permanent garden space in model block/neighborhood planning	●			●			●			
	21	Establish strategies for controlling use and new models for holding land										
	22	Develop policies and practices within the Cleveland Water Department to streamline farmers and gardeners access to water					●	●		●		
	23	Explore new ways of bringing water to site					●	●		●		
	24	Explore potential for municipal composting facility and community composting projects				●		●		●		
Energy Generation	25	Support the adoption of an Ohio renewable energy portfolio				●				●		
	26	Support efforts toward energy conservation, optimization and generation				●				●		

Notes:

1. Actions are from *Re-Imagining a More Sustainable Cleveland: Citywide strategies for reuse of vacant land (Collaborative 2008).*
2. Climate impacts are adapted from the *Synthesis of the Third National Climate Assessment for the Great Lakes Region* (Baule, Gibbons et al. 2014), and Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment (Winkler, Andresen et al. 2014).

4. Overlay of Cleveland CAP and Re-Imagining a More Sustainable Cleveland

Communities across the United States have become more aware of the need to address climate change, many have produced several mitigation and adaptation plans, with long-term and short term implications. While establishing climate change mitigation and adaptation strategies is crucial for any community, there is a need for collaboration between organizations, agencies, and communities at different levels to enable a more efficient approach to tackling climate change. By setting common goals, this helps to harmonize the various climate actions and strategies between the different levels, and with other community planning goals.

Table 3 below compares the Cleveland Climate Actions Plan strategies and the Re-imagining more sustainable Cleveland actions, identifying where various strategies overlap. An examination of these actions aid in understanding the direction of current climate change policies and provides us with a rationale for reinforcing and encouraging certain strategies within this report

It is clear that from this table that there are synergies between multiple actions from both plans, each reflecting the same broader goal of addressing climate change impacts. But at the same time the focus of these actions differ from a specific target such as vacant lands in the Re-imagining plan to city wide targets in the CAP. The main intersect between the two plans correlates with strategies in the water and land use focus areas. Energy efficiency and energy generation strategies in the CAP are more detailed and address different components of the focus area, while the same focus area in the Re-imagining plan is identified in a broader manner.

Actions 25 and 26 in the Re-imagining plan correlate with CAP actions 8-12 and 1 -14 respectively, while action 33 in the CAP correlates with almost all of the actions in the Re-imagining plan.

The Cleveland CAP reflects policies with broad targets in various fields, while the re-imaginings policies are concentrated on strategies applicable to vacant land within the city. Though similarities help in pointing out strategies that are agreed upon in both plans, looking at actions that don't intersect provides clues to strategies that need reinforcing. The Re-imagining Cleveland plan focuses on vacant land; therefore no emphasis was placed on vehicular use, public transportation and carpooling, an aspect of the sustainability mobility actions in the Cleveland action plan.

Table 3: Overlay of Cleveland Climate Action Plan and Re-Imagining a More Sustainable Cleveland

			Land Use				Data						Green Infrastructure							Urban Agriculture							Energy	
Focus Area	**#**	**Actions**	1 Establish a task force for new vacant land reutilization strategies	2 Adopt land use decision-making mechanism	3 Streamline the disposition of properties in the city's land bank	4 Encourage use of hydrological data and soil characteristics for land use and storm water management strategies	5 Develop methods to classify and geo-code vacant land	6 Develop detailed parcel-based mapping of environmental contaminations	7 Parcel-level mapping on sites where children have high blood-lead levels & connect to building demolition decision making	8 Map and document wetland criteria and drainage patterns	9 Map and document soil properties	10 Delineate areas of existing vegetative cover by using aerial photos	11 Expand green space and land preservation areas in the 2020 land use plan	12 Identify city-wide green infrastructure initiative	13 Adopt design guidelines for ecosystem preservation in riparian and headwaters areas	14 Enhance, preserve and create wetland systems	15 Encourage or mandate use of bioswales and pervious paving	16 Encourage rain gardens on residential properties	17 Link green infrastructure projects to the Cleveland Carbon Fund	18 Prioritize agricultural land uses and create land use category for urban agriculture	19 Establish a minimum half a mile radius between residents and community or market gardeners	20 Integrate permanent garden space in model block/neighborhood planning	21 Establish strategies for controlling use and new models for holding land	22 Develop policies and practices within the Cleveland Water Department to streamline farmers and gardeners access to water	23 Explore new ways of bringing water to site	24 Explore potential for municipal composting facility and community composting projects	25 Support the adoption of an Ohio renewable energy portfolio	26 Support efforts toward energy conservation, optimization and generation
Energy efficiency and green building	1	Retrofit residential buildings																●										●
	2	Retrofit commercial & industrial buildings																										●
	3	Exceed existing building codes	●																									●
	4	Make utility data easily accessible																										●
	5	Expand smart grid																										●
	6	Expand energy & green building challenges																										●
	7	Green Cleveland's existing schools																										●
anced and renewable ene	8	Install renewable energy at homes & businesses																									●	●
	9	Incorporate renewable energy into municipal aggregation																									●	●
	10	Install renewable energy projects on vacant land																									●	●
	11	Develop an offshore wind farm																									●	●
	12	Meet energy efficiency & renewable energy standards																									●	●
	13	Accelerate conversion of organic waste to energy																										●
	14	Create low-carbon district heating & cooling systems																										●
	15	Support businesses to reduce industrial emissions						●																				
Sustainable Mobility	16	Drive more efficient vehicles																										
	17	Encourage anti-idling citywide																										
	18	Expand carpooling & car sharing																										
	19	Increase the use of public transit																										
	20	Make biking & walking easier & safer												●					●									
	21	Create complete & green streets												●			●		●									
Waste reduction and resource conservation	22	Encourage waste reduction by residents & businesses																								●		
	23	Increase deconstruction & recycling of demolished buildings							●																			
	24	Develop an integrated waste management plan for Cleveland																								●		
Land use and clean water	25	Green Cleveland's codes to encourage sustainable development	●	●			●															●						
	26	Rightsize the City's infrastructure												●														
	27	Develop & implement an urban tree plan										●		●														
	28	Scale up the local food system																		●	●			●				
	29	Implement green infrastructure to capture storm water				●				●				●			●		●									
	30	Increase water conservation & efficiency											●					●						●	●			
Community engagement and public health	31	Promote businesses striving to meet energy & carbon goals																										●
	32	Recognize neighborhood capacity to take climate action															●									●		
	33	Build resiliency against the impacts of climate change		●		●		●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●		●

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Appendix I:

Cleveland Climate Action Plan: Building Thriving and Healthy Neighborhoods

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SUSTAINABLE CLEVELAND 2019

CLEVELAND CLIMATE ACTION PLAN

BUILDING THRIVING AND HEALTHY NEIGHBORHOODS

2013

CONTENTS

**See pages 26 - 27 for a summary of all climate actions!*

"This implementation plan is a major step in an informed and coordinated effort to ensure a healthy, economically resilient, and secure community that is the vision of the Sustainable Cleveland 2019 initiative."

- Mayor Frank G. Jackson

ACKNOWLEDGEMENTS

The Mayor's Office of Sustainability would like to thank City staff and Green Team members, the Sustainable Cleveland 2019 Stewardship Council, and the following members of the Climate Action Advisory Committee who participated in the planning process.

FIGURES & TABLES

MAYOR JACKSON'S LETTER

CITY OF CLEVELAND
Mayor Frank G. Jackson

Dear Friends,

The global increase in greenhouse gas emissions has created social, economic, budgetary, health, ecological and security impacts for cities across the country, prompting local governments to plan differently for the future. In 2006, I signed the U.S. Mayor's Climate Protection Agreement, indicating that the City of Cleveland takes climate change seriously.

Taking action around climate change—reducing greenhouse gas emissions while at the same time planning for adaptation and resilience—integrates many of the sustainability initiatives we are working on in municipal government and as a community. The Cleveland Climate Action Plan is designed to build off of the Sustainable Cleveland 2019 Action and Resources Guide and the annual sustainability summits.

I would like to thank the 50-member advisory committee, the Sustainable Cleveland Stewardship Council, and dozens of community members and working group members from business, government, nonprofit, and institutional sectors for co-creating an actionable response to climate change that is built upon collaborative problem solving.

This plan is about much more than climate change. It provides opportunities for Clevelanders now, and into the future. There are 33 actions in this plan that strengthen our economy, clean our environment, and improve the health and wellness of Clevelanders. Whether it's planting trees, building green, creating healthier transportation options, or reducing waste and recycling, we can increase the livability of our neighborhoods and enhance the quality of life for all Clevelanders. By working together, we will:

- Educate Clevelanders to make smart, sustainable choices at home, at work, and in their community
- Create healthier, more comfortable living and working environments
- Reduce costs for homes, businesses, schools, and government
- Create jobs by strengthening our economy
- Improve air quality, water quality, and public health

We can achieve this plan. It requires a commitment not only from government but also from civic leaders, individuals, businesses, institutions, and neighborhoods throughout the City of Cleveland. While this plan centers on the City of Cleveland, it requires a broader community effort. We look forward to collaborating with communities across Northeast Ohio to enable the regional prosperity we all seek.

While access to fresh water and a temperate climate make Cleveland better positioned for increased heat and a changing climate compared to many cities, there is much we can do to improve the city's resilience. By focusing on the strategies that reduce greenhouse gas emissions while at the same time creating conditions for a sustainable economy, a healthy community and a Cleveland resilient and adaptable to changes in climate, we are building a thriving green city on a blue lake.

Sincerely,

Mayor Frank G. Jackson

INTRODUCTION

Someday, our children, and our children's children, will look at us in the eye and they'll ask us, did we do all that we could when we had the chance to deal with this problem and leave them a cleaner, safer, more stable world?

– President Barack Obama's Climate Speech, June 25, 2013

CLIMATE CHANGE IN A NUTSHELL

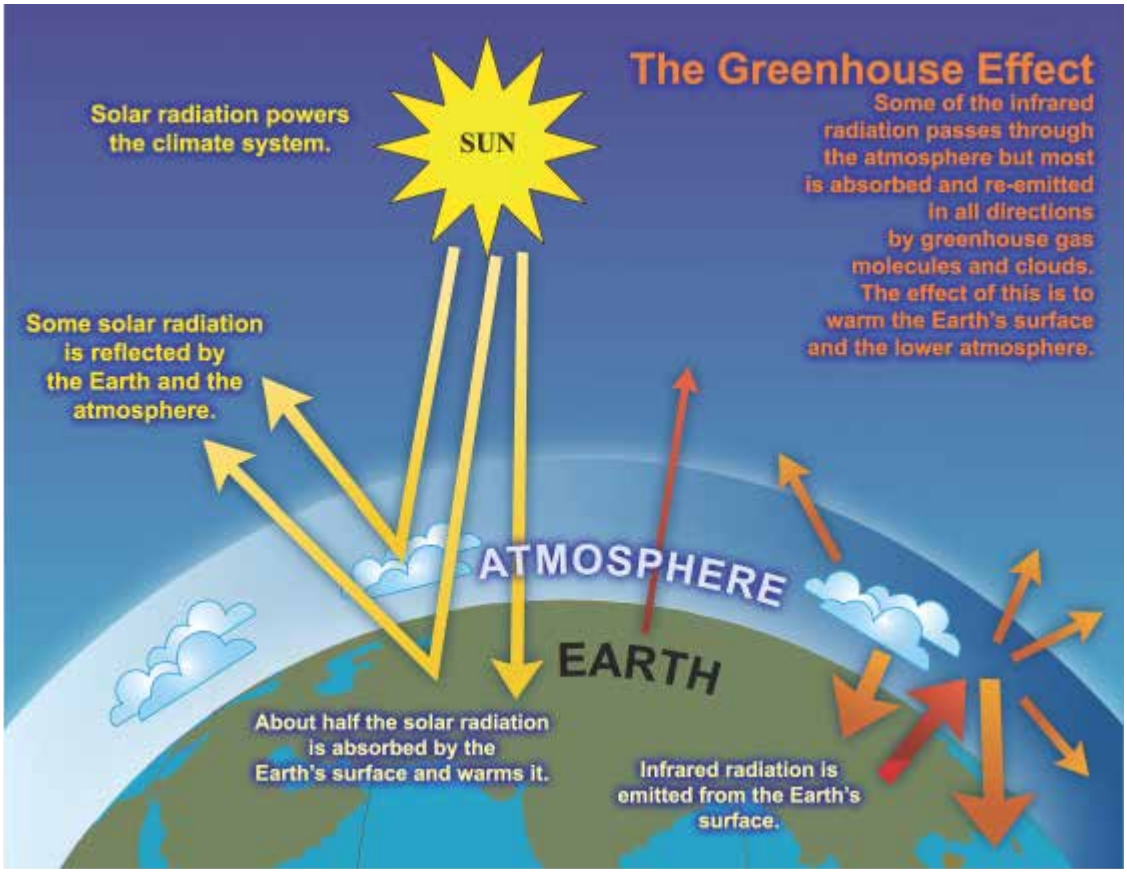
Taking action around climate change is a key component of the Sustainable Cleveland 2019 initiative. We can reduce greenhouse gas emissions, make our neighborhoods more resilient against the impacts of climate change, and grow the economy by integrating sustainability into the City of Cleveland's municipal operations, our residents' lives, and the priorities of our corporate and institutional partners.

SCIENCE OF CLIMATE CHANGE

Over the past century, human activities have released large amounts of carbon dioxide and other greenhouse gases (GHGs) into the Earth's atmosphere. Most of these GHGs have come from the burning of fossil fuels - such as oil, coal, and natural gas - to produce energy for heating and lighting our homes, running our vehicles, and keeping businesses and factories operating. Deforestation, industrial processes, and some agricultural practices also emit GHGs into the atmosphere.

GHGs act like insulation around Earth, trapping heat and energy in the atmosphere and causing the Earth to warm. This phenomenon is called the greenhouse effect. It is natural and necessary to support life on Earth. The excessive buildup of GHGs, however, is changing the Earth's climate, resulting in largely negative consequences on human, environmental, and economic health.

Figure 1: Model of the natural greenhouse gas effect
(Source: IPCC[i])



Global warming refers to the recent and ongoing rise in global average temperature near Earth's surface. It is caused mostly by increasing concentrations of GHGs in the atmosphere. Global warming is causing climate patterns to change. However, global warming itself represents only one aspect of climate change.

Climate change refers to any significant change in the measures of climate lasting for an extended period of time - including major changes in temperature, precipitation, or wind patterns - among other effects - that occur over several decades or longer.

Figure 2 below illustrates how the Earth's surface temperature (red line) is linked to carbon dioxide levels (blue line), indicating that as CO_2 levels increase, so does the Earth's surface temperature. The global atmospheric concentration of CO_2 increased from a pre-industrial value of about 280 parts per million (ppm) to 379 ppm in 2005[ii] and surpassed 400 ppm in 2013. This trend is evident in the right side of the graph.

According to the Intergovernmental Panel on Climate Change (IPCC), an international body of climate scientists, the period from 1995 to 2006 ranked among the 12 warmest years on record (since 1850). Since that time additional record warm years have occurred, including 2012, which was the warmest year on record in Cleveland. Sea levels have also been rising, and the observed annual coverage of the Earth's surface in snow and sea ice have shrunk[iii]. This warming trend in the Midwest is illustrated in Figure 3 below. Projected changes in summer average temperature and rainfall for Illinois and Michigan (shown in the figure) indicate that summers in these states will feel progressively more like summers currently experienced by states to their southwest under both higher (red) and lower (yellow) future emissions scenarios. In other words, parts of the Midwest are projected to feel like Texas by the end of this century unless we act.

Figure 2: Historic Carbon Dioxide and Temperature Fluctuations ***(Source: IPCC)***

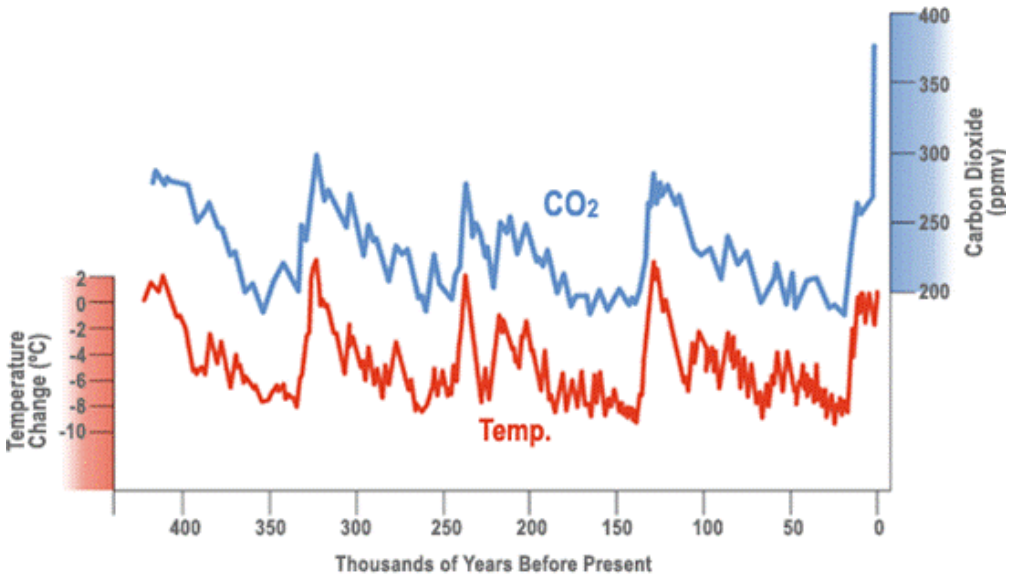
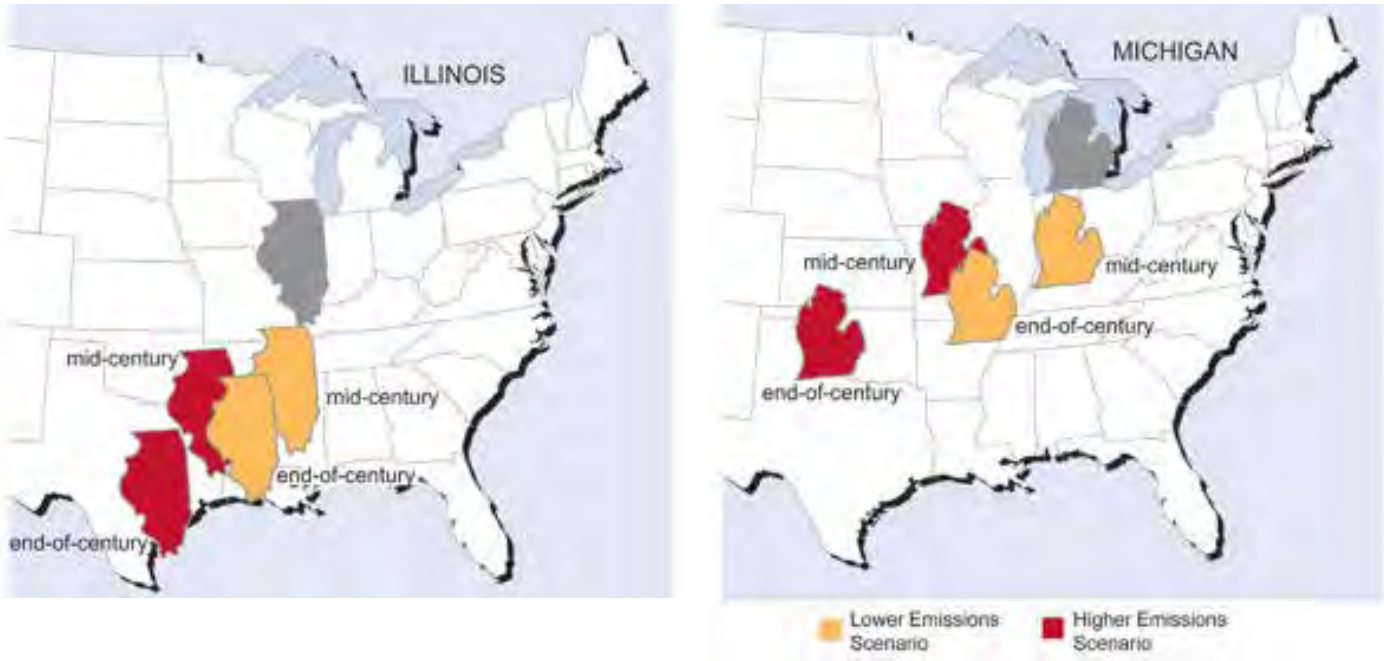
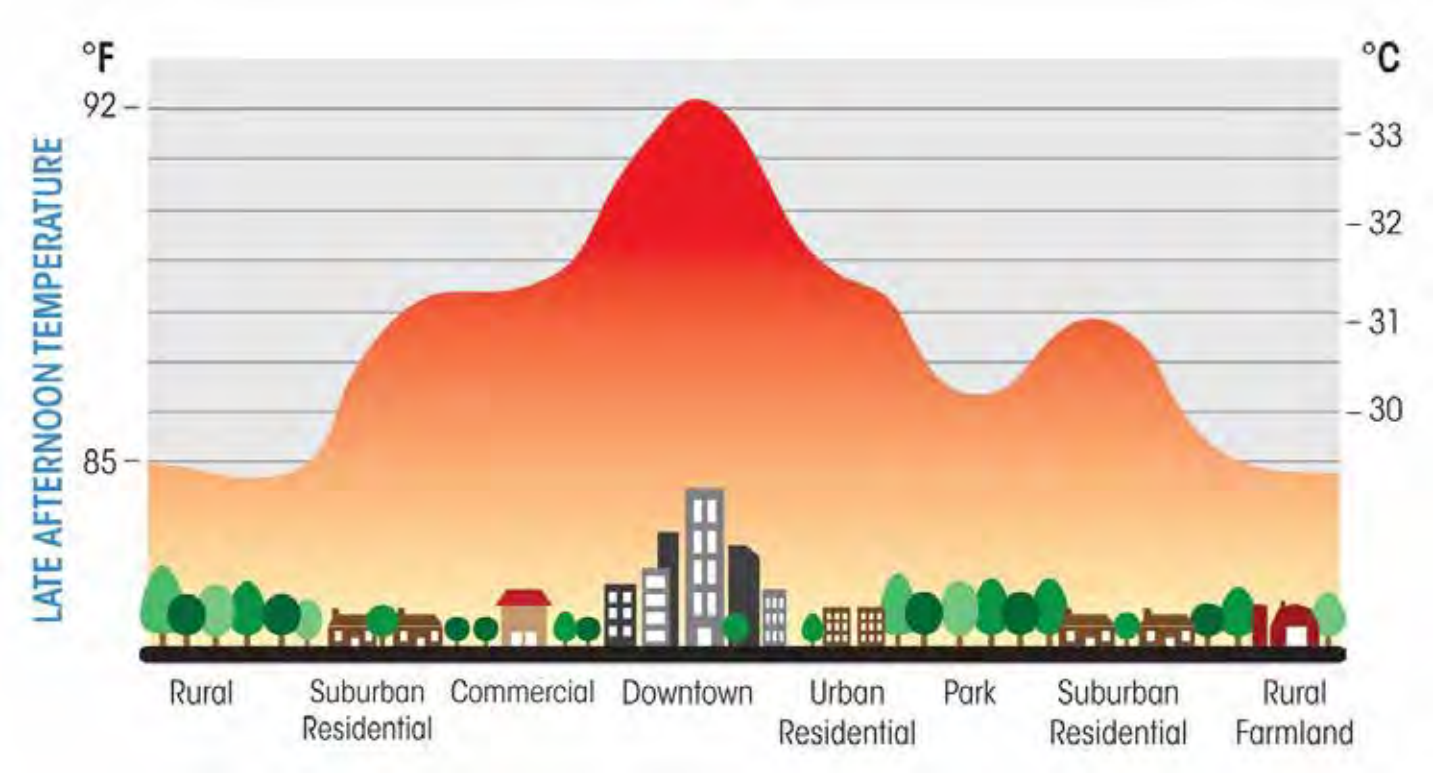


Figure 3: Migrating Temperatures ***(Source: Union of Concerned Scientists[iv])***



In Cleveland, one key impact of climate change are worsened heat islands, characterized by urban air and surface temperatures that are higher than nearby rural areas (see Figure 4 below). Many urban areas have air temperatures up to 10°F (5.6°C) warmer than surrounding areas with open land and vegetation. Heat islands form as dense built-up areas replace natural land cover with pavement, buildings, and other infrastructure. As an example, see the photo below of a parking lot in downtown Cleveland's Warehouse District. Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution, heat-related illness and mortality.

Figure 4: Urban Heat Island Profile[v] ***(Source: Clean Air Partnership)***



Pavement and buildings contribute to the urban heat island effect, while trees help reduce it (Warehouse District) ***(Photo: David Beach)***

Doan Brook combined sewer overflow event (*Photo: David Beach)*

Lake Erie shoreline erosion (*Photo: David Beach)*

WHY CLIMATE ACTION MATTERS IN CLEVELAND

According to the U.S. Environmental Protection Agency, annual temperatures in the Midwest, including Northeast Ohio, have increased over the last several decades. Heat waves are becoming more frequent and cold periods are becoming rarer. Snow and ice are arriving later in the fall and are starting to melt earlier in the spring. Heavy downpours now occur twice as frequently as they did a century ago. These trends are likely to continue under future climate change: average summer temperatures are projected to increase by 3°F over the next few decades and could increase by over 10°F by the end of this century[iv].

Unless we act, climate change is likely to have wide-ranging impacts on people and the environment in Northeast Ohio. Generally, these impacts would exacerbate existing management challenges by putting additional stress on vulnerable populations, infrastructure and ecosystems.

Anticipated impacts on **public health** include:

- More heat-related stress, particularly among the elderly, the poor, and other vulnerable populations; Fewer extreme cold-related health risks
- Greater risk of vector-borne illnesses (e.g., West Nile)
- Reduced summer air quality in urban areas due to increases in ground-level ozone and fine particulates

Climate change will also place additional stress on **water resources**, a key lifeblood in Cleveland and Northeast Ohio. Impacts include:

- Warmer water temperature in lakes and rivers causing increased evaporation
- Decreasing Great Lakes water levels, including Lake Erie, the shallowest of the lakes
- Increased competition for water
- Stress on wetlands
- Increased water-based transportation costs; Declines in ice cover will continue to lengthen the commercial navigation season.
- Reduced hydropower generation
- Increased heavy precipitation events and combined sewer overflow, increasing flooding risk
- Earlier spring snowmelt and peak runoff, increasing flooding risk

Additional climate impacts to **biodiversity and ecosystems** in Northeast Ohio include:

- Shift in the distribution and range of species, including trees such as sugar maples and hemlocks moving northward
- Loss of species not able to adapt to changes, and facing increased competition from invasive species
- Decline in beach health and more harmful blooms of algae
- Longer growing seasons over the next few decades will increase yields of some crops, but benefits will be offset by occurrence of extreme events such as heat waves, droughts, and floods.

Finally, climate change is likely to upset **economic activities** in the Great Lakes. For instance, in a warmer climate, evaporation from the lakes is projected to increase, which could cause water levels to drop by one to two feet by the end of the century. Although such a drop in water levels could benefit public beach access, it could adversely affect coastal ecosystems. Lower water levels would also make some key shipping channels too shallow for fully loaded ships, requiring more dredging. On the other hand, warmer temperatures may have a positive impact on shipping, as ice-free seasons lengthen. The net impact of these changes, however, is likely to impose costs on the Midwest through increased shipping, maintenance, and repair costs, as well as lost recreation and tourism.

THE BUSINESS CASE FOR ACTION

Many institutions, regional organizations, and companies in Northeast Ohio are already embarking on efforts to reduce their GHG emissions associated with energy use, transportation, solid waste and other areas. While reducing GHG emissions is a driving force for many of these efforts, there are many other benefits to individuals, organizations, and Cleveland's neighborhoods. In fact, **even if climate change was not a factor, taking the actions laid out in this plan would still make sense** from an economic, environmental, and equity perspective. The fact of climate change simply adds urgency to acting now.

Dozens of cities have begun to see firsthand that the implementation of climate mitigation strategies, such as improving building energy efficiency and public transit, have a positive impact on local and regional economies. As one example, between 2005 and 2011, Fort Collins, CO, implemented a number of programs and policies identified in its Climate Action Plan. While population increased 13%, the City reduced its GHG emissions by 11% and simultaneously grew its economy by 4% while being recognized nationally for its livability and business-friendly climate.

The goals and actions contained in this plan seek to reduce Cleveland's dependence on non-renewable fossil fuels, prioritize sustainable uses of land and water, reduce waste, and support neighborhood progress. If implemented, these actions will not only reduce Cleveland's GHG emissions, but also enhance its economic vitality, resilience, and viability as a healthy, livable city.

KEY BENEFITS OF TAKING CLIMATE ACTION

- Local job creation and economic development
- Reduced utility and operational costs for homes, businesses, and government
- Improved risk management and resilience to the impacts of climate change
- Healthier, more comfortable homes
- Improved air quality, public health, and quality of life
- Improved water quality in Lake Erie and other habitats
- A more educated and empowered population with the tools to take action at home, at work, and in their community

CLIMATE ACTION AND ECONOMIC DEVELOPMENT

Cities across the country are experiencing the economic benefits of taking climate action, especially as a result of investing in energy efficiency and advanced and renewable energy. Cleveland has the potential to achieve similar or better results as other cities because of the opportunities to improve building efficiency and to transition from coal to more sustainable sources of energy.

Cleveland residents and businesses spend approximately $1.7 billion/year, or 1.6% of the region's Gross Domestic Product, on utilities and transportation costs. These costs lead to 60% of the community's greenhouse gas emissions. Money spent on electric, gas, and water utility bills, or paid at the gas pump, could spur the economic growth of the region. For example, the actions outlined in this plan for Energy Efficiency & Green Building alone would save residents and businesses an estimated $170 million/year by 2030 (or $20 million/year in net savings) – effectively cutting their utility and gas bills while at the same time investing in the creation of a more sustainable economy.

There are three major job-generating components in this plan: 1) demand related to annual household and business utility cost savings; 2) demand related to the construction of infrastructure; and 3) demand related to the plan's ongoing actions.

The energy savings is significant, but the economic case is even greater when considering the multiplier effect from households and businesses having more money to spend elsewhere. For households, additional money translates into greater expenditure on retail goods and services, as well as potentially greater rates of investment and saving, all of which generate demand for jobs in the existing economy. To put that into perspective, the GDP multiplier for household spending in Cleveland is 0.65, meaning that for every additional $1 a household spends, local GDP increases by $0.65. For businesses, annual cost savings mean lower operational costs and potentially greater profitability, which can support local workforce expansion, promote hiring, and potentially support increased employee earnings. All of this means that the ripple effects of household and business cost savings are regionalized; i.e. the benefits are felt throughout the local economy in terms of more jobs and greater earnings in all sectors.

Beyond the economic benefits of reinvesting energy cost savings, perhaps the most compelling economic case for the plan comes from the numbers and types of jobs the strategies in this plan will generate. Cross-referencing the strategies in this plan with the United Nations Environment Programme's (UNEP) Green Jobs Definition and Classification System[vii], the investment that would result from implementing this plan would go largely to wages in high-growth job sectors as well existing businesses throughout Cleveland's economy. Many employment sectors comprise the green job industry, such as green building and construction trades, manufacturing, including cleantech equipment manufacturers and their suppliers, energy, transportation, and civil engineers, and other professional/technical trades like environmental policy experts and planners, among others. In Cleveland, where manufacturing and professional/technical trades account for nearly 25% of the GDP, an investment such as this is really a reinvestment in the long-term stability of the City's existing economic infrastructure. For example, whereas the average GDP multiplier for the all manufacturing industries in Cleveland is approximately 0.83, the multipliers for industries likely to benefit most from the strategies of this plan range from 0.88 to 0.96, meaning that the reinvestment in local GDP is nearly one-for-one (GDP multipliers rarely exceed 1.00.). Similarly, the job multipliers for industries related to implementation of this plan are also above-average. For every additional $1 million spent in the Cleveland economy (any sector), demand for an average of 7.3 local jobs is generated, but for each $1 million spent in industries related to plan implementation, demand for an average of 9.2 local jobs is generated.

In Cleveland, where manufacturing and professional/technical trades account for nearly 25% of the GDP, an investment such as this is really a reinvestment in the long-term stability of the City's existing economic infrastructure.

NorTech, a regional nonprofit technology-based economic development organization serving 21 counties in Northeast Ohio, developed an Advanced Energy Cluster roadmap to identify high growth sectors within the advanced energy economy in Northeast Ohio. Since June 2010, NorTech's advanced energy cluster member companies have grown by 602 jobs. Member growth is an indication of growth in the entire advanced energy cluster in Northeast Ohio.

Nortech has predicted market opportunity and job growth impact for four clusters of the advanced energy economy: Waste and Biomass, Smart Grid, Fuel Cell, and Energy Efficiency. Many of the actions in this plan rely on sectors of those clusters, including thermal depolymerization, anaerobic digestion, smart meter software and communications, energy management systems, solid state lighting, non-fiberglass insulation, and building efficiency systems.

Advanced Energy Cluster	Market Opportunity	Potential Job Impact by 2020
Waste and Biomass	$7 Billion	1,820 Jobs
Smart Grid	$7 Billion	1,040 Jobs
Fuel Cell	$900 Million	1,650 Jobs
Energy Efficiency	$17.3 Billion	2,700 Jobs

Additional economic benefit could be achieved through employee growth across the hundreds of businesses and organizations already involved in Sustainable Cleveland 2019. Implementing this plan could also attract new sustainable companies to the region, while accelerating the commercialization of research from Cleveland's top institutions into new start-ups, especially in the clean energy and clean water sectors.

Many climate plans throughout the U.S. touch on these economic benefits in qualitative terms. Because of the quantitative tools used to analyze and design the recommended strategies within this plan, the economic perspective is a key component of this plan, helping to shape the pathway for reducing per capita emissions while growing a sustainable economy.

Allen Theater Renovations (*Photo: Tony Brown, The Plain Dealer*)

CARBON REDUCTION IN A STEEL TOWN

More than 35 percent of the City of Cleveland's greenhouse gas emissions come from industrial processes – primarily the production of steel for customers in the United States and around the globe. According to the American Iron and Steel Institute, the American steel industry, overall, has steadily reduced its environmental footprint and improved its energy intensity per ton of steel (a near 30 percent reduction) in the past several decades through investments in new technologies and innovation on the shopfloor. Still, steel production is, by its very nature, a carbon intensive process.

The City of Cleveland's goal is to reduce greenhouse gas emissions 16 percent by 2020, and this plan recognizes an equally important goal of increasing the efficiencies of industry. Our city's manufacturers, including our largest steel producer, have been important participants in our Climate Action planning process, creating a vision for a sustainable manufacturing town.

ArcelorMittal's Cleveland facility is the largest industrial manufacturer in Cleveland and is one of the largest integrated steelmaking facilities in the United States, employing more than 1,800 people and generating thousands more jobs linked to the steel industry. Located along the Cuyahoga River in downtown's Industrial Valley, ArcelorMittal Cleveland is recognized as one of the most productive integrated steel facilities in the world with one ton of steel produced for slightly more than one

Electric Arc Furnace (*Photo: ArcelorMittal)*

worker hour. The plant operates two blast furnaces that feed two steelmaking facilities, a hot mill, cold mill and hot dip galvanizing line, serving the automotive, appliance, service center, construction and converter markets.

ArcelorMittal is focused on the importance of industrial energy efficiency in today's global economy, taking advantage of declining natural gas prices and rising demand for renewable energy, fuel efficiency and energy efficiency. ArcelorMittal USA remains the first and only steel company to be named an Energy Star® partner for energy management. The company has received this award for six consecutive years, and the Cleveland facility has contributed significantly to this recognition.

ArcelorMittal's Cleveland plant has already made significant operational improvements that protect and preserve natural resources, reduce emissions and increase energy efficiency, including:

The steel industry in North America has been recycling steel scrap for more than 150 years. The steel industry needs scrap to produce new steel, which ensures that all steel products contain anywhere from 25 percent up to 100 percent recycled content.

- Since February 2010, ArcelorMittal Cleveland has captured additional energy from recycled blast furnace gas and produces up to 30 megawatts of electricity an hour, resulting in less electricity being taken from the power grid. This is enough to power 30,000 homes, or the equivalent of the electric power generated by 30 large wind turbines. ArcelorMittal Cleveland projects greater efficiency in the coming years with up to a 10 percent increase in internal power generation forecasted at the site.

- The facility also reduced natural gas consumption at two of its boilers, reducing CO2 emissions by approximately 3,600 tons per year – the same amount of CO2 generated by using 370,000 gallons of gasoline.

- Twenty locomotives in the ArcelorMittal Cleveland Works Railway fleet have been equipped with special hot start anti-idling technology, saving about 88,000 gallons of diesel fuel a year.

- ArcelorMittal Cleveland and its predecessor companies have invested more than $1 billion related to improving water treatment systems and assisting with the restoration of the Cuyahoga River for more than 40 years. The facility operates eight wastewater treatment plants that meet or exceed U.S. EPA's Best Available Technology (BAT) standards. The company partners with several organizations working to protect and restore the health and habitat of the Cuyahoga River and Lake Erie basin and, in 2009, was recognized by the Cuyahoga River Community Planning Organization for its stewardship of the river.

- On average, ArcelorMittal Cleveland recycles more than 600,000 tons of steel scrap each year.

- In 2012, an office recycling program was launched at the Cleveland administrative offices. Employees participated in recycling more than 100 tons of paper, glass, plastic and aluminum in the program's first year.

As a global company, ArcelorMittal has a global goal to reduce greenhouse gas emissions by eight percent. As the company strives for greater efficiency in its processes, ArcelorMittal is also innovating sustainable solutions in its products. As our nation's energy infrastructure evolves, demand for steel for wind, solar and other energy applications will likely increase. And through innovative collaborations with customers, ArcelorMittal is developing new steel products that are cost-effective, lightweight, high quality and environmentally-friendly.

Here in Cleveland, ArcelorMittal is fast becoming a leading producer of advanced high-strength steels uniquely designed to help automotive manufacturers meet aggressive new fuel-efficiency standards while not compromising vehicle safety. The eco-friendly cars of the future will be made with some of the lightest, strongest coated steels ever made, produced in Cleveland, Ohio.

THE ROLE OF CITIES

Cities are at the front lines of climate change, and Cleveland is no exception. Climate change is a global phenomenon and half of humanity now lives in cities. That number is expected to rise to 70 percent by 2050 (Population Reference Bureau). Cities are in a unique position to provide good quality of life with relatively low levels of greenhouse gas (GHG) emissions per person. An increasingly urbanized world has the potential to play a central role in reducing global emissions.

Cities also have a key role to play in adaptation: protecting people from floods, storms, heat waves, and other impacts of climate change. Hurricane Sandy is a prime example, along with the Chicago heat wave of 1995 that killed more than 750 people.

It is particularly important for cities to make decisions today that will decrease future emissions, while also anticipating and encouraging population and economic growth. Cities can do this by promoting density, public transportation ridership, walkability, bikability, waste disposal, efficient energy use, and an economy creating green products and services.

Therefore, cities have a responsibility to address climate change in a proactive manner. Cities must:

- Provide leadership on the urgency for action;
- Set an example by reducing carbon emissions from municipal operations;
- Create incentives and policies that encourage residents and businesses to reduce carbon emissions;
- Promote the development of beautiful buildings, streets, and neighborhoods that use less energy and natural resources; and
- Practice preparedness by adapting infrastructure, public health programs, and other essential services to meet the risks of a changing climate.

It is "good government" to be proactive. Cities that plan well in the face of change are likely to be more livable, resilient, innovative, and more competitive places in the long run.

SUSTAINABLE CLEVELAND 2019 TOGETHER, WE'RE BUILDING A THRIVING GREEN CITY ON A BLUE LAKE

Sustainable Cleveland 2019 is a 10-year initiative that engages the region to build economic, social and environmental well-being for all (www.SustainableCleveland.org). In autumn 2009, the City of Cleveland hosted the first Sustainable Cleveland 2019 Summit and announced an ambitious plan to transform Cleveland into a Green City on a Blue Lake in just ten years. Sustainable Cleveland is about taking actions now to prepare for a successful future. The regional economy can be strong and resilient, with investment opportunities in growth sectors, job creation, and smart use of natural resources and human capital. Cleveland has the natural resources, the people and the ideas to be successful in this transformation. Sustainable Cleveland has gained support and grown in scope, breadth and numbers since it launched in 2009. There are hundreds of businesses and organizations now engaged. Working groups and more than 200 volunteers have worked on a wide variety of initiatives.

Because of this work, the integration of sustainability and economic development is becoming a model of how to prepare for the future, and cities across the country are now beginning to adopt this approach. New businesses and non-profit organizations have emerged, new programs have been developed,

SUSTAINABLE CLEVELAND KEY MILESTONES

2005

Office of Sustainability Formed

2006

Mayor Jackson signs U.S. Mayor's Climate Protection Agreement

2008

Mayor Jackson signs UN Global Compact

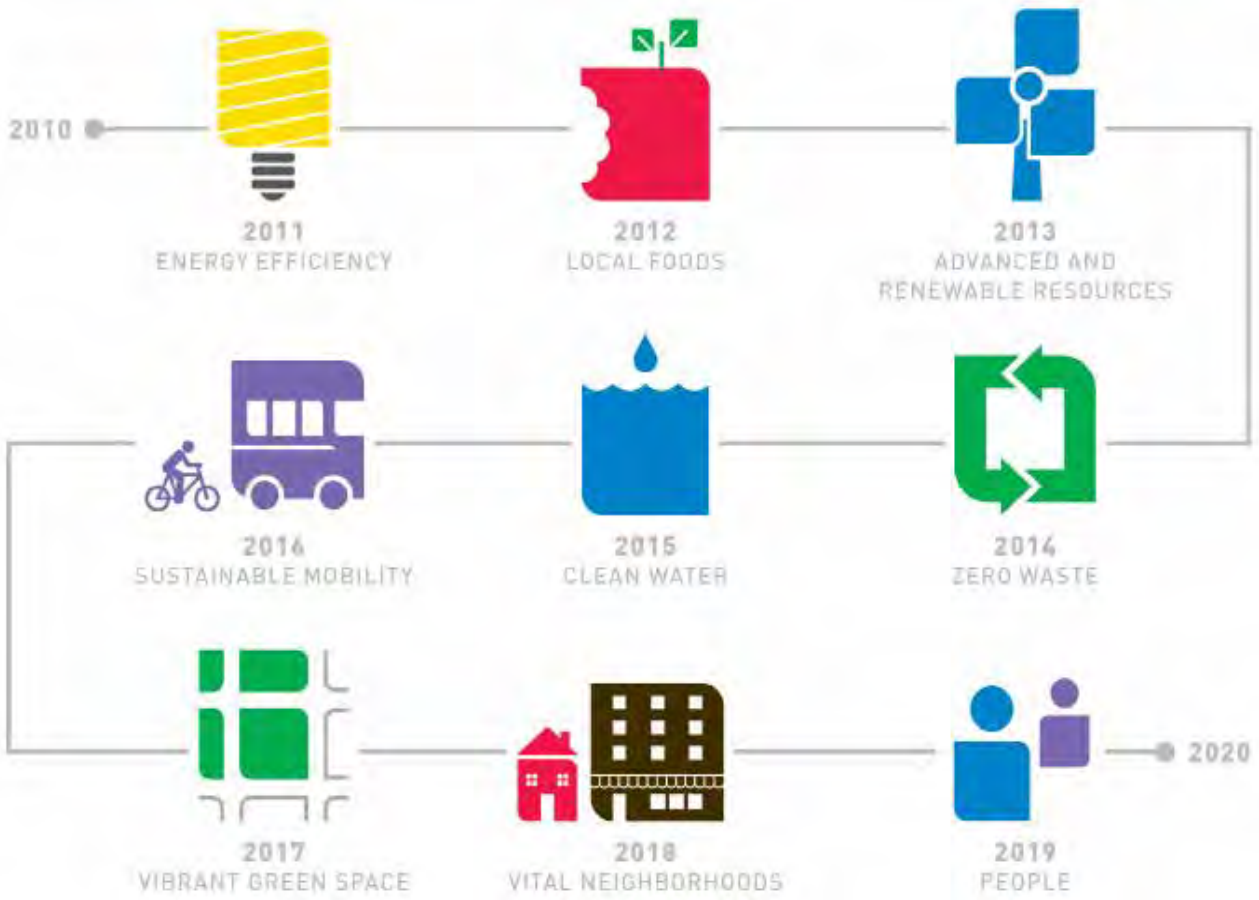
2009

1st Sustainable Cleveland Summit, Sustainability becomes part of Mayor's Office, Chief of Sustainability position created

and new jobs have been created by integrating sustainability into the way Cleveland operates. It is important that the broader community remain focused on this tremendous opportunity to position Cleveland for the future and that the City of Cleveland fully supports efforts to build a sustainable economy.

Every year leading up to 2019, Cleveland focuses on one of the key areas fundamental to a sustainable economy. The Sustainable Cleveland Celebration Years are designed to be accessible to all members of the community - households, neighborhoods, businesses, and institutions can all participate, either in collaboration or independently. One key purpose of the CAP is to integrate each sustainability topic (see Figure 4) into a comprehensive whole, highlighting how they are connected and dependent upon each other. By doing so the City not only developed community consensus regarding actions for each topic, but also found opportunity to celebrate successes to date. While some actions are new, most build upon policies, programs, and projects that community leaders have been working on for years.

Figure 5: Sustainable Cleveland Celebration Years



2010

Sustainable Cleveland 2019 Action and Resources Guide Developed, More than 20 Working Groups established

2011

Celebration Years Concept Announced, Celebration Year Logos shared with the community

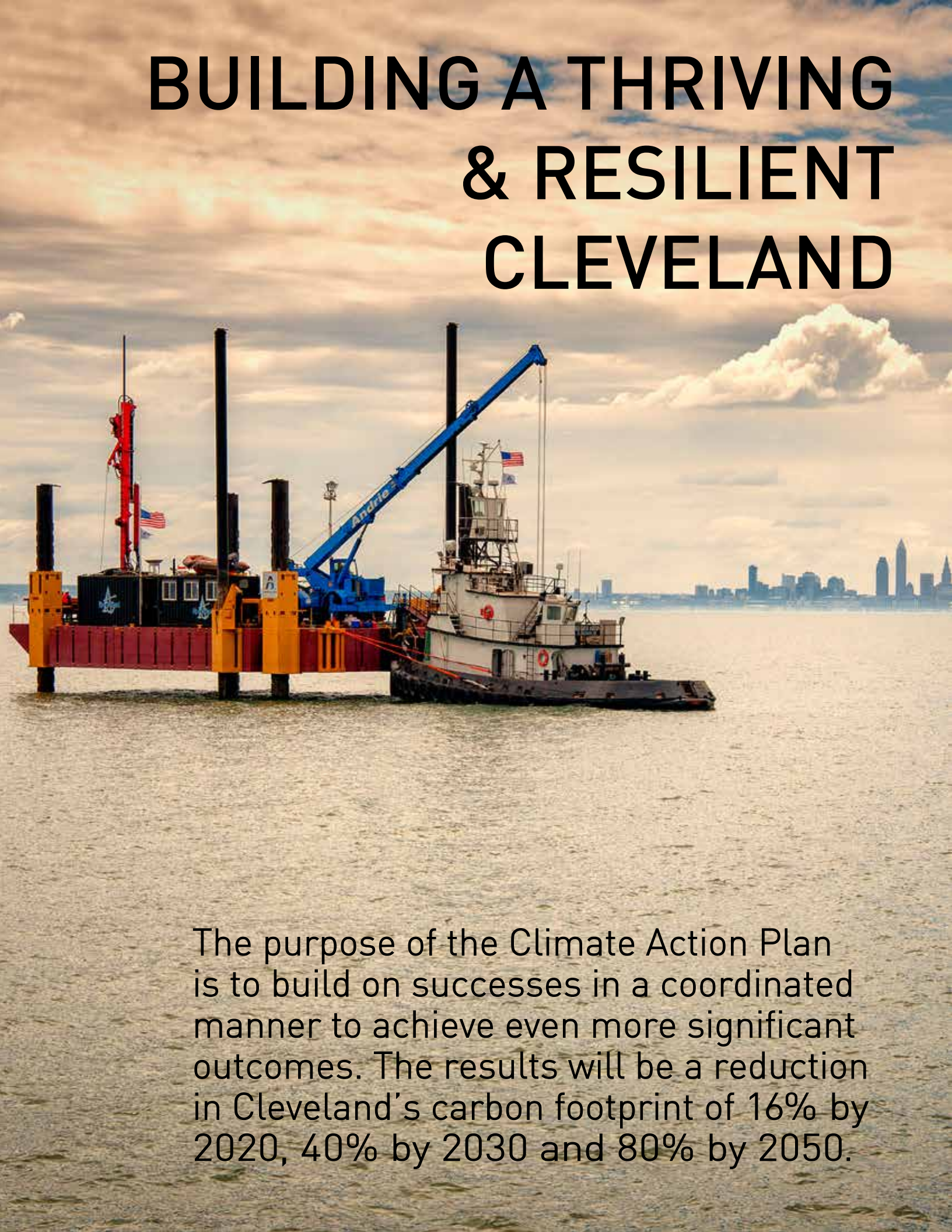
2012

Sustainable Cleveland Center Opens, SustainableCleveland.org and Indicator dashboard launched

2013

Municipal and Community Climate Action Plans, 5th Annual Sustainability Summit, Photo Contest and "I am Sustainable, Cleveland" campaign

BUILDING A THRIVING & RESILIENT CLEVELAND



The purpose of the Climate Action Plan is to build on successes in a coordinated manner to achieve even more significant outcomes. The results will be a reduction in Cleveland's carbon footprint of 16% by 2020, 40% by 2030 and 80% by 2050.

HOW THE PLAN WAS CREATED

In July 2012, the City of Cleveland utilized federal grant money to contract with a team of experts to create an action-oriented approach to sustainability and climate action planning. Working with a core group of stakeholders and building on the Sustainable Cleveland 2019 efforts to date, the team decided to create two separate, but interrelated plans:

1. A Sustainable Cleveland Municipal Action Plan (SC-MAP) for the City's internal operations; and

2. A community-wide Cleveland Climate Action Plan (CAP) for the City proper (this document)

Both action plans include near-term objectives and actions that largely build upon current initiatives and achievements.

SUSTAINABLE CLEVELAND MUNICIPAL ACTION PLAN

Development first began on the SC-MAP, a sustainability plan for Cleveland's municipal operations. Cities across the country, including the City of Cleveland, have embraced sustainability as a tool to enhance the viability of their organizations and communities, benefit from increased efficiencies and reduced operating costs, enhance social services, drive innovation, and preserve valuable environmental resources. The SC-MAP establishes an organizational philosophy toward sustainability through proven policy, goals, actions, and performance metrics. While it is primarily intended to lay out specific actions for City staff, the SC-MAP also provides context for the public to understand the City's approach to sustainability in its operations, and track the results.

The City is already practicing sustainability in many areas. The purpose of the SC-MAP is to accelerate progress in a more coordinated manner and help the City achieve even more significant outcomes. Key to this process was development of a City Green Team in May 2012, consisting of representatives from across City government serving to integrate sustainability into City operations.

The overall goal is to reduce GHG emissions from Cleveland's municipal operations below 2010 levels 10% by 2016, 20% by 2020, and 45% by 2030. The SC-MAP, also completed in 2013, includes 25 actions and targeted goals, broken into the following focus areas:

- Design, Construction and Maintenance
- Energy
- Transportation
- Water
- Materials Management and Procurement

For more information on the Sustainable Cleveland Municipal Action Plan, visit the City of Cleveland's website at **www.city.cleveland.oh.us/sustainability**.

COMMUNITY-WIDE CLEVELAND CLIMATE ACTION PLAN

In October 2012, the Office of Sustainability convened a 50-member Climate Action Advisory Committee (CAAC) with representatives of leading Cleveland organizations from the commercial, industrial, educational, government, and non-profit sectors to inform and create the Climate Action Plan. The project team convened meetings and workshops with CAAC committee members and other key stakeholders to develop and vet the objectives, actions, and goals of the Plan and discuss GHG Inventory findings. The project team also:

- Conducted surveys of Cleveland residents, CAAC members, and other key stakeholders to obtain input on the Plan;

- Held a Public Outreach Meeting to present information about the Plan and obtain feedback, followed by a one-month public comment period; and

- Obtained GHG Inventory data from local utilities, the City of Cleveland, Cleveland-Cuyahoga County Port Authority, Cuyahoga County, the Northeast Ohio Area Coordinating Agency (NOACA), the Northeast Ohio Regional Sewer District (NEORSD), the U.S. and Ohio Environmental Protection Agency offices, and other sources.

CLEVELAND'S CARBON FOOTPRINT

One of the first steps in developing the Cleveland CAP was to create a baseline GHG inventory (or carbon footprint) to understand the sources of emissions. This involved the definition of a physical boundary for the inventory as well as identifying emissions sources to include based on data availability and climate impact.

Cleveland's city limits were selected as the boundary for the Cleveland community GHG inventory. To varying degrees, all activities that occur within this boundary can be influenced by the City via policies, incentive programs, and educational campaigns (Figure 6, Next Page). The inventory, therefore, seeks to quantify the GHG emissions of all activities within this boundary area.

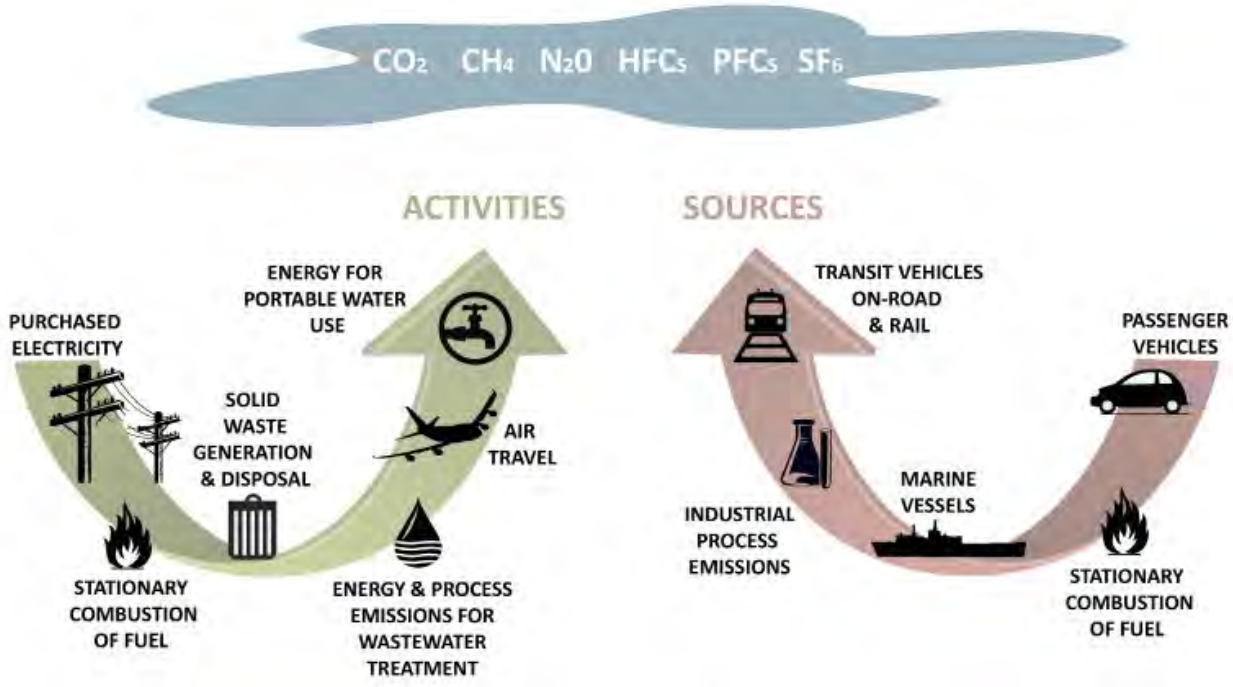
There are two general categories of emissions for the City's inventory:

- **Sources:** Any physical processes inside the jurisdictional boundary of the City that release GHG emissions into the atmosphere.
- **Activities:** The use of energy, materials, and/or services by the community that result in the creation of GHG emissions, directly or indirectly.

The GHG inventory revealed that in 2010 emissions in the City totaled almost 13 million metric tons of carbon dioxide equivalent ($MTCO_2e$). Electricity and natural gas consumption in buildings contribute over 50% of total emissions followed by industrial emissions (36%), such as burning fuels on-site for manufacturing.

Figure 6: City of Cleveland Limits *(Source: Teaching Cleveland[v])*

Figure 7: GHG Inventory Categories [vi]



The total annual emissions of almost 13 $MTCO_2e$ is equivalent to the entire population of Cleveland commuting from Cincinnati every day for the year. Conversely, covering an area the size of Lake Erie and Lake Ontario with trees would absorb this same amount of CO_2e. Figures 8 and 9 present the breakout of total emissions by sector and source, respectively. In Figure 8, note that Industrial Facilities (25%) includes electricity and natural gas consumption related emissions for the industrial sector, while Industrial Emissions (36%) includes specific industrial process emissions and large emitters' stationary combustion sources as reported to the EPA.

Figure 8: GHG Emissions by Sector

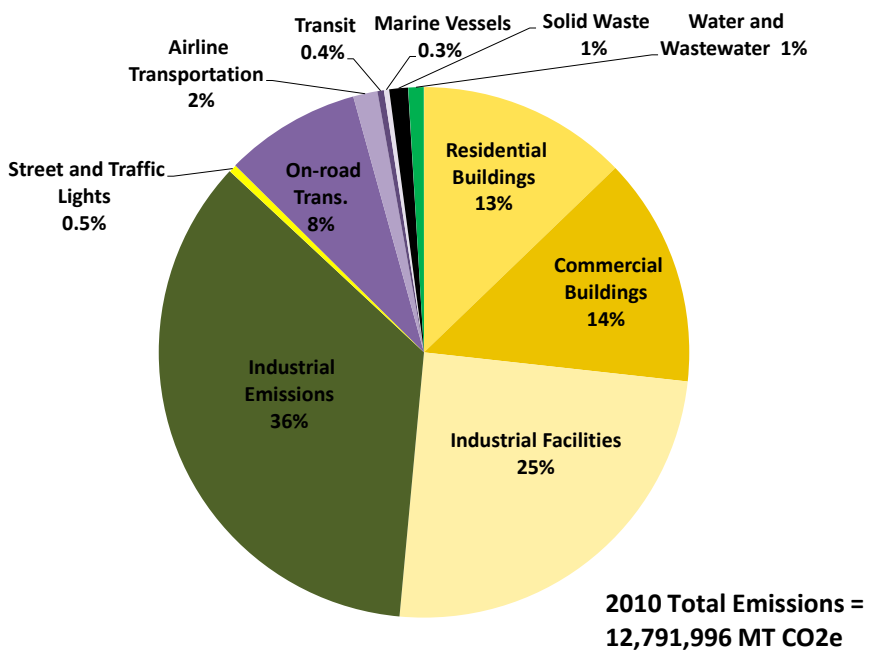
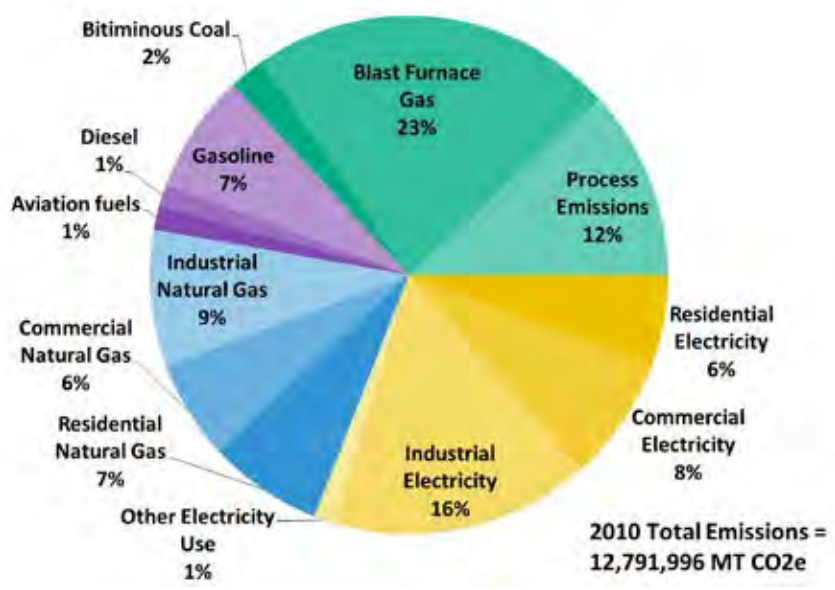


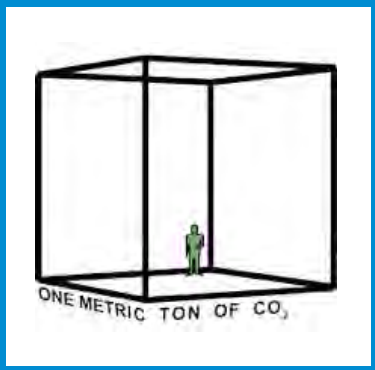
Figure 9: GHG Emissions by Fuel Source



WHAT IS A $MTCO_2e$?

There are six main greenhouse gases that contribute to climate change, and each one has a different level of impact. For example, the emission of 1 ton of methane (CH_4) has a global warming potential (GWP) 21 times larger than that of the emission of 1 ton of carbon dioxide (CO_2). To avoid confusion between emissions of the different types of gases, all emissions are converted to the common unit of **CO_2e**, or **carbon dioxide equivalent.**

If a cube was built to represent one metric ton of CO_2, it would measure 27 feet across by 27 feet deep by 27 feet high. One metric ton equals 2,204 pounds.



Some equivalencies for 1 metric ton of carbon dioxide equivalent (CO_2e) include:

- Driving 2,000 miles in a car that averages 23 miles per gallon (e.g., 4 round trips between Cleveland and Cincinnati, 250 miles each way).
- Flying 3,700 miles by commercial airline (e.g., one round-trip from Cleveland to Las Vegas).

By comparison, the seven-county Northeast Ohio region generated 64 million MTCO2e in 2005 as determined in a baseline inventory conducted by the GreenCityBlueLake Institute. As in the City, buildings contributed the largest share of emissions in the region. However gasoline and diesel used for transportation played a larger role, likely the result of differences in land uses that cause more driving in suburban areas. If industrial process emissions are removed from the Cleveland inventory (because this emission source was not included in the regional inventory), Cleveland contributes around 13% to the region's total emissions.

FUTURE PROJECTIONS

After the baseline GHG emissions inventory was prepared, a business-as-usual (BAU) forecast was calculated to estimate what emissions would likely be in the future if no action were taken. There are a number of different factors that can impact future emissions in the City of Cleveland. Population and economic growth tend to be two of the more significant drivers of BAU emissions projections. Other factors such as projected development patterns in the city and whether those patterns tend towards infill development or a more sprawling development pattern can impact activities such as driving habits, and therefore impact future GHG emissions.

Due to the high level of uncertainty associated with this type of forecasting exercise, a flat line BAU forecast was assumed for now. However, this assumption of no growth or decline in emissions can be adjusted in the future to account for changing conditions.

THE PLAN'S FRAMEWORK

The Cleveland Climate Action Plan (CAP) framework consists of Focus Areas, Objectives, Goals, Actions, and Next Steps. Each of these components is described below.

Focus Areas: Focus Areas are used to organize the CAP actions into themes in a consistent manner. Specifically, these Focus Areas include:

Energy Efficiency and Green Building

Advanced & Renewable Energy

Sustainable Mobility

Waste Reduction & Resource Conservation

Sustainable Land Use & Clean Water

Community Engagement & Public Health

Objectives: The objectives summarize what the Cleveland community plans to achieve, and are used as a means to organize the various Actions.

Goals: The Goals embody the desired outcomes that the Cleveland community intends to achieve for each Focus Area. Where applicable, Goals include numeric targets and time frames for achieving these targets. In other instances, goals are more qualitative but still articulate a desired future end state.

Actions: Actions consist of specific strategies that will be implemented to meet the Goals. It is at this level where potential costs and benefits, both in financial and resource efficiency terms, are quantified to help scale and prioritize possible actions. For any given Goal there are generally several supporting Actions. It is indicated which sectors (Home, Work, Community) are served by each Action.

Next Steps: Specific task to complete by 2016 in order to achieve significant progress on each Action

MITIGATION VS. ADAPTATION

Mitigation: Reducing GHG emissions and lessening impacts from additional warming of the atmosphere.

Adaptation: Preparing for the impacts of an already-changing climate.

While Cleveland must take steps to reduce GHG emissions and lessen impacts from additional warming of the atmosphere ***(Mitigation)***, it can also prepare for the impacts of an already-changing climate ***(Adaptation)***. These adjustments can be protective (i.e., guarding against negative impacts of climate change), or opportunistic (i.e., taking advantage of any beneficial effects of climate change). In some cases, adaptation and mitigation strategies are closely related and intertwined (see Figure 10). For example, planting trees and green roofs reduce emissions by taking carbon out of the atmosphere, but they also help protect people on extreme heat days by cooling the air, thereby reducing the urban heat island effect.

Many governments and communities across the U.S. and around the world have already begun plans to adapt to a changed climate. They recognize that this will be a permanent part of planning resilient communities. Many GHGs remain in the atmosphere for 100 years or more, so those already emitted into the atmosphere will continue to warm the Earth for a long time even if new emissions were stopped today.

Cleveland can start adapting now to the changes that are already being experienced in Northeast Ohio. This includes measures to protect vulnerable populations, such as the sick and elderly, anticipating needed changes in infrastructure (e.g., stormwater capture),

and constructing buildings to be more efficient – particularly during hotter summers when more energy will be needed for cooling. Examples of adaptation-related actions are provided in the Community Engagement & Public Health focus area.

GOALS AND ACTIONS

The Cleveland Climate Action Plan (CAP) contains an overarching GHG reduction goal of 80% reduction below baseline emissions by 2050, with interim goals of 16% reduction by 2020 and 40% reduction by 2030. These goals are comparable to the City's targets for municipal operations as outlined in the SC-MAP. Goals will be achieved through the implementation of the **33 actions** outlined in the plan. These actions are split into **6 focus areas** all with the aim of reducing Cleveland's climate impact and preparing the City for the changing climate of the future. Goals are designed to be bold yet achievable.

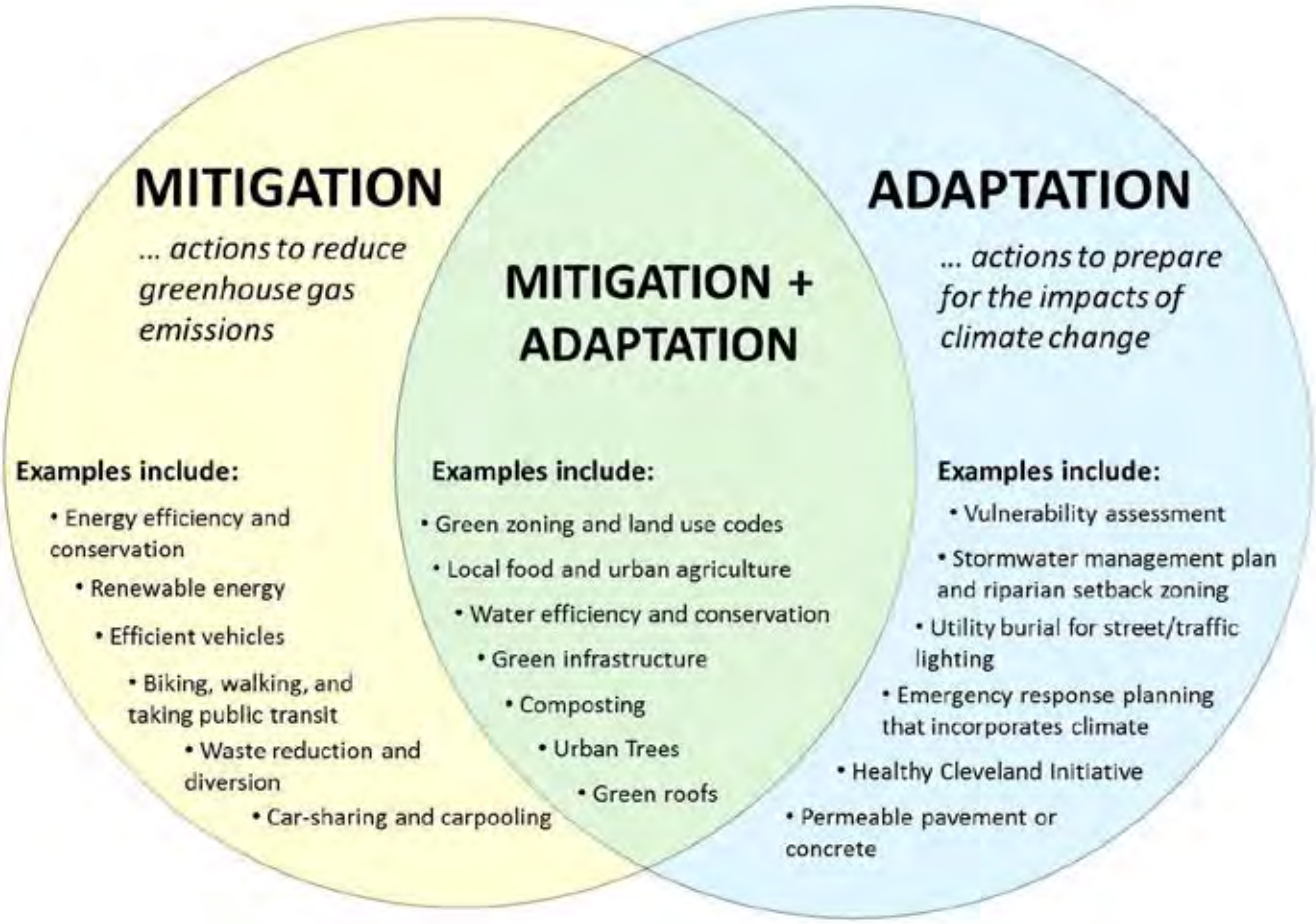
Figure 11 illustrates the contribution of each focus area to meeting the GHG reduction goal. For example, actions in the Energy Efficiency & Green Building focus area contribute 14% of the 40% reduction in GHGs by 2030 we are seeking. Table 1 provides a brief summary of all the actions included in the Climate Action Plan, organized by focus area and including:

- **Sectors**: Indicates the involvement level(s) for each action; At Home, At Work, or In Your Community
- **Climate Change Impact**: Indicates how each action addresses climate change; reduces GHG emissions (mitigation) or preparing for the impacts of an already changing climate (adaptation)
- **2030 Reduction Potential**: The annual GHG reduction by the end of the planning horizon, 2030

In addition to goals based on overall reduction, this Climate Action Plan recognizes the benefit of tracking our city's carbon intensity. For the purposes of this plan, carbon intensity is the amount of CO2e per person and per gross domestic product (GDP). Because decreasing sprawl and increasing urban density is key to improving efficiency and sustainability on a regional and global scale, understanding the effect of increased population and economic growth on total carbon emissions is important. As we increase efficiency and improve community behaviors, we expect the carbon intensity of our businesses and population to improve even if our overall carbon footprint decreases less rapidly due to job and population growth.

More detail on each action provided in the following sections.

Figure 10: Mitigation-Adaptation Connection



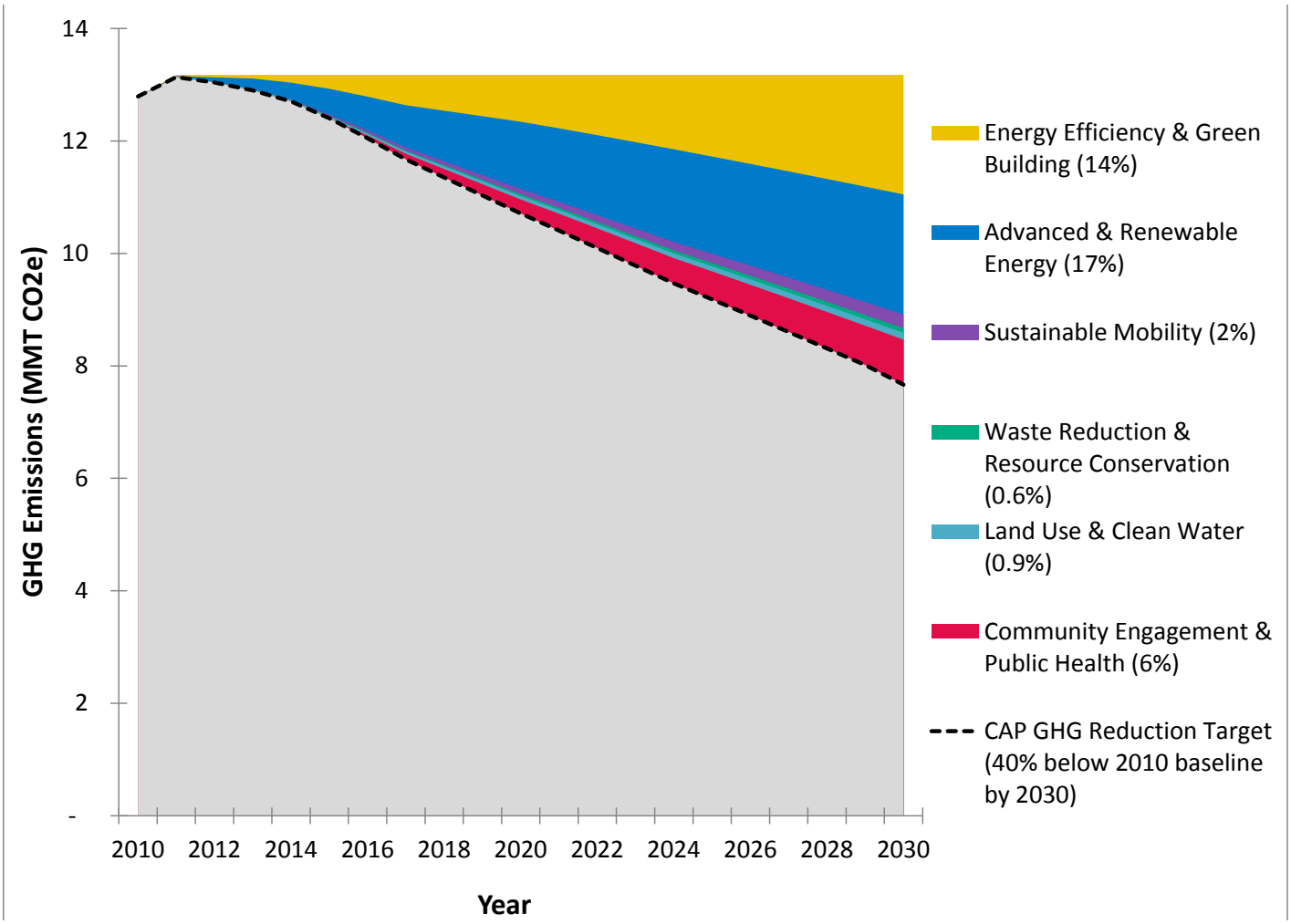
SETTING PRIORITIES

The following factors were considered when identifying the 33 actions contained in this plan:

- Cost-effectiveness
- Quality of life and environmental benefits
- Feasibility (technical, cultural, political, legal)
- Stakeholder support
- Tie to local priorities and current initiatives
- Potential for spurring innovation

Reducing Cleveland's GHG emissions by 40% is equivalent to the energy used by **410,000 homes.**

Figure 11: Reduction Wedge Diagram




WIND POWER FOR Indiana
BY CLEVELAND STATE UNIVERSITY

Table 1: Cleveland's Climate Action Plan at a Glance

Focus Area	Objective	Sectors	Climate Change Impact	Action	Annual Reduction Potential by 2030 (MT CO_2e/yr)
ENERGY EFFICIENCY & GREEN BUILDING Annual Emissions Reduction by 2030 = 2,100,000 MT CO2e (39% of total GHG reduction)	**Retrofit and renovate existing buildings**		M A	Action 1. Support programs and policies to retrofit residential buildings	430,000 8%
			M	Action 2. Support programs and policies to retrofit commercial and industrial buildings	1,300,000 24%
	Make green building the standard for all new construction		M A	Action 3. Incentivize new construction to exceed existing building codes	1,500 0.03%
	Implement neighborhood-level solutions		M	Action 4. Make utility data easily accessible for residents and businesses	n/a
			M	Action 5. Expand use of smart grid and advanced meter technologies	120,000 2%
			M	Action 6. Expand energy and green building challenges	290,000 5%
			M A	Action 7. Build on existing green school initiatives in the City	n/a
ADVANCED & RENEWABLE ENERGY Annual Emissions Reduction by 2030 = 2,100,000 MT CO2e (38% of total GHG reduction)	**Accelerate renewable energy use by Cleveland's residents and small businesses**		M A	Action 8. Increase distributed energy installations	35,000 0.6%
			M	Action 9. Incorporate renewable energy into municipal aggregation	340,000 6%
	Use local projects to help meet or exceed the utility renewable energy standards		M	Action 10. Become national leader in reusing vacant land for renewable energy projects	23,000 0.4%
			M	Action 11. Develop a pilot offshore wind farm	67,000 1%
			M	Action 12. Utilities invest in additional projects to meet renewable energy standards	1,100,000 20%
	Implement advanced energy technologies		M	Action 13. Accelerate conversion of organic waste to energy using anaerobic digestion	52,000 1%
			M	Action 14. Switch to low-carbon fuel sources for district heating and cooling systems	120,000 2%
			M	Action 15. Support Cleveland businesses to reduce industrial process emissions	390,000 7%
SUSTAINABLE MOBILITY Annual Emissions Reduction by 2030 = 250,000 MT CO2e (5% of total GHG reduction)	**Reduce congestion and vehicle emissions**		M	Action 16. Develop and promote policies and programs that encourage more efficient vehicles	150,000 3%
			M	Action 17. Encourage anti-idling citywide	8,500 0.2%
			M	Action 18. Expand use of carpooling and car sharing	8,700 0.2%
			M	Action 19. Increase the use of public transit through incentives and system improvements	84,000 2%
	Create Complete and Green Streets		M	Action 20. Make biking and walking easier and safer	2,600 0.05%
			M A	Action 21. Develop a streamlined process to implement complete and green streets policy	n/a

Focus Area	Objective	Sectors	Climate Change Impact	Action	Annual Reduction Potential by 2030 (MT CO_2e/yr)
WASTE REDUCTION & RESOURCE CONSERVATION Annual Emissions Reduction by 2030 = 77,000 MT CO2e (1% of total GHG reduction)	**Significantly reduce the amount of waste sent to landfills**	At Home, At Work, In The Community	M	Action 22. Implement programs and policies to encourage waste reduction and diversion by residents and businesses	56,000 1.0%
		In The Community	M	Action 23. Develop a cost-effective approach to deconstructing and recycling demolished buildings	n/a
		In The Community	M	Action 24. Develop and implement a sustainable integrated waste and energy plan for the City of Cleveland	21,000 0.4%
LAND USE & CLEAN WATER Annual Emissions Reduction by 2030 = 120,000 MT CO2e (2% of total GHG reduction)	**Encourage vibrant downtown and neighborhoods**	In The Community	M A	Action 25. Green the zoning and land use codes to encourage sustainable development	1,500 0.03%
		In The Community	M A	Action 26. Prioritize sustainability and rightsizing in City infrastructure upgrades and improvements	n/a
	Restore and regenerate the natural environment	In The Community	M A	Action 27. Develop and implement an urban tree plan to grow the canopy	110,000 2%
		At Home, At Work, In The Community	M A	Action 28. Scale up the local food system	n/a
		At Home, At Work, In The Community	M A	Action 29. Implement green infrastructure to capture stormwater on-site	1,900 0.03%
		At Home, At Work, In The Community	M A	Action 30. Increase water conservation and efficiency	9,300 0.2%
COMMUNITY ENGAGEMENT & PUBLIC HEALTH Annual Emissions Reduction by 2030 = 800,000 MT CO2e (15% of total GHG reduction)	**Organizations, neighborhoods, and individuals become climate leaders**	At Work, In The Community	M	Action 31. Promote leading local businesses striving to meet energy and carbon reduction goals	800,000 15%
		At Home, At Work, In The Community	M A	Action 32. Recognize capacity of neighborhood and community groups to implement climate mitigation and adaptation initiatives	n/a
	Improve public health and resiliency to climate change impacts	At Home, At Work, In The Community	A	Action 33. Conduct climate change vulnerability assessment and integrate projected impacts into existing plans	n/a
				Total Estimated Annual Reduction by 2030 (MT CO2e/yr) =	**5,500,000**

KEY

(XX%)	Percent contribution of each action (and total of all actions) to meeting overall GHG reduction goal of 40% reduction below 2010 baseline by 2030
TBD	Analysis/results that will be included in the final CAP but is not yet available
n/a	Actions for which GHG reductions and costs are not be quantified as part of the CAP

Sectors: At Home, At Work, In The Community

Climate Change Impact: M Mitigation, A Adaptation

ENERGY EFFICIENCY & GREEN BUILDING

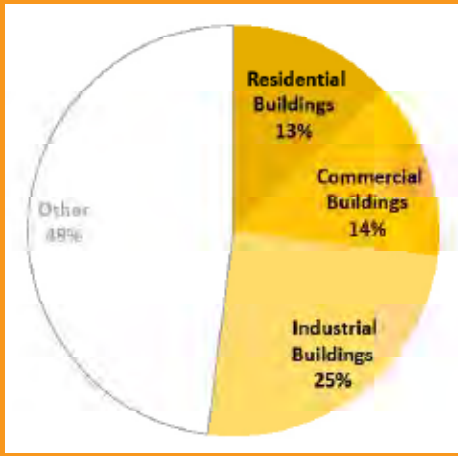
FOCUS AREA 1

GOALS:

- By 2030, reduce residential and commercial energy and water use 50%, and industrial use by 30%
- Reduce Annual Cleveland GHG Emissions 2.1 million $MTCO_2e$ by 2030
- By 2030, $170 million saved annually by Cleveland households and businesses due to reduced energy use

KEY FACTS:

Energy use in buildings makes up more than **50% of Cleveland's total GHG emissions.**



The energy use intensity of Cleveland's housing stock is **54% higher than National averages** (58% higher than average Midwest stock), while commercial buildings in Cleveland use **36% more energy** than U.S. averages (22% higher than Midwest averages). This is partially due to an older building stock in Cleveland.

THE IMPORTANCE OF ENERGY EFFICIENCY & GREEN BUILDING

Ohioans spend roughly $4,700 per person and 11.5% of our gross state product on energy, according to the Energy Information Administration. These costs strain the budgets of residents, businesses, and government. In addition, Ohio ranks sixth nationally for the total amount of energy we use, and third nationally for the amount of pollution we emit when generating electricity.

Energy efficiency and conservation are often the most cost-effective approaches for reducing emissions and energy costs in buildings. Energy consumed by residential, commercial, and industrial buildings located in the City of Cleveland contributed to more than 50% of the City's greenhouse gas (GHG) emissions in 2010. Existing residential buildings represent 13% of Cleveland's total emissions while commercial and industrial buildings make up another 39% of Cleveland's total emissions.

Significantly reducing energy use in existing buildings through efficiency projects and conservation is a critical mitigation strategy. Efficient housing has lower utility and maintenance costs, reducing energy poverty for low-income residents. Encouraging building design that considers future climate impacts, such as innovative cooling and stormwater management, is an important adaptation strategy.

Energy demand curtailment offers additional cost savings opportunities for building owners. Demand Response is a consumer's ability to reduce electricity consumption at their location when wholesale prices are high or the reliability of the electric grid is threatened. Common examples of demand response include: raising the thermostat temperature so the air conditioner runs less frequently, occasionally slowing down manufacturing production, or shutting off lights - basically any action to reduce load in response to short-term high prices or a signal from the utility grid operator.

PJM Interconnection is a regional transmission organization that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia, including Ohio. PJM's wholesale electricity markets provide opportunities for end-use customers to realize value for reducing their demand for electricity. In PJM's Energy Market, end-use customers participate in demand response by reducing their electricity use either during an emergency event or when marginal prices are high on the PJM system.

FOCUS AREA 1

ENERGY EFFICIENCY & GREEN BUILDING

OBJECTIVE: RETROFIT AND RENOVATE EXISTING BUILDINGS

Since building energy use makes up more than 50% of the total GHG emissions for the City, making the existing building stock as efficient as possible is a top priority for the CAP.

ACTION 1: SUPPORT PROGRAMS AND POLICIES TO RETROFIT RESIDENTIAL BUILDINGS

2030 Emissions Reduction Potential: **430,000 $MTCO_2e$ = 32,000 Cleveland homes.**

There are great opportunities to significantly improve the energy efficiency of existing homes through improved insulation and air sealing, more efficient heating and cooling equipment, and efficient appliances and electronics. Efficient buildings reduce strain on power distribution systems, are more resilient to increasing utility costs, and are less affected by extreme weather events.

KEY BENEFITS OF ENERGY EFFICIENCY & GREEN BUILDING

- Cost savings
- Less risk from energy price volatility
- Increased property values & rental rates
- Reduction in energy poverty
- Healthier, more comfortable homes
- Local job creation and economic development
- Leadership and recognition
- Education and awareness

CLEVELAND ALREADY HAS SEVERAL EXISTING PROGRAMS TO BUILD ON, INCLUDING:

- Home Weatherization Assistance Program
- Warm & Healthy Homes
- House Warming and Good Cents (Dominion)
- Cleveland Energy$aver Program
- Efficiency Smart Program offered by Cleveland Public Power
- FirstEnergy programs (e.g., appliance turn-in, lighting and HVAC incentives, traffic signal)

ACTION 2: SUPPORT PROGRAMS AND POLICIES TO RETROFIT COMMERCIAL AND INDUSTRIAL BUILDINGS

2030 Emissions Reduction Potential: **1,300,000 $MTCO_2e$ = 97,000 Cleveland homes.**

The energy efficiency of existing commercial and industrial buildings can be improved through insulation, building envelope, and lighting upgrades, more efficient heating and cooling equipment, efficient motors and drives, and efficient processes and equipment. Efficient buildings cost less to operate, adding directly to bottom-line profits and the strength of local businesses.

Figure 12: *Architecture 2030 Challenge* - Existing Buildings

Figure 13: *Architecture 2030 Challenge* - New Buildings & Major Renov.

Stakeholders can build on existing programs and explore others, such as:

- On-bill financing option for businesses
- Lease and PACE financing
- Re-commissioning/tune-up program; audit requirements/services
- Energy benchmarking and disclosure
- Green Leasing

These programs can be expanded, and others, such as point-of-sale retrofit requirements and energy efficient mortgages, would support residents and businesses in improving their properties with the goal of achieving a 50% reduction in energy use in 50% of existing homes and businesses by 2030. As an added benefit, businesses with more efficient buildings will be affected less by changes in economic and climatic conditions. According to a 2008 CoStar study, LEED buildings command rent premiums of $11.33 per square foot higher than conventional buildings and boast 4.1 percent higher occupancy rates.

Many existing initiatives, programs, and leading organizations already focus on commercial and industrial energy efficiency. One example is the Cleveland 2030 District, which is working with property owners/managers, developers and other stakeholders to create high-performance, sustainable building districts throughout Greater Cleveland. Performance targets shown in Figures 12 and 13 are based on the targets of the Architecture 2030 Challenge for Planning, a national effort to improve buildings and meet climate goals. The Cleveland 2030 District downtown footprint includes approximately 75 million square feet of building space and 1,000 structures.

OBJECTIVE: MAKE GREEN BUILDING THE STANDARD FOR ALL NEW CONSTRUCTION

When considering development within Cleveland, it is important to minimize the impact of new construction through the establishment of policies and incentives that encourage energy efficiency and green building.

ACTION 3: INCENTIVIZE NEW CONSTRUCTION TO EXCEED EXISTING BUILDING CODES

2030 Emissions Reduction Potential: **1,500 $MTCO_2e$ = 110 Cleveland homes.**

FOCUS AREA 1

ENERGY EFFICIENCY & GREEN BUILDING

In addition to complying with state building codes to ensure that all new construction is meeting a specified energy efficiency standard, the City can also implement incentive programs to encourage green building. The Cleveland Green Building Standard is already required not just of residential projects receiving property tax abatement, but also for all residential development projects receiving direct assistance from the City. This policy has resulted in hundreds of homes meeting the Enterprise Green Communities standard or receiving Leadership in Energy and Environmental Design (LEED) third party certification.

Additional incentives could extend to the commercial sector, such as expedited permitting, updating the requirement for green building at a specified percent efficiency over code as a prerequisite for public financing, and public recognition and promotion.

OBJECTIVE: IMPLEMENT NEIGHBORHOOD-LEVEL SOLUTIONS

Rather than just looking at opportunities on a building-by-building basis, it is also important to consider enabling programs and systems that can be implemented neighborhood-wide or community-wide.

ACTION 4: MAKE UTILITY DATA EASILY ACCESSIBLE FOR RESIDENTS AND BUSINESSES

There is a familiar phrase that you can't manage what you don't measure. Utility data is measured by a utility company, but it is not often accessible in a form that owners, staff, and occupants can easily use to manage their energy use. The Green Button program is a national initiative encouraging utilities to provide easy access to utility data in a standard format that is both consumer- and computer-friendly. Energy and cost savings can then be achieved with timely information on a building's performance and behavior. This action calls for utilities, in collaboration with regional and national stakeholders, to make data transparency a priority.

ACTION 5: EXPAND USE OF SMART GRID AND ADVANCED METER TECHNOLOGIES

2030 Emissions Reduction Potential: **120,000 $MTCO_2e$ = 9,000 Cleveland homes.**

Advanced metering infrastructure (AMI) gives consumers and utilities access to real-time electricity usage information that can be used to reduce costs and improve power reliability by managing supply and demand more effectively. AMI also supports the Green Button Initiative (Action 4) and behavior changes by providing better access to utility data. A pilot can be used to demonstrate the capabilities and potential of the smart grid to reduce peak demand, save energy, reduce costs, and increase grid reliability.

In 2012, Cleveland Public Power launched a pilot project which involved the installation of 160 AMI's in areas prone to unauthorized use. These meters allow CPP to respond to customer requests within 3-5 minutes. Furthermore, the cost of the meters pay for themselves in a single service call. First Energy has installed 5,000 smart meters in the Cleveland Electric Illumuniating service area, and plans on expanding to 37,000 more customers.

ACTION 6: EXPAND ENERGY AND GREEN BUILDING CHALLENGES

2030 Emissions Reduction Potential: **290,000 $MTCO_2e$ = 22,000 Cleveland homes.**

Building occupants have measureable control over the resources their homes or workplaces use. Building challenges are a call to action to reduce energy consumption in buildings, both commercial and residential, through the combined effects of these individual occupants and operators. Challenges start with educating and engaging occupants about how they use energy and suggesting low to no-cost ways to reduce that use, such as turning off computers and lights, unplugging non-essential equipment, or adjusting thermostats by a degree or two. For residential occupants or even targeted neighborhoods, simply comparing energy consumption with other

residents or neighborhoods on a scale of high to low performance can motivate changes in habit. For commercial buildings, organized efforts over set periods of time with guided activities, such as shut-down days, cold lunch days, 1-degree days (temperature adjustments), etc., can serve as catalysts for competition and long-term behavior change. Challenge participants gain public recognition for their performance and access to best practices through peer-to-peer exchanges. The Northeast Ohio Chapter of the U.S. Green Building Council has already organized successful challenges in downtown, midtown, University Circle neighborhood, and in Independence. Multiple Northeast Ohio organizations have also participated in EPA's National Building competition. These existing challenges provide a foundation for new locations and expanding into sustainability topics such as waste reduction and transportation.

ACTION 7: BUILD ON EXISTING GREEN SCHOOL INITIATIVES

M A

Ohio is a leader in green and LEED-certified schools. The State's Ohio School Facilities Commission (OSFC) has an Energy Conservation Program to support facility improvements and a Green Schools initiative that requires LEED Silver Certification for new schools. The Ohio Department of Education also participates in the Green Ribbon Schools program to recognize achievements in sustainability, energy efficiency, and healthy environments. Schools that follow green school practices tend to cost less money to operate, have a healthier learning environment, and higher performing students and staff.

PNC Smart Home

FOCUS AREA 1

ENERGY EFFICIENCY & GREEN BUILDING

ENERGY EFFICIENCY & GREEN BUILDING NEXT STEPS TO BE COMPLETED BY 2016:

1. Pursue efficient one-touch approach to low-income housing programs by layering healthy homes, lead, and weatherization programs. At the same time, research options for incentivizing low-income residents who do not pay utility bills to practice conservation.(1)
2. Build on the success of deep energy retrofit demonstrations by incorporating deep energy reduction principles in local rehabs and new construction, and continue to foster demonstrations that advance and disseminate advanced knowledge of energy efficiency. (1)
3. Expand on existing programs that have provided energy efficiency education and incentives through local community development organizations, including programs that provide home visits on low cost interventions such as weather-stripping and caulking. (1)
4. Promote education on identifying opportunity points for energy efficiency improvements throughout the life-cycle of the home, for example, when replacing a roof, doing foundation work, or replacing windows. (1)
5. Explore strategies to establish a permanent revolving fund for commercial and residential energy efficiency programs such as the Energy$aver program. (1)
6. Encourage all local utilities to make available the Home Performance with ENERGY STAR® Program to its customers. This program uses a whole-house approach to make any size or style of home more energy efficient, thus lowering energy costs. (1)
7. Review residential and commercial programs to determine which ones have the greatest impact. (1, 2)
8. Engage individuals and organizations involved professionally in energy efficiency in an organizational network that can collaborate in advocating for private, state, and federal funding for energy efficiency and for progressive energy efficiency policies. (1-7)
9. Complete pilot on-bill financing / repayment for commercial customers. If successful, create a program for other potential customers to utilize. (2)
10. Thoroughly explore the possibility of an energy benchmarking and disclosure policy in the City of Cleveland, in tandem with other policies to accelerate improved efficiency. (2)
11. Support the industrial sector's transition to less energy and water intensive practices through the development of collaborative programs, incentives, training, and data collection. (2)
12. Explore strategies for expanding use of green roofs and other sustainable roof technologies, building on the City's municipal policy. (2, 7)
13. Engage all major downtown property owners, managers and developers to become Cleveland 2030 District members, share their utility data and discuss energy efficiency and building retrofit projects. (2)

14. Identify proper incentives to encourage adoption of above-code construction and renovation projects, especially for commercial buildings. (3)
15. Complete automated meter reading (AMR) rollout for water meters. (5)
16. Continue to expand Advanced Metering Infrastructure solutions and develop plan to test in a smart grid pilot. (5)
17. Build on success of building challenge program for the residential and commercial sectors (6):
    a. Work with Northeast Ohio Chapter of the U.S. Green Building Council (NEOGBC) to learn from their existing building challenge program and identify key opportunities.
    b. Work with utilities to identify neighborhoods that could most benefit from this program and develop comparison utility data reporting to encourage competitive reductions.
    c. Expand the forum for public recognition for high performing buildings, organizations, and neighborhoods
18. Coordinate with Cleveland Metropolitan School District and other schools in the City to identify key next steps for building upon the state's requirements for green schools. (7)

Note: (Related Action numbers shown in parentheses)

LEADING BY EXAMPLE

MEDICAL CENTER COMPANY ENERGY EFFICIENCY GRANT FUND

Medical Center Company (MCCo) Energy Efficiency Grant Fund

The MCCo Energy Efficiency Fund (EEF) is a $3 million revolving grant fund that provides up-front capital for projects that reduce their Member Institutions' environmental impact through energy efficiency efforts.[i] MCCo was founded in 1932 as a non-profit district energy system in the University Circle neighborhood of Cleveland to serve the energy needs of their Member Institutions, including Case Western Reserve University, University Hospitals, The Cleveland Museum of Art, Severance Hall, and Cleveland Botanical Garden. The EEF eligibility guidelines state that projects must result in energy savings to a facility served or committed to be served by MCCo and have a payback period of five years or less. The EEF was developed as one of MCCo's Energy Management programs to reduce the neighborhood carbon footprint through greater efficiency in energy use and consumption. Implementation of the program's initial projects began in late 2012. Additional information can be found at: www.mcco.org

FOCUS AREA 1

ENERGY EFFICIENCY & GREEN BUILDING

LEADING BY EXAMPLE

ENERGY EFFICIENT AFFORDABLE HOUSING

Renovations of older, distressed homes throughout the City of Cleveland are meeting improved green standards because of incentive programs and funding opportunities. Over the past two years, Environmental Health Watch (EHW) managed a HUD-funded technical study of green retrofits of 12 affordable homes. Six of the houses were upgraded to EHW's deep energy retrofit specs to achieve at least 70% energy-use reductions. The other six were renovated to Cleveland's "Green Building Standard," which included affordable green housing standards established by Enterprise Community Partners (www.greencommunitiesonline.org) and energy-efficiency standards set by Energy Star v.2.

Some of the key improvements made to these houses include tighter building enclosures, better windows and doors, more efficient mechanical systems, energy-efficient lighting and appliances, energy recovery ventilation, and increased insulation. EWH is monitoring energy usage (actual vs. predicted) and indoor air quality in all 12 homes.

The homes were developed by a nonprofit community development organization, Cleveland Housing Network (CHN), for lease-purchase to low-income residents. Other partners in the project included the Swetland Center for Environmental Health at Case Western Reserve University's School of Medicine, and Intwine Connect, a Northeast Ohio tech company.

A house before retrofit

A house after retrofit (Note: The above images are not of the same house)

LEADING BY EXAMPLE

CLEVELAND ENERGY $AVER

The Cleveland Energy $aver program is an affordable, common-sense way for Cleveland homeowners to improve their homes' comfort, durability, resale value and overall health and safety -- while simultaneously saving money on utility bills through improved energy efficiency. The City of Cleveland, Cleveland Housing Network, and Cleveland Action to Support Housing (CASH) have collaborated to create the program through which qualified City of Cleveland homeowners can save up to 40% off the cost of home energy efficiency improvements.

In 2009, the City of Cleveland allocated $550,000 of Energy Efficiency and Conservation Block Grant (EECBG) funds from the US Department of Energy to plan and conduct a pilot program for residential homeowners throughout the City. This pilot, now known as the Cleveland Energy $aver program (CE$), has developed into one of the most comprehensive home energy assessment programs in the country today.

The program is a 3-step process: Energy Assessment, Upgrade, and Savings. There are a variety of eligible home energy upgrades, such as installing:

- insulation, air sealing, and weatherstripping
- high efficiency furnaces (or repairing old units)
- energy efficient air conditioning units
- lighting, such as compact fluorescent lamps (CFL) or Light Emitting Diodes (LED)
- high efficiency water conservation devices
- Energy Star appliances
- doors and windows

CE$ provides homeowners with a 20% discount on the price-approved measures, up to $2,500. The remainder of the cost can be financed by a low-interest loan (as low as 2.3%) with flexible financing and payment terms made available through CASH and their lending partners. After the work is completed, the homeowner receives a check in the mail from CE$, up to $1,250, depending on which improvements were made.

Because similar programs already exist for lower-income residents, CE$ is targeted to middle- and upper-income households making 200% or more above 2012 federal poverty guidelines.

Ultimately, CE$ is overcoming the barriers to home energy efficiency by providing simplified financing, little to no up-front costs, and support services. As of September 2013, of more than 300 audits, approximately 150 homes have moved forward with recommended retrofit work. Program participants saw an average savings of more than 30% off the cost of this work, with 49 homeowners utilizing the low-interest financing options offered through CASH. Additionally, CE$ provides verified savings reports based on utility information for each property upgraded. Initial reports show an average savings of 30% off utility bills, with some homeowners saving as much as 53%.

FOCUS AREA 1

ENERGY EFFICIENCY & GREEN BUILDING

LEADING BY EXAMPLE

COSE ENERGY CHOICE

Many small business owners have little time on their hands to dedicate to energy management, but smart and efficient energy use can yield major savings that can be reinvested back where it counts – into their businesses. That's why the Council of Smaller Enterprises (COSE), the region's largest small business support organization, has worked to be its members trusted energy adviser through the COSE Energy Choice program. For nearly 14 years, COSE Energy Choice has helped its members lower electricity and natural gas rates, reduce their energy consumption and improve their bottom lines. Businesses that take advantage of COSE Energy Choice's turnkey solutions receive customized energy-savings opportunities that combine quick payback through utility savings, rebates, and flexible financing.

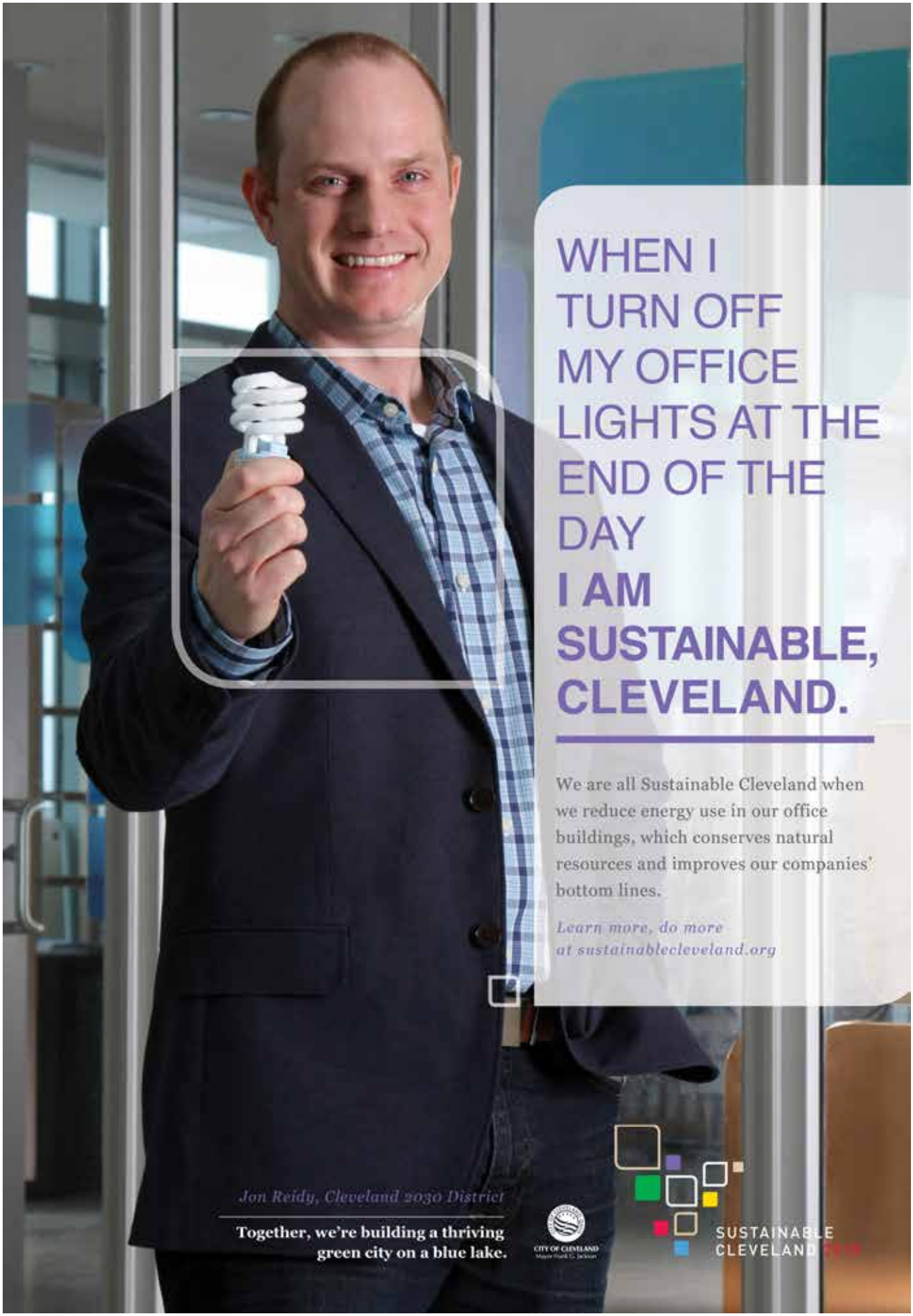
The success of the COSE Energy Choice program is evident. In 2012 alone, businesses benefitted from $5.6 million in utility rebates plus $7.8 million in annual utility savings through a reduction of 78,692,834 kWh. In 2012, COSE completed 150 energy assessments and is on target to perform 1,450 by 2016. For businesses small and large, these simple energy assessments can help identify wasted energy and provide recommendations to develop an actionable energy efficiency strategy.

The COSE Energy Choice programming has resulted in real savings and emissions reductions for Cleveland-based businesses. For example, entrepreneur Paul Benner opened The Cleveland Brew Shop in 2012 and was dismayed by his business' high utility bills. As a young startup, he could not imagine continuing to pay such high bills. Therefore, he participated in a no-cost energy assessment offered by COSE and Dominion East Ohio. As a result of the assessment, he made targeted efficiency investments and he will save $1,250 a year from lighting retrofits and adjustments to how he uses his HVAC system.

While energy efficiency is proven to reduce operating expenses and produce long-term savings, COSE is working to eliminate the first cost barrier of implementing more efficient measures, such as new insulation or lighting retrofits. To lessen the impact of those costs, COSE has developed two pathways aimed to help small businesses finance an energy efficiency investment.

- COSE Energy Loan Program: COSE is partnering with KeyBank to introduce the COSE Energy Loan Program, which is designed to help Ohio small businesses unlock capital for energy efficiency investments. The concept is simple: Loans are structured such that the reduction in utility bills covers the loan repayment, spreading out the cost of the equipment without negatively impacting cash flow. COSE provides a loan guarantee as a credit enhancement tool for small businesses that have difficulty obtaining financing from a bank.

- Ohio Efficiency Resource Fund: COSE has partnered with efficiency-services financer Metrus Energy and CalCEF, two leading organizations focused on accelerating clean energy technologies, to create the Ohio Efficiency Resource Fund. The Ohio Efficiency Resource Fund is a pioneering financial tool that provides otherwise hard-to-get financing for mid-sized market businesses to make energy efficiency improvements, with no upfront costs and no risk. This is made possible through an innovative structure called an Efficiency Services Agreement, which converts the capital investment typically associated with energy efficiency into a long-term operating expense.


WHEN I TURN OFF MY OFFICE LIGHTS AT THE END OF THE DAY
I AM SUSTAINABLE, CLEVELAND.
We are all Sustainable Cleveland when we reduce energy use in our office buildings, which conserves natural resources and improves our companies' bottom lines.
Learn more, do more at sustainablecleveland.org
Jon Reidy, Cleveland 2030 District
Together, we're building a thriving green city on a blue lake.
CITY OF CLEVELAND
SUSTAINABLE CLEVELAND

ADVANCED & RENEWABLE ENERGY

FOCUS AREA 2

GOALS:

- 25% of energy use in Cleveland is supplied from renewable sources by 2030 (15% by 2020)
- Reduce Cleveland GHG Emissions 2,100,000 MTCO2e by 2030
- Minimize brownouts during heat waves with on-site energy generation and storage

THE IMPORTANCE OF ADVANCED & RENEWABLE ENERGY

When combined with energy efficiency and conservation strategies, advanced and renewable energy technologies offer additional ways for property owners/managers to reduce energy consumption and costs. Renewable energy sources are clean and inexhaustible. Types of renewable resources include moving water (hydro, tidal, wave power), thermal gradients in ocean water, biomass, geothermal, solar, and wind. Cogeneration, anaerobic digestion, energy recovery from waste plastic, and municipal solid waste are considered types of advanced energy generation. (Note that advanced vehicle technologies, such as alternative fuel vehicles, are addressed in the Sustainable Mobility section) Increasing the amount of energy supplied from advanced and renewable sources can offset energy generation from traditional, non-renewable fuel sources and their associated GHG emissions.

Advanced and renewable energy sources can help to diversify energy supplies providing a hedge against long-term price volatility associated with traditional non-renewable fuels. When equipped with battery storage back-ups, these systems can allow residences and businesses to continue operating during power outages caused by storms and heat waves. The advanced and renewable energy industry also offers the greater Cleveland area significant economic development benefits, including job creation, local capacity building, and the attraction of skilled professionals to Northeast Ohio. In addition, a strong local economy can be more capable of adapting to stresses caused by climate change.

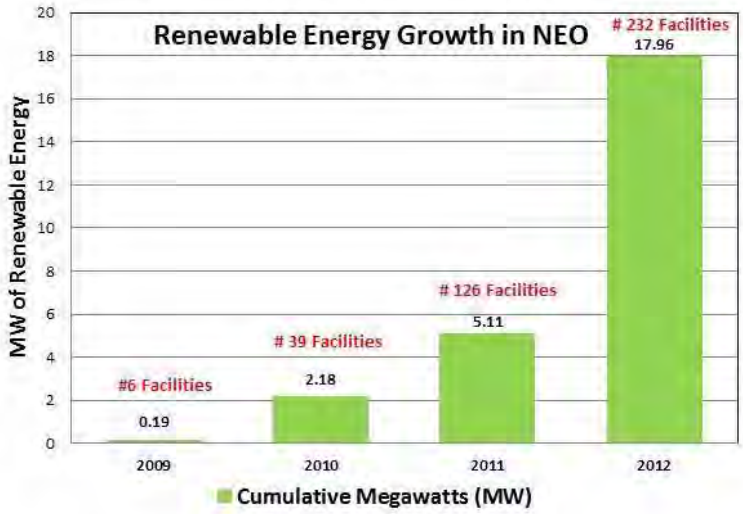
Case Western Reserve University Wind Turbine

OBJECTIVE: ACCELERATE RENEWABLE ENERGY USE BY CLEVELAND'S RESIDENTS & SMALL BUSINESSES

KEY FACTS:

From 2009 - 2012, **232 renewable energy facilities in Northeast Ohio** were installed with a generating capacity of **17.96 Megawatts*.** This supports the **electricity requirements of 13,100 average homes.**

Figure 14: Cumulative Capacity of Renewable Energy Facilities in Northeast Ohio



Source: **Public Utilities Commission of Ohio (PUCO)** certified cases of Renewable Energy Installations (Solar Photovoltaic, V Biomass, Fuel Cells) required to sell Renewable Energy Credits (RECs).

ADVANCED & RENEWABLE ENERGY

Distributed energy generation provides Cleveland residents and businesses with a local, clean energy supply that helps to protect against energy price volatility, reduce energy costs over time, and also provide opportunities for local job creation through system development and installation.

ACTION 8: INCREASE DISTRIBUTED ENERGY INSTALLATIONS

2030 Emissions Reduction Potential: 35,000 $MTCO_2e$ = 2,600 Cleveland homes

Encouraging residents and businesses to install on-site renewable energy systems, such as solar photovoltaic panels, solar thermal systems, geothermal systems, or wind turbines, can help to reduce building energy costs, potentially improve property values, and also help energy utilities better manage peak demand. Providing households and business owners with information on the solar potential for their home/business, as well as available incentives and financing mechanisms to support implementation will increase the adoption of on-site energy generation. Adoption can also be encouraged by streamlining project permitting and removing code barriers that prevent or hinder renewable energy installations. Additional assistance can be provided by engaging utilities to make it easier for interconnections and virtual net-metering setup for on-site and small-scale renewable energy projects.

Geothermal systems save energy at the Cleveland Museum of Contemporary Art *(Dean Kaufmann, Courtesy of MOCA Cleveland)*

By developing on-site generating capacity with storage capabilities, Cleveland residents and businesses will also be able to better respond to and manage the increased energy load that is expected to accompany more intense heat waves in the future.

ACTION 9: SAVE MONEY AND SUPPORT RENEWABLE ENERGY THROUGH MUNICIPAL AGGREGATION

2030 Emissions Reduction Potential: 340,000 $MTCO_2e$ = 25,000 Cleveland homes

The City of Cleveland currently purchases electricity for 58,500 residents and 7,200 small business customers of the Cleveland Electric Illuminating Company, leveraging its "buying power" to solicit the lowest price for those participating, while also supporting renewable energy. Beginning in July 2013, these customers receive both a 21% electricity bill savings compared to the market rate, and 100% of their electricity from renewable sources like wind and hydropower. More than half of the wind energy purchase is generated in Ohio, helping to support the state's renewable industry. Municipal aggregations in the future will continue to explore opportunities to support local renewable energy projects.

OBJECTIVE: USE LOCAL PROJECTS TO HELP MEET OR EXCEED THE UTILITY RENEWABLE ENERGY STANDARDS

To meet their organization's renewable energy standards, Cleveland Public Power, Cleveland Electric Illuminating Company, and others can purchase power from local renewable energy projects which would support local economic development.

ACTION 10:BECOME A NATIONAL LEADER IN REUSING VACANT LAND FOR RENEWABLE ENERGY PROJECTS

2030 Emissions Reduction Potential: 23,000 $MTCO_2e$ = 1,700 Cleveland homes

Great Lakes Science Center Wind Turbine

Collinwood Bioenergy Facility

There are more than 200 acres of brownfield land located in the City of Cleveland, as well as other vacant and City land. While challenging to manage, these sites also present opportunities, including the potential for spurring renewable energy projects, especially solar photovoltaic (PV). Some of the initial research related to renewable potential on vacant land was led by the City Planning Commission, which is summarized in the report "8 Ideas for Vacant Land Reuse." It's important to build off the success of a couple 1-MW solar PV projects on vacant land, and perform a more comprehensive screening of land most suitable for renewables.

ACTION 11: DEVELOP A PILOT OFFSHORE WIND FARM

2030 Emissions Reduction Potential: 67,000 $MTCO_2e$ = 5,000 Cleveland homes

The Lake Erie Energy Development Corporation (LEEDCo) is a regional non-profit organization spearheading an effort to build and install an 18-megawatt (MW) wind project in Lake Erie. This project would be the first freshwater offshore wind farm in North America. With this initial project, LEEDCo and its partners aim to make Ohio a cornerstone of the American offshore wind industry and re-energize Northeast Ohio's economy.

ACTION 12: UTILITIES INVEST IN ADDITIONAL PROJECT TO MEET RENEWABLE ENERGY STANDARDS

2030 Emissions Reduction Potential: 1,200,000 $MTCO_2e$ = 90,000 Cleveland homes

In 2008, the City of Cleveland adopted a voluntary Advanced Energy Portfolio Standard (AEPS) that calls for 15% of Cleveland Public Power's energy to come from advanced or renewable sources by 2015, 20% by 2020, and 25% by 2025. To help meet these voluntary goals, CPP is currently purchasing electricity from the Collinwood BioEnergy facility. This facility uses anaerobic digestion to produce electricity from organic waste. CPP also committed to purchase a portion of energy generated from the proposed pilot off-shore wind farm in Lake Erie (see Action 11), as well as hydro-power from regional sources. CPP is on track to meet its renewable energy goals. Because CPP is a municipal utility, it is not subject to the requirements of Ohio's Renewable Portfolio Standard (RPS) that took effect in 2008. However, the Cleveland Electric Illuminating Company (part of FirstEnergy) is subject to Ohio's RPS, which requires the state's four investor-owned utilities to generate at least 12.5% of their electricity from renewable sources (e.g., wind, solar, landfill gas) by 2024 and 12.5% from advanced energy sources (e.g., clean coal, advanced nuclear, combined heat and power) by 2025.

ADVANCED & RENEWABLE ENERGY

OBJECTIVE: IMPLEMENT ADVANCED ENERGY TECHNOLOGIES

ACTION 13: ACCELERATE CONVERSION OF ORGANIC WASTE TO ENERGY USING ANAEROBIC DIGESTION

2030 Emissions Reduction Potential: 52,000 $MTCO_2e$ = 3,900 Cleveland homes

The Northeast Ohio Regional Sewer District (NEORSD) provides wastewater service to the City of Cleveland and surrounding areas at three treatment facilities. The energy required to treat wastewater generated by Cleveland residents comprises about 1% of the total energy consumed within the City. Wastewater treatment plants provide a significant opportunity for renewable energy generation through the capture of biogas from anaerobic digestion for electric or thermal energy generation, as well as energy capture during the incineration of dry solids from the facility. NEORSD's Renewable Energy Facility at its Southerly Wastewater Treatment Center will save $1-2 million/year in electricity costs[xii].

ACTION 14: SWITCH TO LOW-CARBON FUEL SOURCES FOR DISTRICT HEATING AND COOLING

2030 Emissions Reduction Potential: 120,000 $MTCO_2e$ = 9,000 Cleveland homes

There are two district energy companies serving the City. Cleveland Thermal serves downtown Cleveland while the Medical Center Company serves non-profit organizations located in University Circle. Distributed/district-scale energy generation is often more efficient than having separate heating and cooling equipment for each facility. And with emerging technologies, the smaller district-scale solutions can often produce energy more efficiently and with fewer emissions than large central power plants, partially due to less electricity losses from distribution.

Alternative fuel sources such as refuse derived fuel pellets and biomass should also be considered as an option to further reduce district energy emissions.

Additionally, combined heat and power (co-generation) is a cost-effective, viable technology, especially for industrial users and should be evaluated as part of any district energy emissions reduction strategies.

NEORSD Southerly Waste Water Treatment Plant - Renewable Energy Facility

Midtown Solar Array

KEY BENEFITS OF ADVANCED & RENEWABLE ENERGY

- Improved air quality and health
- Local Job Creation and Economic Development
- Reduced Vulnerability to Energy Price Volatility
- Leadership and Recognition
- Education and Awareness

ACTION 15: SUPPORT CLEVELAND BUSINESSES TO REDUCE INDUSTRIAL PROCESS EMISSIONS

2030 Emissions Reduction Potential: 390,000 $MTCO_2e$ = 30,000 Cleveland homes

Industrial process emissions make up 36% of the total emissions generated within the City of Cleveland and will be an important emission source to address for the City to meet its reduction goals. These emissions come from burning fuels on-site to generate energy needed for manufacturing. The City should support industrial players within the City to achieve their emissions reductions goals and projects.

LEADING BY EXAMPLE

SOLAR ARRAY FOR CMHA HEADQUARTERS

Carbon Vision, a renewable energy analysis and project development firm, worked with the Cuyahoga Metropolitan Housing Authority and Cleveland Public Power to contract, design, build and operate a one-megawatt solar field next to CMHA's headquarters at the intersection of Kinsman Avenue and East 82nd Street. The solar field consists of 4,212 solar panels capable of generating enough electricity to meet 70% to 80% of the building's needs. The system uses four Eaton inverters and racking from Toledo based AP Alternatives.

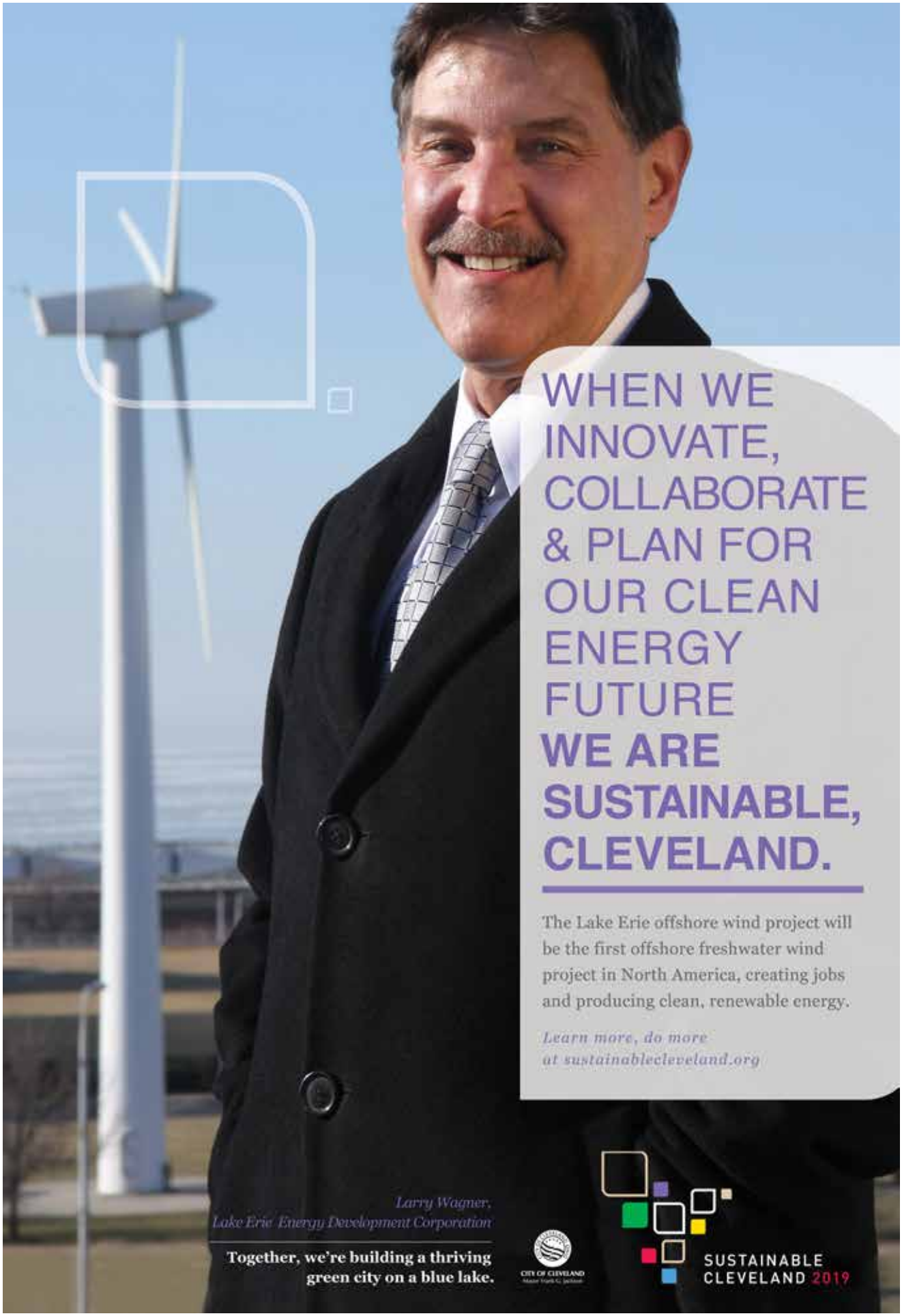
CMHA is purchasing the electricity that the solar system will generate over a 20 year power purchase agreement. Carbon Vision is leasing the six-acre piece of land from the housing authority, which is a former brownfield.

ADVANCED & RENEWABLE ENERGY

ADVANCED & RENEWABLE ENERGY NEXT STEPS TO BE COMPLETED BY 2016:

1. Create and/or utilize an online solar mapping tool that identifies the solar potential on every building in Cleveland, and provides a high level financial analysis for residents and businesses. (8)
2. Review current zoning, height, permitting, interconnection, net-metering, and other regulations related to development of small-scale renewable energy in order to reduce implementation costs while ensuring system safety. (8)
3. Cleveland Pubilc Power to offer 100% renewable option for customers. (8)
4. Further develop an array of financing mechanisms and educate customers on options: (8)
   a. Rebates (build on Green Energy Ohio solar thermal program)
   b. Renewable Energy Certificate (REC) purchases and Power Purchase Agreements (PPAs)
   c. Loans (e.g. KeyBank program) and on-bill repayment
   d. PACE and lease financing
   e. Tax credit financing
   f. Local fund
5. Establish Cleveland as a national leader in reusing vacant land for large renewable energy projects:
   a. Complete analysis of renewable potential on brownfields and other underutilized land, and implement findings. (10)
   b. Identify good candidates for community solar pilot projects in terms of buyers (e.g. EcoDistricts) and location (e.g. brownfield site): (10, 12)
   c. Work with electric utilities on virtual net metering pilot, allowing a customer to assign the net production from an electric generator (e.g. solar panels) to other metered accounts that are not physically connected to that generator. (12)
6. Identify opportunities to support LEEDCo to ensure completion of offshore wind pilot. (11)
7. Cleveland Thermal and Medical Center Company to transition from coal to cleaner energy sources. (14)
8. Identify potential for cogeneration (combined heat & power) in Cleveland, complete additional site-specific feasibility studies as necessary, and break down any barriers to implementation. (14, 15)
9. Work to strengthen and meet renewable energy requirements in state and national policy. (8-15)

Note: (Related Action numbers shown in parentheses)


WHEN WE INNOVATE, COLLABORATE & PLAN FOR OUR CLEAN ENERGY FUTURE
WE ARE SUSTAINABLE, CLEVELAND.
The Lake Erie offshore wind project will be the first offshore freshwater wind project in North America, creating jobs and producing clean, renewable energy.
Learn more, do more at sustainablecleveland.org
Larry Wagner, Lake Erie Energy Development Corporation
Together, we're building a thriving green city on a blue lake.
CITY OF CLEVELAND
SUSTAINABLE CLEVELAND 2019

SUSTAINABLE MOBILITY

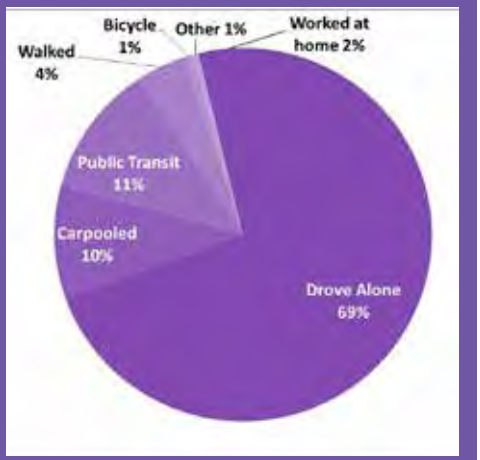
FOCUS AREA 3

2030 GOALS:

- Reduce single occupancy vehicle mode share from 69% to 62% by 2020, 55% by 2030
- Reduce Cleveland GHG Emissions 250,000 $MTCO_2e$ by 2030
- By 2030, $56 million saved by Cleveland households and businesses due to reduced energy costs ($24 million saved by 2020)
- Reduce pedestrian and bicyclist fatalities at least 50% by 2020 with the goal of zero fatalities by 2030
- Improved air quality due to reduced vehicle emissions, particularly during the warmer summer months when ground level ozone and fine particulate concentrations are high

KEY FACTS:

Almost **three-quarters of the commuters in Cleveland** get to work in a single occupancy vehicle.



Over **5.7 million vehicle miles** are traveled on Cleveland roadways each day. This equates to **14.5 miles per Cleveland resident per day.**

THE IMPORTANCE OF SUSTAINABLE MOBILITY

Reducing fuel consumption, vehicle emissions and vehicle miles traveled (VMT) are important emission-reduction strategies. On-road transportation from passenger cars and trucks in the City of Cleveland contributed to approximately 8% of the City's GHG emissions in 2010 while airline travel at both Cleveland Hopkins International and Burke Lakefront Airports contributed 2% (Figure 8). Of the transportation emissions, gasoline fuel consumption (typically by passenger vehicles) is by far the largest contributor (Figure 9). It should be noted that freight rail emissions were not included in the GHG inventory, but preliminary analysis suggests that these emissions are relatively low. Emissions associated with electricity use for electric vehicles are also considered negligible.

In addition to reducing emissions, Complete and Green Streets initiatives will have co-benefits of reducing stormwater runoff, providing more tree canopy for urban cooling, and improving the health of Clevelanders.

OBJECTIVE: REDUCE CONGESTION AND VEHICLE EMISSIONS

Increasing the use of transportation options such as public transit, cycling, and carpooling reduces congestion on roadways and transportation related emissions in the City while providing health benefits, such as increased activity levels and improved air quality. Additional ways to reduce transportation related emissions include encouraging Cleveland residents and businesses to purchase more fuel efficient vehicles, supporting improvements to national fuel efficiency standards, and reducing the carbon intensity of fuel sources.

ACTION 16: DEVELOP POLICIES AND PROGRAMS THAT PROMOTE MORE EFFICIENT VEHICLES

2030 Emissions Reduction Potential: 150,000 $MTCO_2e$ = 11,000 Cleveland homes

On-road transportation accounts for 8% of the City's total emissions. Programs and policies can be used to educate, promote, and facilitate more efficient vehicles and practices. Federal policies like the

FOCUS AREA 3
SUSTAINABLE MOBILITY

Corporate Average Fuel Economy (CAFE) regulation raises the fuel efficiency standards of new vehicles and over time will result in a more fuel efficient fleet in Cleveland. In addition to improving the efficiency of current fuels, incentivizing the adoption of alternative fuels, such as electricity and compressed natural gas (CNG), should be considered. Facilitating infrastructure, such as electric vehicle charging stations and compressed natural gas (CNG) fueling stations, and providing incentives like preferential parking and lane incentives for low-emission vehicles will encourage residents and businesses to use more alternative fuels.

ACTION 17: ENCOURAGE ANTI-IDLING CITYWIDE

Driving 2030 Emissions Reduction Potential: **8,500 $MTCO_2e$ = 640 Cleveland homes**

RTA Healthline, a bus rapid transit best practice in the U.S.

KEY BENEFITS OF SUSTAINABLE MOBILITY ACTIONS

- Better air quality and less asthma
- Improved health from exercise
- More vibrant public spaces
- Local job creation and economic development
- Cost savings
- Less vulnerability to fuel price volatility

Driving behaviors, such as excessive idling, have a significant impact on fuel consumption and unnecessarily contributes to air pollution. A citywide effort to improve traffic management and synchronize traffic signals would reduce emissions across the board by reducing congestions and delays. Tools such as the parking guidance currently being used at Cleveland Hopkins Airport also reduce idling. Through public and private education programs Cleveland residents can learn eco-driving skills and behaviors reduce fuel consumption. Additionally, businesses can improve fleet efficiency by reducing diesel vehicle idling and adopting policies similar to the City of Cleveland's anti-idling ordinance such as GPS tracking/efficient routes and trip optimization.

ACTION 18: EXPAND USE OF CARPOOLING AND CAR SHARING

2030 Emissions Reduction Potential: **8,700 $MTCO_2e$ = 650 Cleveland homes**

Carpooling for commuters and car sharing for individuals making personal trips can reduce fuel use, parking costs, vehicle costs, and traffic congestion in Cleveland. Options for increasing carpooling include incentivizing the use of OhioRideshare as a resource for identifying carpool opportunities, implementing lane incentives for carpoolers, and establishing preferential parking for carpoolers. OhioRideshare also has a guaranteed ride home program (www.noaca.org/grh.html).

Car-sharing is typically a membership-based rental alternative to owning or using a private vehicle for occasional trips. It lowers the cost and reduces the burden of traditional transportation. Members reserve a vehicle online for a specific trip, pick up and return the vehicle at a designated location, and have the benefit of a private vehicle without the burden and expense of upkeep and ownership. The car-sharing service typically covers fuel, maintenance, and basic insurance costs. While there is an increase in vehicle miles traveled for those who do not have their own vehicle, there is a greater reduction in vehicle miles traveled for those who have a vehicle but opt to car-share. It can eliminate the need for a second vehicle and encourages smarter trip planning.

ACTION 19: INCREASE THE USE OF PUBLIC TRANSIT THROUGH INCENTIVES AND ADDITIONAL INFRASTRUCTURE

2030 Emissions Reduction Potential: 84,000 $MTCO_2e$ = 6,300 Cleveland homes

The Greater Cleveland RTA already provides an extensive transit system that serves the City of Cleveland and surrounding communities. Further improving this service to better meet the needs of the community through efforts such as financial incentives and revisions to the current fee structure, real-time information about routes and schedules, and expanded service could further increase ridership and decrease vehicle miles traveled within the city. Educating Clevelanders about the potential cost savings associated with using public transit as compared to personal vehicles could also help to increase ridership.

Greater Cleveland Regional Transit Authority

OBJECTIVE: CREATE COMPLETE AND GREEN STREETS

In September 2011 the Cleveland City Council passed the Complete and Green Streets ordinance that requires best practices in complete and green streets be implemented during re-construction and resurfacing of City streets. Complete and Green Streets means designing streets for all transportation modes, all users of all abilities and to provide environmental benefit. This program considers features such as bike lanes, enhanced crosswalks, energy-efficient lighting, and porous pavement that will increase the use of alternative transportation options, reduce transportation GHG emissions, and also manage stormwater impacts in the City.

ACTION 20: MAKE BIKING AND WALKING EASIER AND SAFER

2030 Emissions Reduction Potential: 2,600 MTCO2e = 190 Cleveland homes

Shifting from driving to cycling or walking as the preferred mode of transportation can reduce GHG emissions, save Cleveland residents money from

FOCUS AREA 3
SUSTAINABLE MOBILITY

The Bike Rack in Downtown Cleveland, the region's first full service bicycle parking and commuter center

reduced fuel costs, and also provide health and fitness benefits. Currently, there are approximately 45 miles of bikeways in the City of Cleveland. In 2012, there were approximately 750 bike commuters and 4.4% of commuters in Cleveland walked. Bicycle communiting increased more than 280% from 2000 to 2010. According to the Bikeway Master Plan developed by the Cleveland Planning Department, there are 180 miles of proposed bike paths throughout the City of Cleveland. There are a number of different activities that can be implemented to encourage more biking and walking in the City, including but not limited to the following:

- Increasing the number of bikeway miles in the City and implementing more bicycle support facilities, such as racks, storage lockers, changing facilities, and bike parking at key locations
- Improving pedestrian and bicycle access in commercial districts, employment centers, and new development
- Ensuring bike facilities are safe, convenient, comfortable, and installed equitably throughout the City
- Developing Safe Routes and Walk to School programs for all CMSD schools focusing on safety through biking and walking programs
- Implement a bike sharing system where determined feasible
- Continuing to increase biking outreach and education (driver education, information on bike paths/routes, etc.)

ACTION 21: DEVELOP A STREAMLINED PROCESS TO IMPLEMENT COMPLETE AND GREEN STREETS POLICY

M A

A number of cities and regions across the U.S. are changing how they design streets, shifting from a design strategy centered on moving cars quickly to one that considers all modes of transportation and enables safe access for all users. A smaller number of cities are also addressing stormwater management and the implementation of green infrastructure into their street design programs. Complete and green streets projects help to increase alternative transportation options and reduce vehicle miles traveled and GHG emissions in the city. Complete Streets also improve safety for all, increase physical activity, and help to stimulate the local economy by reducing transportation costs for residents and

making local businesses more accessible. Because the City of Cleveland is integrating Complete and Green Streets into its existing Capital Improvement Plan, it will be automatically included within the transportation budget and transportation grants requested.

Detroit Superior Bridge Walkway

FOCUS AREA 3
SUSTAINABLE MOBILITY

LEADING BY EXAMPLE

EUCLID HEALTHLINE

In the 1990s, the City of Cleveland, Greater Cleveland Regional Transit Authority (RTA), Northeast Ohio Areawide Coordinating Agency (NOACA) and other stakeholders embarked on a plan to revamp the Euclid Avenue Transportation Corridor in order to improve access to the City's two largest employment centers, downtown Cleveland and University Circle. Completed in 2008, the RTA HealthLine route runs down 6.8 miles of Euclid Avenue from Downtown to East Cleveland, connecting the city's cultural and educational institutions, medical and business centers and numerous locally owned businesses and restaurants. The 21 rapid transit vehicles utilize hybrid technology that combines a clean diesel engine with an electronic transmission, resulting in 97% lower particulate emissions and 75% better fuel economy . Additional features include dedicated bicycle lanes, over 1,500 new trees, and 58 transit stations.

Over $4.3 billion has already been invested along the route. This includes the rehabilitation of old buildings into housing and retail centers, new construction for business startups, plus major expansions of universities, museums and hospitals. New enterprises like bioscience and tech firms now proudly call Euclid Avenue home and the corridor leads the state in job creation and research.

MORGANA RUN TRAIL

Morgana Run Trail is a paved, off-road trail, completed in 2007, that runs along an old Wheeling & Lake Erie Rail corridor through the Slavic Village Neighborhood. The trail begins on E. 49th Street just north of Fleet Ave and terminates near the Garfield MetroParks Reservation. This rail/trail connects residents and visitors to the Cleveland Metro Parks Mill Creek Park and Trail through the Slavic Village/Broadway and Union-Miles neighborhoods of Cleveland over to Washington Park and the new "First Tee" Golf Course and then further to the established Ohio & Erie Canal Way Reservation and Tow Path Trail.

The trail is located near a 95-home development, dubbed Trailside at Morgana Run, that will feature affordably-priced homes within a completely new urban subdivision with access to green space and the trail. This project demonstrates that bicycling infrastructure is good for economic development and quality of life, as illustrated by the associated housing development. The project was a joint partnership between local community organizations, the City of Cleveland, Cuyahoga County, NOACA, State of Ohio, and private, grant-making foundations. The trail was completed at a total cost of approximately $2.5M.

SUSTAINABLE MOBILITY NEXT STEPS TO BE COMPLETED BY 2016:

1. Support the development of renewable and alternative fuel infrastructure, including the identification of locations for installing electric vehicle charging stations and CNG fueling stations. (16)
2. Identify and implement eco-driving educational programs. (17)
3. Identify businesses with large fleets to participate in anti-idling program. (17)
4. Encourage carpooling: (18)
    a. Identify and engage large employers in OhioRideShare,
    b. Identify problematic parking areas within the City and select a pilot area for less expensive fees for carpoolers (or increased fees for single occupant vehicles),
    c. NOACA to continue analyzing the feasibility of High Occupancy Vehicle (HOV) lanes throughout the region and on a project basis.
5. Identify organizations and proactive neighborhoods willing to push for community membership and contract with a car sharing company, much like the Case Western and Cleveland State programs. (18)
6. Expand upon the success of RTA's commuter advantage program with the goal of encouraging increased use of public transit. (19)
    a. Explore possibility of providing a discount for purchasing bulk (e.g., monthly) passes,
    b. Subsidize transit passes for small businesses, discount for employers purchasing tickets in bulk for employees, etc.
7. Evaluate options for expanding RTA system around job center nodes. (19)
8. Build off NOACA's 2013 Bikeway Plan to update the City's Bikeway Master Plan, allowing for a more coordinated approach to creating bicycling infrastructure. (20)
9. Implement Bike Share in Cleveland. (20)
10. Review parking space requirements and prioritize advanced parking strategies (such as the Cleveland Hopkins Airport's Smart Parking program), especially in areas of compact, mixed-use development. (20)
11. NOACA to develop a Regional Strategic Plan and a complete streets policy. (21)
12. Finalize Complete and Green Streets toolkit and report on implementation progress annually. (21)

Note: (Related Action numbers shown in parentheses)

WASTE REDUCTION & RESOURCE CONSERVATION

FOCUS AREA 4

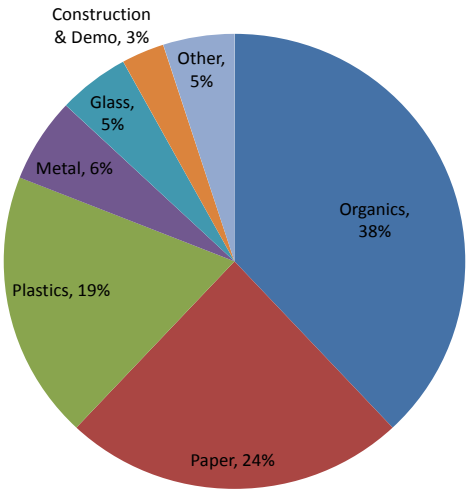
2030 GOALS:

- Achieve diversion rate of at least 50% by 2030 for both residential and commercial waste (25% by 2020)
- Reduce Cleveland GHG Emissions 77,000 $MTCO_2e$ by 2030

KEY FACTS:

In 2010, Cleveland residents generated over **230,000 tons of solid waste**

89% of this waste was sent to the landfill



38% of waste in Cleveland is made up of **organic** materials that could be **composted or processed to extract energy.**

The majority of waste can be reduced, reused, or recycled.

THE IMPORTANCE OF WASTE REDUCTION & RESOURCE CONSERVATION

As organic material decomposes in a landfill it releases GHG emissions. Recycling, composting, and other waste reduction and diversion efforts are important strategies for reducing GHG emissions, prolonging the life of landfills, and reducing disposal costs. Solid waste collected from residential, commercial, and industrial properties in the City of Cleveland contributed to approximately 1% of the City's GHG emissions in 2010 (Figure 8).

OBJECTIVE: SIGNIFICANTLY REDUCE THE AMOUNT OF WASTE SENT TO LANDFILLS

Major facilities and tracts of land are required to accommodate waste, and monitoring and mitigation are needed long after disposal. Actions that promote diversion of solid waste from landfills, such as recycling, composting and waste-to-energy initiatives, can reduce GHG emissions, prolong the life of landfills, and reduce disposal costs.

ACTION 22: IMPLEMENT PROGRAMS AND POLICIES TO ENCOURAGE WASTE REDUCTION AND DIVERSION BY RESIDENTS AND BUSINESSES

2030 Emissions Reduction Potential: 56,000 $MTCO_2e$ = 4,200 Cleveland homes

A coordinated approach to waste reduction and diversion across Cleveland, starting with policies that restrict certain materials, such as plastic bags, or divert others, such as organic waste, are important tools in encouraging waste reduction both at the residential and commercial level. Furthermore, a coordinated approach provides consistent messaging and education to guide businesses and community members. For example, outreach to businesses could include guidelines for sustainable purchasing policies, supply chain engagement, zero waste events, hazardous materials diversion, and incentives for meeting waste reduction targets.

FOCUS AREA 4
WASTE REDUCTION & RESOURCE CONSERVATION

KEY BENEFITS OF WASTE REDUCTION & RESOURCE CONSERVATION

- Cost savings
- Reduced natural resource consumption
- Local job creation and economic development
- Education and awareness
- Improved water quality
- Improved air quality

Similarly, neighborhood outreach, such as consistent signage, updated recyclable materials lists, and locations for organic waste drop-off, has the potential to empower residents to reduce waste.

Continuing the roll-out of citywide curbside residential recycling and creating a more robust recycling program overall will increase the rate of recyclable waste diverted from the landfill. A large part of successful recycling and diversion involves consumer education, consistent messaging, ease and availability of ways to divert materials, and partnerships with businesses to coordinate recycling efforts across organizations. While a variety of opportunities for recycling exist in Cleveland, a coordinated approach strengthens the opportunity for aggressive waste diversion. This includes expanding existing single-stream curbside service; identifying target recycling streams, such as glass bottles from bars and restaurants; and conducting neighborhood sweeps and business recycling seminars.

In addition to recycling, composting organics also helps to increase diversion rates. Not only do organics, including food and yard waste, account for approximately 38% of Cleveland's waste that ends up in landfills, it is typically heavy with moisture and removing it from the waste stream can reduce tipping fees that are paid by weight. This action can be built off the City's pilot composting effort at the West Side Market, where organic material (primarily food waste) from vendors and customers is collected in closed bins and sent to a composting facility. The resulting product is used for soil amendment. To address the larger volume of yard debris, it is important to offer more drop-off sites and ultimately curb-side collection. This action is closely linked with increased recycling and can leverage community education efforts that inform residents and businesses about composting and disposal of yard debris.

ACTION 23: DEVELOP A COST-EFFECTIVE APPROACH TO DECONSTRUCTING AND RECYCLING DEMOLISHED BUILDINGS

Deconstruction aims to remove building material with as little damage as possible, thus increasing the likelihood the material will be re-used rather than recycled. In almost any case, re-using material has higher environmental value than recycling. Traditional demolition projects yield diversion rates in the range of 0 to 10%. Given the value of metals, effort is usually made to salvage metals during the demolition, if practical. Full structural deconstruction projects often result in diversion rates of 75% or higher. Diversion rates over 90% are considered exemplary.

While traditional demolition and landfilling of materials creates little to no environmental or economic benefit, full deconstruction also has a point of diminishing return as the time and money invested becomes disproportionate to the resulting environmental, social, and economic benefits. The concept of an optimized approach, somewhere in the range between standard demolition and full deconstruction – based on the four indicators of cost, time, diversion rate, and economic development potential – can be a viable option for many buildings. High value materials can be removed for reuse while medium to low value materials can be diverted using the most cost effective method with preference of reuse whenever possible. Achieving a moderately aggressive diversion rate of 60% to 80% should be possible if materials such as metals, concrete, stone, wood, and unpainted drywall can be diverted.

ACTION 24: DEVELOP AND IMPLEMENT A SUSTAINABLE INTEGRATED WASTE AND ENERGY PLAN FOR THE CITY OF CLEVELAND

A variety of technologies exist to convert waste into energy or usable materials that reduce GHG emissions. The City seeks a sustainable, cost effective and long-term solid waste management solution. The solution will include recycling and keeping organic waste out of the landfill. There is potential for energy generation – whether through anaerobic digestion or the creation of refuse derived fuel (RDF) pellets. The City has identified opportunities for these technologies and is establishing a framework for implementation. Technologies being considered include:

- Opportunity 1: RDF production, after mixed waste processing to recover recyclables and compostable materials;
- Opportunity 2: RDF production with energy production; and,
- Opportunities 3A and 3B: RDF production and anaerobic digestion with or without energy production.

Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen. The process produces a biogas that can be used directly as cooking fuel, in combined heat and power gas engines, upgraded to natural gas-quality biomethane, or converted to electricity. Quasar Energy Group has built a series of anaerobic digesters throughout Ohio, including a 1.3 MW facility in Cleveland. Cleveland Public Power currently purchases energy from the Collinwood BioEnergy facility.

RDF pellets can be sold on the open market as a coal replacement to local businesses and utilities such as Cleveland Thermal. The City's Ridge Road Transfer Station could become a materials recovery facility (MRF) in addition to be being a recycling disposal facility. A MRF is a specialized plant that receives, separates and prepares recyclable materials for marketing to end-user manufacturers.

Thermal depolymerization involves heating waste plastic extracted from the municipal solid waste stream (e.g., plastic bottles and lunch containers) and converting it to synthetic crude oil that can be refined into gasoline and diesel fuel. While the City of Cleveland is not currently pursuing this technology, two Northeast Ohio businesses, Vadxx Energy and PolyFlow, currently work in this market.

Overall, these technologies offer significant opportunities for waste diversion, renewable energy generation, healthier soils, cleaner air, and economic development in Northeast Ohio.

Recycling Dumpster

Curbside Recycling Bins

FOCUS AREA 4
WASTE REDUCTION & RESOURCE CONSERVATION

LEADING BY EXAMPLE

COLLINWOOD BIOENERGY FACILITY

To meet the voluntary goals of the City's Advanced Energy Portfolio Standard, CPP is currently purchasing electricity from the Collinwood BioEnergy facility, which uses anaerobic digestion to produce electricity from organic waste. The plant, developed by Quasar Energy Group, can generate 1.3 megawatts of electricity per day and will be able to divert 42,000 wet tons of biomass from landfills each year. The biomass that is used as fuel for the production of electricity primarily comes from a variety of sources including food processing waste, expired beverages (dairy, soda, beer), and other fats oils and greases. The residual byproduct of anaerobic digestion is sent to local farms and used as a soil nutrient. Anaerobic digestion has been commonly used in energy facilities in Europe, with over 8,000 systems in operation today. In the United States, anaerobic digestion is emerging as a key component of the country's renewable energy portfolio.

WASTE REDUCTION & RESOURCE CONSERVATION NEXT STEPS TO BE COMPLETED BY 2016:

1. Complete rollout of mandatory residential curbside recycling throughout Cleveland. (22)
2. Expand neighborhood outreach programs to educate residents on waste streams, costs, long-term effects, diversion, and how their actions make a difference collectively. (22)
3. Identify and implement the most cost-effective approach to bringing back yard waste and leaf collection. If successful, consider citywide programs to encourage diversion of yard and organic waste from curbside garbage collection. (22)
4. Create more drop-off sites for organic waste and expand composting in and beyond West Side Market. Explore development of community composting programs on a neighborhood scale, with initial pilots in the EcoDistricts and/or major residential and commercial buildings. (22)
5. Educate businesses about environmentally preferable purchasing, zero waste events, and leveraging supply chains to reduce the volume of waste generated at their sites. (22)
6. Develop and implement approach that significantly reduces the use of disposable plastic bags, implemented in tandem with a public education campaign. (22)
7. Establish a requirement for household hazardous waste, such as paint, be removed and properly disposed before demolition. (23)
8. Develop guidelines for assessing the feasibility of deconstruction incorporating the four indicators of cost, time, diversion rate, and economic development potential. (23)
9. Issue a request for proposals to develop an integrated waste management system for the City of Cleveland and work with the community to identify an optimal approach. (24)

Note: (Related Action numbers shown in parentheses)


WHEN I COMPOST THE FOOD SCRAPS FROM OUR KITCHEN
I AM SUSTAINABLE, CLEVELAND.
We are all Sustainable Cleveland when we recycle food waste for improved soil and to reduce the amount of organic materials that are trucked to landfills.
Learn more, do more at sustainablecleveland.org
Employee at University Hospital
Together, we're building a thriving green city on a blue lake.
CITY OF CLEVELAND
SUSTAINABLE CLEVELAND 2019

FOCUS AREA 5

SUSTAINABLE LAND USE & CLEAN WATER

GOALS:

- Increase Cleveland's population density from 4,800 to 6,000 people per square mile by 2030
- Plant 75 new acres of trees within the City by 2020 and 150 new acres by 2030
- Reduce effective impervious surface in the city 10% by 2030 (5% by 2020)
- Install stormwater control measures on all redevelopment projects
- Reduce Cleveland GHG Emissions 120,000 $MTCO_2e$ by 2030

KEY FACTS:

The land use density of Cleveland is **4,800 people per square mile.**

Cleveland currently experiences approximately **80 combined sewer overflow events** annually.

There are more than **300 community gardens and urban farms** in Cleveland.

THE MPORTANCE OF LAND USE & CLEAN WATER

Reducing stormwater runoff, planting trees, and encouraging sustainable land use are important climate resiliency and emission-reduction strategies. The topics of land use and clean water are at the center of the intersection between climate change mitigation and adaptation. For example, improvements to zoning and land use codes can help create more vibrant communities and reduce transportation emissions, while improvements to stormwater infrastructure can help manage the impact of impervious surfaces and projected increases in flooding as a result of climate change. Actions outlined below address future reductions in water supply, reduce the number of Combined Sewer Overflow (CSO) events, and minimize impacts from flooding and erosion. More sustainable land use practices can also reduce the "heat island" effect caused by the summer heating of heat-absorbing surfaces such as roads and parking lots.

OBJECTIVE: ENCOURAGE VIBRANT DOWNTOWN AND NEIGHBORHOODS

High-density development in both downtown and Cleveland's neighborhoods, creates civic vibrancy, enables greater energy efficiency, and reduces auto use.

ACTION 25: GREEN THE ZONING AND LAND USE CODES TO ENCOURAGE SUSTAINABLE DEVELOPMENT

M A

2030 Emissions Reduction Potential: 1,500 $MTCO_2e$ = 110 Cleveland homes

Cleveland's compact development patterns use land efficiently and provide a range of living choices, employment opportunities, and access to services using transit and active transportation modes. The City needs to build on its history of compact development and continue this sustainable trend. Through a combination of possible incentives (e.g., streamlined permitting, density bonuses, financial incentives, market incentives) and revisions in land use and zoning codes, Cleveland can encourage and promote higher density and more diverse development, mixed-use development, and commercial/residential infill (re)development and preservation of existing building stock within the City. The more efficient use of land could also increase green space, reducing the urban heat island effect and providing more resiliency to flooding and erosion.

FOCUS AREA 5
SUSTAINABLE LAND USE & CLEAN WATER

ACTION 26: PRIORITIZE SUSTAINABILITY AND RIGHTSIZING IN CITY INFRASTRUCTURE IMPROVEMENTS

Infrastructure throughout much of the City, such as roads, is oversized for the current population and economy of Cleveland. Sustainable Infrastructure can be defined as a decision making framework for capital spending that links asset management to an interest in green outcomes and an understanding that the most effective capital investments often integrate efforts across departmental silos. This approach often includes a triple bottom line framework for construction and operation, where project options are compared based on consistent environmental, social and economic metrics. Such strategies also adopt a more holistic approach to cost accounting including use of an asset management system for life cycle analysis, examining project costs from pre-construction to decommissioning to factor into decision making considerations such as durability, operations and maintenance costs, and end-of-life project costs. As upgrades are made to the current systems including water, sewer, and transportation, among others, considerations should be made to allow for flexibility to accommodate a variety of future growth scenarios, to potential impacts of a changing climate such as increased flooding, and the evaluation life cycle impacts in the design selection process. Opportunities should also be found in the existing infrastructure in the City, such as utilizing the excess capacity of Cleveland's streets to provide greater opportunities for complete and green streets programs.

Tree lined street in Cleveland

BENEFITS OF SUSTAINABLE LAND USE & CLEAN WATER

- Cost savings
- Reduced natural resource consumption
- Increased property values
- Improved aesthetics
- Improved air and water quality, health, and quality of life
- Comfort and livability
- Job creation and economic development
- Leadership and recognition
- Education and awareness
- Lower infrastructure costs per capita
- Reduced urban heat island effect

Ohio City Farm

OBJECTIVE: RESTORE AND REGENERATE THE NATURAL ENVIRONMENT

By valuing and leveraging the natural environment in new ways, Cleveland can create new sources of economic value while also creating a healthy and attractive place to live, work, and play.

ACTION 27: DEVELOP AND IMPLEMENT AN URBAN TREE PLAN TO GROW THE CANOPY

2030 Emissions Reduction Potential: 110,000 $MTCO_2e$ = 8,200 Cleveland homes

Trees provide many beneficial functions in cities, from helping capture and store carbon dioxide to providing shade and cooling to minimize the "heat island" effect. Shaded surfaces in cities may be 20-45°F cooler than the peak temperatures of un-shaded surfaces. Urban forests can also provide one long-term solution among many for the use of vacant lots across Cleveland while also helping to manage water runoff during and after rainstorms. For many native tree species, including oaks and maples, each tree planted prevents more than 1,000 gallons per year of stormwater from entering the sewer system. These long-term benefits of tree planting frequently outweigh the costs for planting and maintaining trees. A five-city study by the U.S. Environmental Protection Agency found that, on a per-tree basis, cities accrued benefits ranging from about $1.50–$3.00 for every dollar invested in trees . It is time to make Cleveland a "forest city" once again.

ACTION 28: SCALE UP THE LOCAL FOOD SYSTEM

Cleveland is a national leader in urban farming and gardening, but there is still much work to do. Some residents in Cleveland lack access to healthy food because they have limited incomes, do not live near markets where they can purchase healthy foods, or lack information on access to healthy and nutritious food choices. Expanding Cleveland's local food production can help provide more food choices and easier access to healthy food options while also enhancing the local economy through an expanded network of food producers, processors, and transporters. While having more access to locally-grown food can mean access to fresher produce, it can also help reduce GHG emissions associated with transporting food. According to the Leopold Center

FOCUS AREA 5
SUSTAINABLE LAND USE & CLEAN WATER

Lake Erie city view

Urban bioswale at Water Pollution Control

for Sustainable Agriculture at Iowa State University, food in the U.S. travels 1,500 miles on average from farm to consumer. By contrast, locally sourced food traveled an average of just 44.6 miles to Iowa markets. The conventional food distribution system used 4 to 17 times more fuel and emitted 5 to 17 times more of the GHG carbon dioxide (CO_2) than the local and regional systems. In addition to long-distant transport, food and farm systems contribute to climate change through the release of soil carbon as a result of common methods of plowing and tillage, the release of nitrous oxides from nitrogen fertilizers, and the embodied energy of farm inputs (which require significant energy to manufacture and distribute).

This action seeks to couple growth of the local food system with climate action by reducing emissions through sequestering carbon in our soils and plants, while at the same time storing and filtering our water.

ACTION 29: IMPLEMENT GREEN INFRASTRUCTURE TO CAPTURE STORMWATER ON-SITE

2030 Emissions Reduction Potential: 1,900 $MTCO_2e$ = 140 Cleveland homes

The City of Cleveland has a combined sewer system in which one pipe conveys both stormwater and sanitary sewage. During a rain storm, water flowing over hard surfaces (runoff) rushes quickly into sewers. To prevent urban flooding and damage to wastewater treatment facilities, some of this flow (a combination of stormwater and sewage) is allowed to overflow into area waterways at points called combined sewer overflows (CSOs). The Northeast Ohio Regional Sewer District (NEORSD) has 126 combined sewer outfalls and averages approximately 80 CSO events each year. Unless we act, climate change is expected to increase this number as a result of more intense rainfall and flooding in the region. The United States Environmental Protection Agency is requiring NEORSD to reduce the number of events to two (2) per year. The NEORSD will meet this goal mainly through a combination of large-scale storage tunnels and treatment plant enhancements.

A third approach being used to meet this goal is the implementation of green infrastructure. Stormwater control measures, such as constructed wetlands and bioswales, store, infiltrate, and evapotranspirate stormwater before it even makes its way to the combined sewer system. This "green infrastructure" can be less costly that traditional gray infrastructure, such as tunnels. In addition to potential cost savings, green infrastructure offers a range of other benefits to communities such as additional urban green space and recreational areas.

NEORSD's efforts to reduce CSO though both gray

and green infrastructure are collectively referred to as Project Clean Lake – a $3 billion, 25 year program for CSO control. In addition to Project Clean Lake, NEORSD has also implemented a Regional Stormwater Management Program. This Program will address flooding and erosion problems caused by a legacy of poor stormwater management within the City and across Northeast Ohio. Under the Program, NEORSD has developed a stormwater fee credit system in which property owners can reduce their stormwater fee through the implementation of approved stormwater control measures that will reduce the rate or volume of runoff.

The City and NEORSD are working together to use vacant lots for green infrastructure projects and implement the Complete and Green Streets program (see Action 21). Implementation of better stormwater management/green infrastructure as land is redeveloped in the City will minimize stormwater runoff, limit the impacts of flooding and erosion, save money for residents and local businesses by reducing their stormwater fee, reduce NEORSD's pumping and treatment costs, clean our water, and provide economic development opportunities to help rebuild our communities.

ACTION 30: INCREASE WATER CONSERVATION AND EFFICIENCY

2030 Emissions Reduction Potential: 9,300 $MTCO_2e$ = 700 Cleveland homes

Water efficiency and conservation includes a variety of solutions to reduce overall water use in the City such as efficiency upgrades to sinks, toilets, showers, and equipment and improved irrigation controls. Additionally, there are a number of instances where drinking water is used for purposes in which water treated to this quality is not required (landscape irrigation, process water use such as cooling towers, etc.) and where water reuse/recycling strategies can be implemented. Conserving water and using it more efficiently reduce distribution and treatment costs (pumping energy, chemicals, etc.) and related greenhouse gas emissions. They also reduce strain on Cleveland's water supplies, which could become stressed in the future as a result of climate change. Some water efficiency strategies, such as rainwater harvesting, also reduce stormwater runoff within the City.

Battery Park

FOCUS AREA 5
SUSTAINABLE LAND USE & CLEAN WATER

SUSTAINABLE LAND USE & CLEAN WATER NEXT STEPS TO BE COMPLETED BY 2016:

1. Conduct a comprehensive review of the city's zoning code to continue encouraging sustainable development and form-based codes. This can be informed by similar initiatives in other cities, such as Buffalo, Columbus, and New York City. (25)
2. Continue exploring creation of agriculture "overlay districts" and innovation zones to encourage local food production and capitalize on opportunities to re-use vacant land for urban agriculture. (25, 28)
3. Support implementation of the Ohio Lake Erie Commission's Protection & Restoration Plan (e.g., priority development and conservation areas). (25)
4. Develop a series of events, projects, and initiatives for 2015, the Celebration Year of Clean Water. (25-30)
5. Building on the "8 Ideas for Vacant Land Re-use in Cleveland" study, identify parcels best suited for tree planting, local food production, renewable energy, and stormwater management. (26-29)
6. Work with Cuyahoga County to develop an Urban Tree Canopy assessment to map the extent of the City's trees. Complement this analysis with neighborhood-level tree inventories. (27)
7. Building off of the data provided by the Urban Tree Canopy assessment, develop a comprehensive urban tree plan that identifies the key steps and resources needed to make Cleveland, once again, the "forest city". Part of this plan will include identifying tree species that can thrive in an altered climate. (27)
8. Along with planting trees, increase green spaces in and around Cleveland to reduce urban heat island effect and provide habitat for plants and animals. (27)
9. Couple growth in local food production with climate action by developing a stronger methodology for emission reductions/sequestration associated with local agriculture, among other actions. (28)
10. Support NEORSD in the development of an implementation strategy to encourage the adoption of on-site stormwater management for Cleveland residents and businesses. (29)
11. Develop a streamlined approach to creating"complete and green streets" that treat stormwater runoff with infiltration into vegetated areas along streets, reducing the amount of pollutants entering streams and lakes. (29)
12. Through education and outreach, link water efficiency and conservation upgrades to any energy efficiency programs being implemented under the Energy Efficiency and Green Building focus area. (30)

Note: (Related Action numbers shown in parentheses)

LEADING BY EXAMPLE

STORMWATER MANAGEMENT AND REINFRASTRUCTURE

The Northeast Ohio Regional Sewer District (NEORSD) is working with various stakeholders to implement numerous stormwater infrastructure projects throughout Cleveland and Northeast Ohio in response to a 2011 consent decree from the U.S. Environmental Protection Agency. The primary purpose of these projects is to reduce combined sewer overflow (CSO) events that result in untreated sanitary sewage waste flowing into waterways and Lake Erie during periods of heavy rain. Reducing and managing stormwater more effectively will reduce flooding, erosion, and water pollution. By involving neighborhood planners and urban designers, the projects will also result in new parks, streetscapes, community gardens, and public amenities.

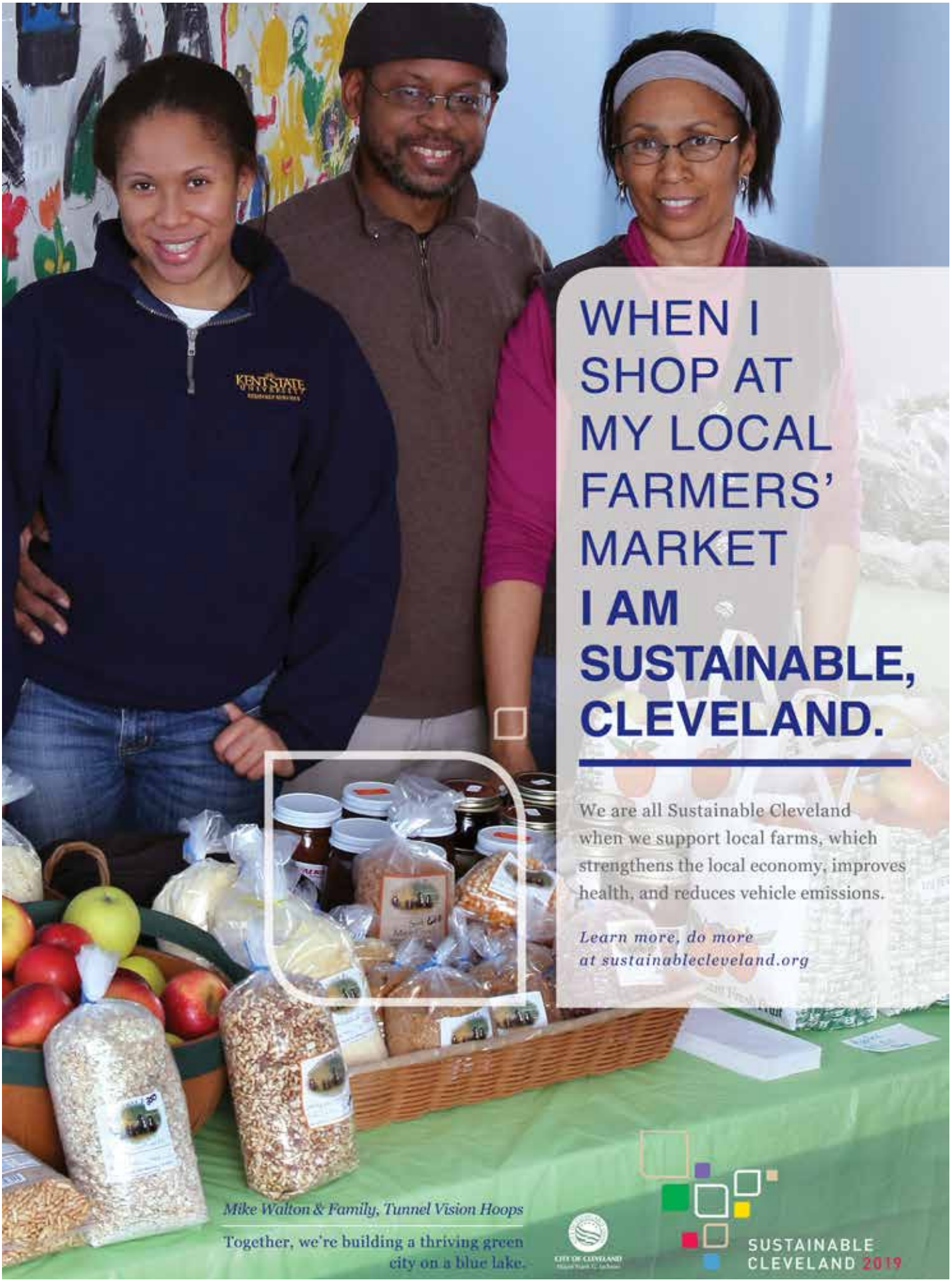
LEADING BY EXAMPLE

OHIO CITY FARM

In 2010 a collaborative effort of Cleveland organizations created one of the largest urban farms in the country. Known as Ohio City Farm, nearly six acres of formerly unused land adjacent to the West Side Market have been repurposed for urban agriculture, community development, and job training. The consortium of partners behind this effort includes Great Lakes Brewing Company, and not-for-profit organizations: The Refugee Response, Ohio City Near West Development Corporation, and Cuyahoga Metropolitan Housing Authority.

The Ohio City Farm is designed to incubate entrepreneurial farm businesses and support workforce development programs. Ohio City Farm provides urban farmers with low-cost land, shared facilities and technical assistance and is designed to develop and support entrepreneurial farmers. Incubator farm tenants are expected to run economically viable businesses and provide financial information on their operations.

(*Photo: Brad Masi*)


WHEN I SHOP AT MY LOCAL FARMERS' MARKET
I AM SUSTAINABLE, CLEVELAND.
We are all Sustainable Cleveland when we support local farms, which strengthens the local economy, improves health, and reduces vehicle emissions.
Learn more, do more at sustainablecleveland.org
Mike Walton & Family, Tunnel Vision Hoops
Together, we're building a thriving green city on a blue lake.
CITY OF CLEVELAND
SUSTAINABLE CLEVELAND 2019

FOCUS AREA 6

COMMUNITY ENGAGEMENT & PUBLIC HEALTH

GOALS:

- Reduce Cleveland GHG Emissions 800,000 $MTCO_2e$ by 2030
- Engage every Cleveland neighborhood in climate action, beginning with the two EcoDistricts and Greater University Circle
- Demonstrate a measurable improvement in climate change resilience related to all key impacts, especially for our most vulnerable populations
- Achieve attainment or maintenance status for all measured criteria pollutants
- Integrate adaptation into all relevant plans at City and County levels

KEY FACTS:

2012 was the warmest year on record in Cleveland, dating back to 1871 when record-keeping began. This excessive heat contributed to a higher number of Unhealthy Air Quality Days for Sensitive Groups in Cuyahoga County.

There are **15 Extreme Heat Cooling Centers** located in the City of Cleveland (59 in Cuyahoga County).

The City of Cleveland Department of Public Health manages **21 Air Quality Monitors**.

THE IMPORTANCE OF COMMUNITY ENGAGEMENT & PUBLIC HEALTH

Sustainable Cleveland's motto, "Together, we're building a thriving green city on a blue lake", emphasizes empowerment, cooperation, action, quality of life, and abundance. People, not programs, are the answer to true and lasting climate action in Cleveland. This means that a whole system, citizen-centered approach will be needed to align climate action with the assets, capacity and priorities of Cleveland residents and business owners. Whole system change is the transformation of an entire organization at one time. For the purposes of this plan, the whole system includes residents from every Cleveland neighborhood, business owners, and stakeholders from many organizations and corporations.

This plan contains a lot of information about the imperative to take action in the face of climate change. However, current research demonstrates that too much information and a fear-based approach is a barrier to individual climate action. People do not generally take action because of information or fear; they take action for something they care about.

Building off of the asset-based Appreciative Inquiry method used during the annual Sustainable Cleveland summits, asset-based community development (ABCD) is a strength-based methodology for sustainable development. The key principles of ABCD are to 1) support communities to discover what their assets are, 2) discover what they care about enough to act on and 3) discover how they can act together to achieve those goals. In order for Cleveland residents to care about and to act upon climate change, it must connect to their everyday lives; they need to recognize climate change and climate action in their own backyards.

By building upon what most people care about—safety, health, youth, education, jobs—there is potential to engage Cleveland's residents and to be led in more creative directions as we take climate action.

"When people discover what they have, they find power. When people join together in new connections and relationships, they build power. When people become more productive together, they exercise their power to address problems and realize dreams."

- Mike Green, When People Care Enough to Act

FOCUS AREA 6
COMMUNITY ENGAGEMENT & PUBLIC HEALTH

Table 2: Examples of Cleveland organizations with Greenhouse Gas and Energy Reduction Goals

Leading Organization	***Reduction Goal***
Case Western Reserve University	Carbon neutral by 2050
City of Cleveland	Reduce GHG emissions 50% by 2030
Cleveland Clinic	Reduce energy use by 20% by 2020
Cleveland Public Power	Reduce dependence on fossil fuels, purchase power from renewable energy sources (15% by 2015, 20% by 2020, 25% by 2025)
Cuyahoga Community College	Carbon neutral by 2050
Eaton Corporation	Reduce energy use 25% by 2015 (global goal)
Greater Cleveland Regional Transit Authority	Reduce GHG emissions by 30% by 2016
KeyBank	Reduce energy use 20% by 2016, 2009 baseline
Parker Hannifin	Reduce energy intensity by 3% per year
Tremco	Reduce energy use 50% by 2020

OBJECTIVE: ORGANIZATIONS, NEIGHBORHOODS, AND INDIVIDUALS BECOME CLIMATE LEADERS

Participation by the Cleveland community is crucial to the successful implementation of this plan.

ACTION 31: PROMOTE LEADING LOCAL BUSINESSES STRIVING TO MEET ENERGY AND CARBON REDUCTION GOALS

2030 Emissions Reduction Potential: 800,000 MTCO2e = 60,000 Cleveland homes

There are a number of stakeholders within the City of Cleveland that have developed their own climate action plans and/or set their own targets for GHG or energy reduction (see Table 2). Supporting the growing number of leading organizations in meeting their internal GHG reduction goals will help the overall Cleveland community achieve its goals for emissions reduction. In order to meet the goal of 40% emissions reduction by 2030, behavior change among residents/employees and additional reductions among leading businesses would need to reduce emissions by a total of 0.8 million MTCO2e in addition to the strategies elsewhere in this plan.

ACTION 32: RECOGNIZE CAPACITY OF NEIGHBORHOOD AND COMMUNITY GROUPS TO IMPLEMENT CLIMATE MITIGATION AND ADAPTATION INITIATIVES

There are many opportunities for partnering with neighborhood and community groups to take action on climate. Examples include:

- Every person who lives or works in the City of Cleveland has the opportunity to sign the Cleveland Commitment, a pledge to incorporate green practices in every aspect of their daily lives. Northeast Ohioans can also sign the LEEDCo Power Pledge, demonstrating support for the offshore wind energy project.

- The Sustainable Cleveland website should be adapted to integrate climate action into the toolkits

for "At Home", "At Work" and "In the Community" as well as link those actions to the Indicators Dashboard. It's valuable to show the link between individual action and macro level indicators.

- The I am Sustainable Cleveland campaign, blog, social media and monthly newsletters can be used to connect people to resources by sharing success stories and new ideas.

- Explore use of the Cleveland Carbon Fund, Neighborhood Connections, and others to fund neighborhood-based climate action in Cleveland.

- Fun and friendly competitions and recognition programs can act as motivators for concrete actions and results. Examples include photo and essay contests for school children or a "most unusual reuse" contest for all ages.

I am Sustainable, Cleveland. campaign

FOCUS AREA 6
COMMUNITY ENGAGEMENT & PUBLIC HEALTH

KEY BENEFITS OF COMMUNITY ENGAGEMENT & PUBLIC HEALTH

- Cost savings
- Reduced natural resource consumption
- Civic engagement
- Increased property values
- Improved quality of life
- Reduced vulnerability to energy cost volatility
- Job creation and economic development
- Improve aesthetics
- Improved air quality and health
- Improved water quality
- Comfort and livability

- Financial incentives have always been a driving motivator for change. These incentives do not have to come in the way of tax credits alone. Emphasis must be placed on the cost/benefit analysis in implementing new sustainable habits. When clearly shown that these practices save money and help make Cleveland a more livable city, change will be accepted and promoted more readily.

- Collaborate with existing neighborhood-based organizations to identify grassroots leaders who are champions in sustainability.

- Several business sector awards programs, which already exist in the market, are well known and have great participation. Partner with Crain's Cleveland Business Emerald Awards, Cleveland Magazine's Best of Cleveland awards, and others to encourage residents and small business owners to live more sustainably.

Community Involvement in creating a rain garden

- The Cleveland Metropolitan School District has been engaged with Sustainable Cleveland since 2009 and most recently has used the Celebration Year topics as the basis for their district-wide Rock Your World with STEAM program. STEAM stands for Science, Technology, Engineering, Arts, and Math and is an integrated curriculum project that each school creates.

- Engaging students at all levels creates future generations of concerned and informed citizens. Sustainability can be integrated into the curriculum of pre-schools, elementary and secondary schools, community colleges, and universities.

- Promote and encourage the Roots of Success Program to help residents become aware of the job opportunities related to climate action and sustainability.

- Develop Climate 101 workshops that can be easily hosted by grassroots organizations and also offered as content for TV20, the Sustainable Cleveland website, and educational materials of partner organizations. These topics (with appropriate interview resources) could also be offered to local media for their use in programming/publication.

To bring many of these ideas together, a neighborhood climate action toolkit is being created that includes best practices for resident engagement around climate and sustainability. This toolkit will be piloted in two EcoDistricts (Detroit Shoreway and Kinsman) and Greater University Circle. The neighborhood toolkits will grow out of learning conversations to identify the priorities of citizens that can be addressed through climate action. Tools will be tested in the neighborhoods to see how well they engage and draw interest and feedback from citizens. In addition, each neighborhood will have a GHG inventory and narrative to allow for tracking performance and identifying key opportunities for taking action. If successful, this toolkit can be rolled out in neighborhoods throughout Cleveland, including a process for financing neighborhood-based climate action projects.

OBJECTIVE: IMPROVE PUBLIC HEALTH AND RESILIENCY TO CLIMATE CHANGE IMPACTS

Improving public health will better prepare Clevelanders for climate change impacts.

ACTION 33: CONDUCT CLIMATE CHANGE VULNERABILITY ASSESSMENT AND INTEGRATE PROJECTED IMPACTS INTO EXISTING PLANS

While the City works to reduce GHG emissions and their impact on climate change, it can also develop strategies to adapt to an already-changing climate. From the GHGs that have already been emitted globally, Cleveland can expect longer and more pronounced heat waves, greater impacts to air quality during such heat waves, and heavier storm events. These changes to our climate can particularly impact vulnerable populations, such as the poor, elderly, children, and those suffering from certain illnesses.

The City's Emergency Operations Plan addresses these impacts with policies and procedures for heat days, power outages, flooding and disease outbreaks. Better understanding the frequency and severity of these impacts will help the City and other agencies plan ahead. This includes, for example, finding ways to cool and shade the City to reduce the heat island effect (see Figure 4 and Urban Forest Action 27) while also providing support such as cooling centers during prolonged heat waves. Rapid response mechanisms such as alerts to reduce driving can also be deployed to reduce air pollution impacts from high levels of ozone on hot days. Models to predict how stormwater runoff will change over time can be used to anticipate what sort of stormwater treatment will be needed in the future. The City can also engage other community stakeholders to develop strategies and response mechanisms including social service agencies and the healthcare sector.

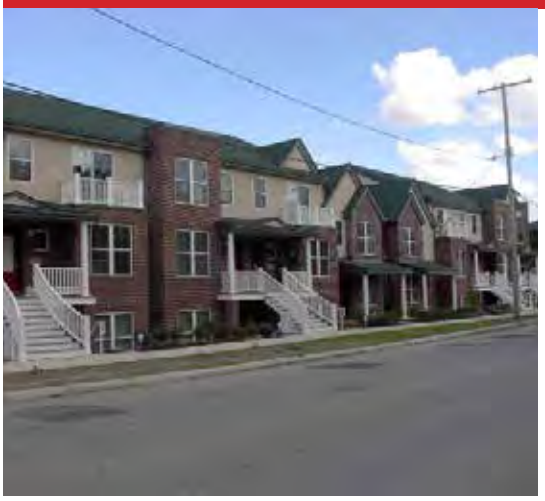
Kurents in Cleveland 2013 Kurentovanje Parade (Photo: Andy Kinney)

Chess at Edgewater (Photo: Trish DiFranco)

FOCUS AREA 6
COMMUNITY ENGAGEMENT & PUBLIC HEALTH

LEADING BY EXAMPLE

KINSMAN AND DETROIT SHOREWAY ECODISTRICTS





EcoDistricts are neighborhoods that develop comprehensive district-scale strategies in the areas of energy, water, waste, recycling, green infrastructure and mobility. When done comprehensively, these strategies can improve affordability, livability and overall quality of life for residents; enhance community identity; and reduce the burden on municipal infrastructure. They also provide a framework from which to implement innovative sustainability features and strategies. Cleveland is home to two EcoDistricts: one in the Kinsman neighborhood on the east side, and one in the Detroit Shoreway area on the near west side.

The EcoVillage in the Detroit Shoreway neighborhood was designated the country's first urban EcoDistrict in 1998 when a grant from the U.S. EPA established the area as a national demonstration project. Projects in the EcoVillage, both completed and underway, have shown that sustainability principles can be used effectively as a long-term vehicle for urban re-investment and socially responsible neighborhood renewal. Features of the EcoVillage include:

- Twenty-four energy efficient market rate and affordable homes
- Twenty-two townhomes being built to Enterprise Green Communities standards (Waverly Station)
- Vacant land reclamation through the creation of greenspace, community gardens, and a resident-run chicken cooperative

- The City's first green, rapid transit station at West 65th Street
- A green surface parking lot to be developed by Metro Catholic School including native vegetation, bioswales and other sustainably developed features

The Kinsman neighborhood contains a unique range of sustainability efforts, centered around the Urban Agriculture Innovation Zone. Burten Bell Carr Development, the neighborhood community development corporation, is in the process of assembling land from the major land holders to turn this food desert into a center of urban agricultural production. Sustainability projects that have been planned, are in progress, or have been completed within the last three years in the Kinsman EcoDistrict include the following:

- **Urban Agriculture Innovation Zone:** Nearly 8 acres of urban agriculture has been established in what is being planned as the largest urban agriculture district in the U.S. The community's vision is to repurpose a total of 28 acres of vacant land.
- **Rid-All Green Partnership:** A group of three childhood friends with roots in the Kinsman neighborhood has cultivated 350 pounds of tilapia, 14,000 pounds of produce, and 1,200 cubic yards of compost on an acre-and-a-half parcel in the Urban Agriculture Innovation Zone in 2012.
- **Kinsman Farm:** Funded by a $1.1 million grant from the U.S. Department of Agriculture, Kinsman Farm is a six-acre urban agriculture incubator for both experienced and beginning farmers. Currently, twelve market gardeners from all walks of life each have a quarter-acre plot of repurposed vacant land for farming. The market gardeners, which harvested more than 22 different types of fruits, vegetables, and herbs in the farm's second year in 2012, sell the produce they grow to local restaurants and at farmers markets.
- **Healthy Food Access Initiative:** This initiative includes four components: 1) a healthy food restaurant, which sells fresh fruits and vegetables in addition to healthy alternatives to fast food; 2) a multi-purpose community space in which cooking, nutrition, and other health-related classes are held; 3) a mobile market that travels to housing estates, apartment complexes, houses of worship, and sells fresh produce where people live, work, and worship; 4) a farmers market.
- **Green City Growers Greenhouse:** A 3.25-acre hydroponic greenhouse in which three million heads of lettuce and 300,000 pounds of herbs are grown annually and distributed within a 150-mile radius opened for business in December 2012. The $17 million project employs low-income residents from the surrounding neighborhoods, and those employees will become owners of the business over time.
- **Heritage View Homes:** A $100 million project, Heritage View Homes replaces 628 units of antiquated public housing units with 350 new-construction townhomes, single-family homes, and apartments. The project, initiated by the Cuyahoga Metropolitan Housing Authority, includes solar panels, geothermal heating, permeable driveways and walkways, well-insulated walls, Energy Star appliances, low-flow water fixtures, and materials built and made in Ohio.
- **Cuyahoga Metropolitan Housing Authority Headquarters:** Cuyahoga Metropolitan Housing Authority centralized its many offices and facilities in one location, bringing more than 400 employees to the Kinsman neighborhood. The building, which was constructed on a former brownfield, received LEED Silver certification. Additionally, 70% to 80% of the housing authority's electricity demands are generated by 4,200 solar panels installed on a six-acre site (see Advanced & Renewable Energy focus area).

FOCUS AREA 6
COMMUNITY ENGAGEMENT & PUBLIC HEALTH

COMMUNITY ENGAGEMENT & PUBLIC HEALTH NEXT STEPS TO BE COMPLETED BY 2016:

1. Coordinate with large emitters in the City to identify opportunities to support their emission reduction efforts, and to inspire others. (31)
2. Provide support services and training tailored to the needs of the local workforce, especially for the growing green job industries. (32, 33)
3. Consider development of a behavior wedge profile for Cleveland to prioritize behavior changes and calculate cost and benefit. (32)
4. Inform houses of worship about Interfaith Power & Light and Greenfaith Certification Programs, among other opportunities. (32)
5. Collaborate with the arts and cultural institutions on performances and exhibits that incorporate sustainability. (32)
6. Consider crowd-funding (e.g., Solar Mosaic) or other models that focus on urban environments (e.g., Cleveland Carbon Fund) as ways to generate funding for neighborhood projects. (32)
7. Partner with education sector to integrate sustainability into pre-K through college curriculum. (32)
8. Expand the "I am Sustainable, Cleveland" marketing campaign. (32)
9. Complete a Neighborhood Climate Action Toolkit pilot in the two EcoDistricts and Greater University Circle, and roll out to all neighborhoods in partnership with Community Development Corporations. (32)
10. Update the GHG inventory at least every two years, and share results with the community. (32)
11. City to report the GHG inventory, mitigation actions, and adaptation actions to the Carbon Disclosure Project at least every two years. (32)
12. Advocate for strong energy efficiency and renewable energy standards. (32)
13. Build off Green Venues work to identify sustainability champions, and celebrate those successes. (32)
14. Develop green guide and map for tourists and Cleveland residents alike. (32)
15. Convene a climate adaptation subcommittee that includes climate scientists, adjacent jurisdictions, regional organizations and coalitions, emergency management, the social service and health care sectors, and community organizations for the purpose of understanding shared vulnerabilities and developing specific adaptation actions. (33)
16. Incorporate the current and projected impacts of climate change into: (33)
    a. City of Cleveland Emergency Operations Plan
    b. Cuyahoga County's Threat and Hazard Identification and Risk Assessment
    c. Cuyahoga County's All Natural Hazards Mitigation Plan
    d. Emergency operations of other key organizations, including hospitals

17. Continue to work with social service and health care stakeholders to increase support for vulnerable populations through actions such as providing cooling shelters during heat waves and alerting people during days of poor air quality. (33)
18. Partner with higher education researchers on a variety of climate and sustainability opportunities, such as modeling future stormwater runoff scenarios to inform stormwater capital improvement planning (34). Coordinate with NOACA to evaluate the feasibility of deploying rapid traffic management strategies to reduce ground-level ozone during times of excessive heat. (33)

Note: (Related Action numbers shown in parentheses)

NEXT STEPS: A ROLE FOR EVERYONE

The development of Cleveland's first community Climate Action Plan is a major step toward managing community GHG emissions and preparing for an already changing climate, while simultaneously furthering community economic development and sustainability. This Plan is meant to be a living document, subject to further review and revision as actions are implemented, progress is monitored and measured, new actions are developed, and objectives and actions are revisited. The Mayor's Office of Sustainability plans to convene key stakeholders every three years to review and revise the Climate Action Plan.

BUILDING ON COMMUNITY PARTNERSHIPS

As discussed under many of the focus areas, objectives, and actions in the Climate Action Plan, partnerships are a particularly important component of implementation. Cleveland is fortunate to have the resources and framework of Sustainable Cleveland 2019 - including many community partners with an interest in sustainability in general, as well as specific actions in the CAP. Valued partners include colleges, universities and other higher education institutions; non-profit and community organizations; the business community; the building industry and professional organizations; communities of faith; and others. Such partnerships can be leveraged to share resources and expertise, but also ensure that climate resiliency becomes part of the fabric of the community, and not an effort dependent on a small handful of champions. Through the Office of Sustainability, the City will continue to work with key stakeholders, Sustainable Cleveland working groups, and community members to build partnerships that support implementation of this Plan.

FUNDING ONGOING EFFORTS

While many of the actions require limited funding, some certainly do. Fortunately, various financing options are available for GHG emission reductions and other sustainability strategies identified in the CAP. One such tool that communities and organizations are using is a revolving loan fund, whereby the City starts by implementing energy saving measures that have no or minimal upfront costs and then uses money savings from these measures to establish the account. This fund can then be used, in turn, to help fund future sustainability initiatives that require some upfront money. Municipalities and businesses can also choose a self-financing model to perform energy/sustainability projects, which allows them to control all aspects of the project while getting assistance from consultants as needed.

Additional popular and successful financing mechanisms for local governments include grants and performance contracts for energy efficiency projects, because neither of these options rely on upfront capital funding. Funding is yet another area where partnerships can be used to leverage resources, such as collaborating with the higher education community on grant proposals; exploring joint public-private partnerships; and seeking out "in-kind" assistance for implementation, such as academic research projects or volunteer programs.

MONITORING PROGRESS

The City and its community partners will be working to establish an implementation monitoring program to track progress over time as the CAP's 33 actions are completed. Implementation of actions will be documented for future reference and shared with the community through SustainableCleveland.org and other outlets. For instance, what was the actual cost of a given action and when was it implemented? Who was involved, and what were their tangible indications of success, such as number of participants, number of residences retrofitted, or tons of GHG reductions achieved? This type of information can be used to celebrate success, adjust actions and implementation steps as desired, or introduce new actions in future updates of the Plan.

A key component of the CAP will also be a set of specific performance metrics that can be used for internal management of GHG reduction and annual public reporting on progress toward the Plan's goals. The City and its community partners are already tracking some performance metrics related to the Plan. As actions are implemented, progress will be tracked and presented on the Sustainable Cleveland website through the Dashboard project and other means.

HOW YOU CAN HELP

While the Climate Action Plan establishes a framework for reducing GHG emissions in Cleveland and provides the initial stepping stones toward goals and objectives, it is ultimately up to all Clevelanders to take steps to reduce GHG emissions at home, at work, and in our communities.

For information, visit www.SustainableCleveland.org.

GLOSSARY

(Adapted from U.S. EPA website, http://www.epa.gov/climatechange/glossary.html)

Adaptation: Actions that help human society and natural systems prepare for and become less vulnerable to a changing environment.

Carbon Dioxide: A naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal human-caused greenhouse gas (GHG) that affects global warming.

Carbon Footprint: The total amount of GHGs that are emitted into the atmosphere each year by a person, family, building, organization, or company. A person's carbon footprint includes GHG emissions from fuel that an individual burns directly, such as by heating a home or riding in a car. It also includes GHG that come from producing the goods or services that the individual uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash is sent.

Climate: Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands of years. The classical period is three decades, as defined by the World Meteorological Organization.

Climate Change: Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.

Evapotranspiration: Evapotranspiration is the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. Evapotranspiration is an important part of the water cycle.

Greenhouse Effect: Trapping and build-up of heat in the atmosphere near the Earth's surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the Earth's surface. If the atmospheric concentrations of these GHGs rise, the average temperature of the lower atmosphere will gradually increase.

Greenhouse Gas (GHG): Any gas that absorbs infrared radiation (heat) in the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.

Mitigation: Actions that reduce GHG emissions and help to slow climate change.

Resilience: A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

Sustainability: Living today in a way that does not degrade natural systems or compromise the ability of future generations to have a high quality of life.

Weather: Atmospheric conditions at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate is usually defined as the "average weather."

END NOTES

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[viii]Teaching Cleveland. Regional Government vs. Home Rule. http://www.teachingcleveland.org/index.php?option=com_content&view=article&id=602:regional-government-vs-home-rule-&catid=50:regional-govt-vs-home-rule&Itemid=124

[ix]Adapted from corporate scope diagram in The Greenhouse Gas Protocol, WBCSD/WRI

[x]Only two-thirds of Arcelor Mittal's operations occur within the City of Cleveland, however all of their emissions have been included in the City's GHG inventory.

[xi]The Medical Center Company. Energy Efficiency Grant Fund. http://www.mcco.org/Services/MCCo_Energy_Efficiency_Grant_Fund.html

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[xiii]OhioRideshare is a tool for matching carpool riders with each other.

[xiv]RTA HealthLine Fact Sheet. http://www.rtahealthline.com/healthline-who-helps.asp

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[xvii]Northeast Ohio Regional Sewer District. Stormwater Fee Credit Manual. http://www.neorsd.org/I_Library.php?a=download_file&LIBRARY_RECORD_ID=4699

Wade Oval Wednesdays in University Circle (Photo: Edward Frierson)

West Side Market (Photo: Jenny Sanders)

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The City of Cleveland would also like to thank the numerous community members that provided valuable input on the Climate Action Plan.

Downtown Cleveland (Photo: Mike Bacanu)

Appendix J:

Re-Imagining a More Sustainable Cleveland: Citywide Strategies for Reuse of Vacant Land

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RE-IMAGINING

A MORE SUSTAINABLE CLEVELAND

RE-IMAGINING A MORE SUSTAINABLE CLEVELAND

Citywide Strategies for Reuse of Vacant Land

Adopted by the Cleveland City Planning Commission on December 19, 2008

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CONTENTS

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PURPOSE

Creating opportunities for all people, fair access to resources, commitment to healthy places for children, and using our ingenuity to capitalize on our assets are the values that are at the core of Re-imagining a More Sustainable Cleveland. This one year planning process explored strategies for reuse of vacant land with the goal of making Cleveland a cleaner, healthier, more beautiful, and economically sound city. The 30-member working group was convened by Neighborhood Progress in collaboration with the City of Cleveland and Kent State University's Cleveland Urban Design Collaborative with funding from the Surdna Foundation.

This report summarizes the goals, principles and strategies for returning vacant properties to productive use at the city-wide scale. It identifies policy changes that will enable the city to better make use of this growing resource. The report also includes a range of potential pilot projects meant to illustrate and test the principles, and to build capacity for the strategic management of vacant land throughout the city.

Going forward, the City of Cleveland has the opportunity to use its excess land in ways that:

- advance a larger, comprehensive sustainability strategy for the city,
- benefit low-income and underemployed residents,
- enhance the quality of neighborhood life
- create prosperity in the city
- and help address climate change.

With the support of community partners, the Surdna Foundation, and other funders, Neighborhood Progress, Inc. is committed to implementing pilot projects over the next several years and assisting the city and other partners in determining how to bring the most successful ones to scale.

FIG 1 **CLEVELAND POPULATION LOSS**[1]

Year	Population
1950	914,808
1990	505,616
2000	478,403
2007	438,042 (estimated)
2016	387, 039 (projected)

INTRODUCTION

Re-imagining a More Sustainable Cleveland starts from the premise that the loss of population over the last 60 years is not likely to be reversed in the near term and that Cleveland's future ability to attract and retain residents depends in large part on how the city adapts to population decline and changing land use patterns. The reuse of vacant land is crucial to Cleveland's potential to be a "green city on a blue lake."

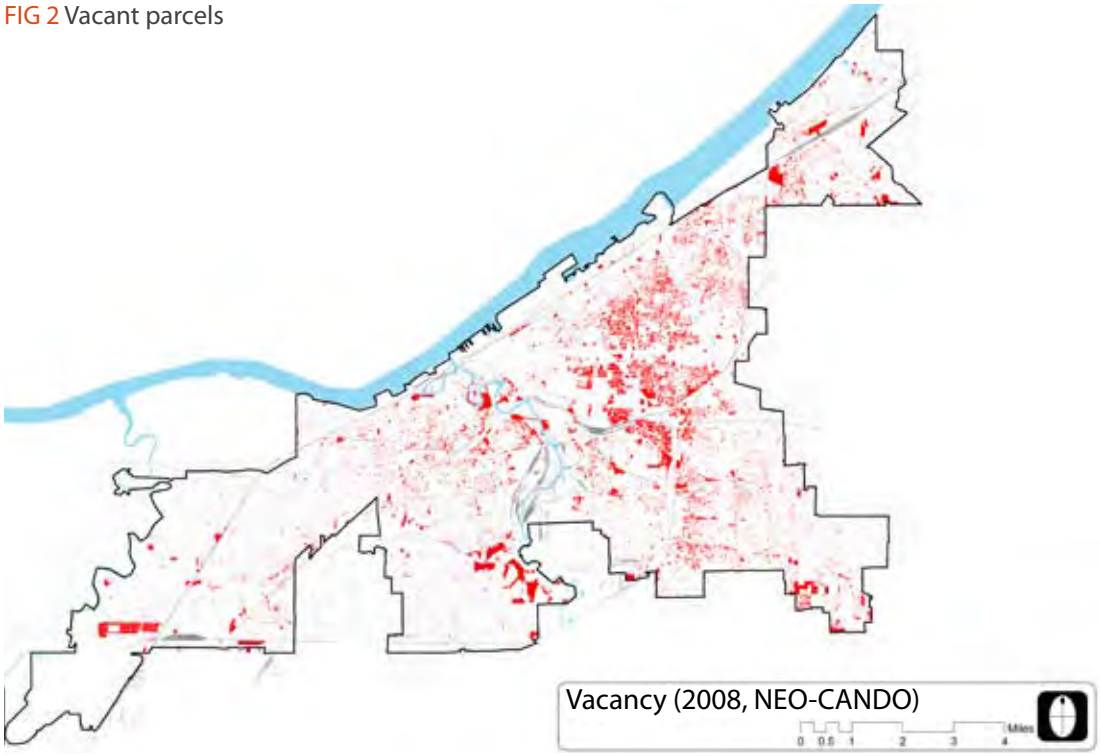
There are approximately 3,300 acres of vacant land within city limits, and an estimated 15,000 vacant buildings. Many of these vacant properties are poorly maintained and they diminish the value of the remaining, more viable buildings and neighborhoods in the city. The city demolishes about 1,000 vacant houses per year; private demolitions and fires are also reducing the number of derelict structures in the city. After demolition, surplus land becomes a raw asset for the city–a resource for future development as the city's population stabilizes and progress is made toward recovery. The *Re-imagining a More Sustainable Cleveland* working group was formed to explore ways to put this land to productive use. This includes short-term holding strategies to stabilize neighborhoods while we anticipate more permanent development solutions, and long-term reuse strategies for parts of the city where demand for traditional development is limited or non-existent.

The *Re-imagining a More Sustainable Cleveland* group included city staff, representatives from community development corporations, local non-profit organizations, the Cuyahoga County Planning Commission, the Northeast Ohio Regional Sewer District, and the Cleveland Metroparks. A complete list of participants is found in the Acknowledgements section.

The *Re-imagining a More Sustainable Cleveland* process was grounded in the principles of the Lake Erie Balanced Growth Initiative. This initiative encourages the establishment of priority development areas and priority conservation areas as a way of promoting smart growth while protecting Lake Erie and other natural resources in Northeast Ohio. Because of the growing supply of vacant land in Cleveland, the city is now in a position to make decisions about where development should occur and where land should be set aside and not developed.

1 The Northern Ohio Data and Information Service, February 2008.

FIG 2 Vacant parcels



The *Connecting Cleveland 2020 Citywide Plan* identifies Core Development Areas that concentrate development in catalytic locations along the lakefront and the river, Euclid Avenue and the opportunity corridor, and the downtown, airport, and University Circle [Figure 4]. These areas are, in effect, the priority development areas for the city of Cleveland. The *Re-imagining a More Sustainable Cleveland* process focuses on the parts of the city outside of the Core Development Areas, to identify ways to derive measurable benefits from vacant properties in these areas. These benefits include cleaner air and water, greater access to parks and recreation, improved local food security, and neighborhood-based economic development.

The lack of strong market demand and an abundance of vacant land create unprecedented opportunities to improve the city's green space network and natural systems. Capitalizing on this moment to set aside land for recreation, agriculture, green infrastructure, and other non-traditional land uses will benefit existing residents and help to attract new residents and development. By balancing current and future demands for new development with the conservation of key sites across the city, Cleveland can reinvent itself as a more productive, sustainable, and ecologically sound city.

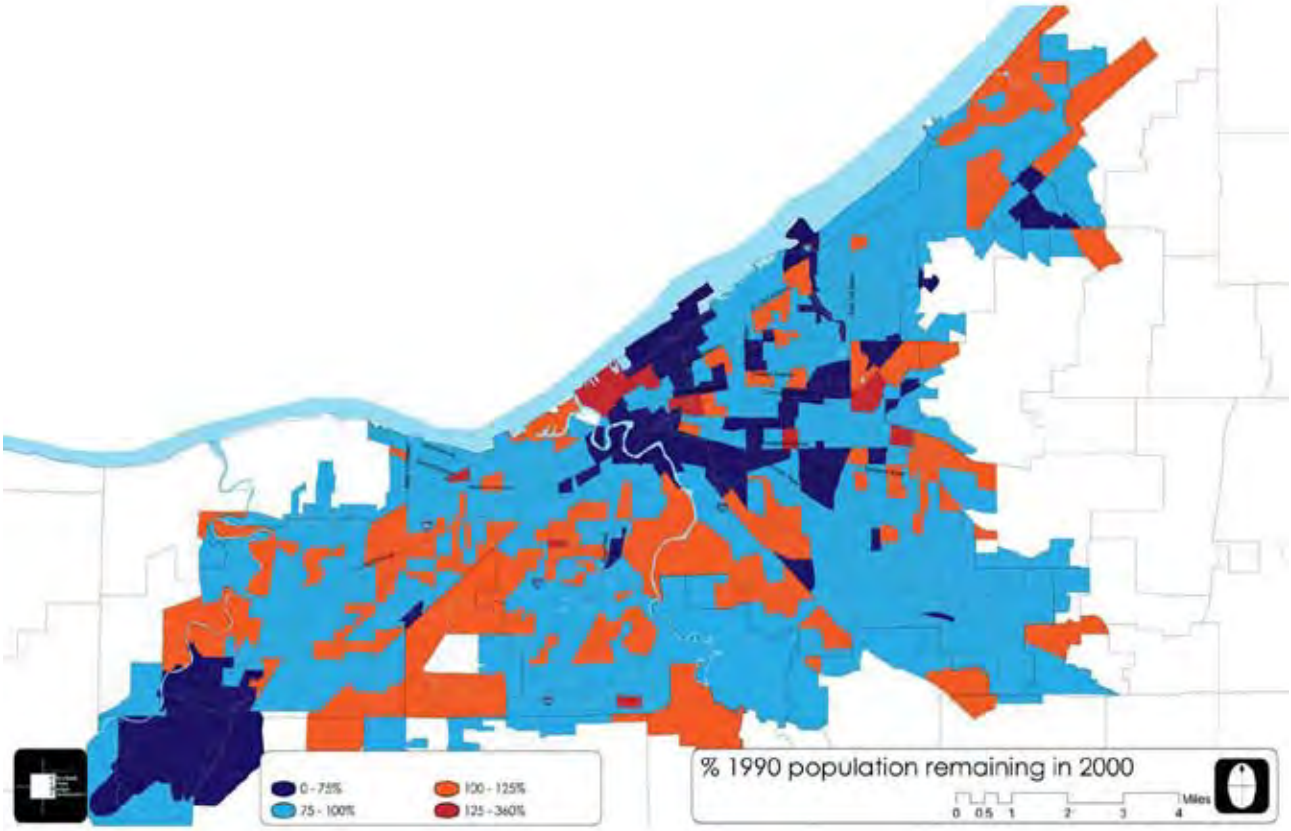


FIG 3 Population Change in Cleveland Neighborhoods

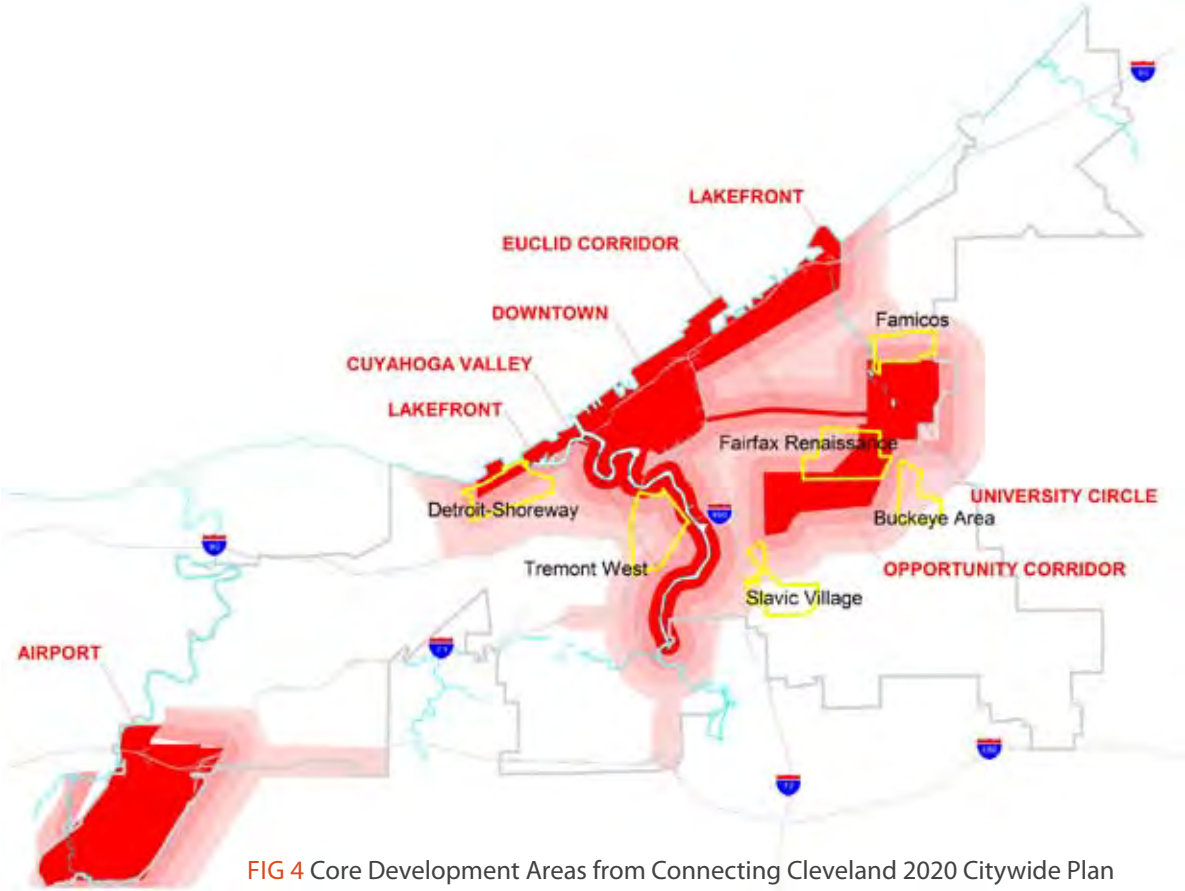


FIG 4 Core Development Areas from Connecting Cleveland 2020 Citywide Plan

EXECUTIVE SUMMARY

Given the large and growing inventory of vacant properties in the City of Cleveland, it is unlikely that all of the city's surplus land will be reused for conventional real estate development in the foreseeable future. The alternative land use strategies described in this document are intended to put vacant properties to productive use in ways that complement the city's long-term development objectives. Whatever the ultimate use of vacant properties in Cleveland will be, the following goals should be addressed:

> **PRODUCTIVE USE / PUBLIC BENEFIT** Whether vacant properties are developed with buildings and infrastructure, preserved as open space, or put into productive use as agriculture or energy generation sites, they should provide an economic return, a community benefit, and/or an enhancement to natural ecosystems.
>
> **ECOSYSTEM FUNCTION** Stormwater management, soil restoration, air quality, carbon sequestration, urban heat island effects, biodiversity, and wildlife habitat should be incorporated into future plans for vacant sites in the city.
>
> **REMEDIATION** Remove the risk to human health and the environment from environmental pollutants at vacant sites, either with targeted remediation projects or with long-term incremental strategies.

This plan identifies a range of vacant land strategies including:

1. Neighborhood stabilization and holding strategies
2. Green infrastructure strategies to expand recreation opportunities and the green space network, improve ecosystem function and remediate contaminated properties
3. Productive landscapes (i.e. agriculture and energy generation)

The plan identifies criteria for implementing each of these strategies, as well as policy recommendations to support and promote the creative re-use of vacant properties throughout the city. The plan also describes a series of initial pilot projects and proposed research initiatives in support of a comprehensive citywide initiative to manage and reuse properties.

GOALS and STRATEGIES for VACANT LAND RE-USE

The goals of the *Re-imagining a More Sustainable Cleveland* process were to:

- Identify ways to derive quantifiable benefits from the city's growing inventory of vacant property;
- Promote opportunities for the strategic reuse of vacant sites that support redevelopment efforts in the City of Cleveland;
- Link natural and built systems within the city in ways that improve the quality of life and the long-term health of residents and the environment; and
- Increase community self-reliance for food and energy production

To achieve these goals, the working group explored a variety of strategies for using and managing vacant properties, including:

1. Neighborhood stabilization and holding strategies in prime development areas and transitional neighborhoods;
2. Green infrastructure strategies, including the expansion of parks and natural areas, and linkages between green space amenities within the city and region, ecosystem restoration to manage stormwater, reduce urban heat island effects, and enhance biodiversity, and remediation for contaminated sites; and
3. Productive landscapes as an economic development strategy;

NEIGHBORHOOD STABILIZATION and HOLDING STRATEGIES can be used to manage vacant and abandoned properties and establish a sense of stewardship and care in transitional neighborhoods. These strategies are intentionally low-cost and low maintenance. They are most effective in areas where development is likely in the near-term.

Neighborhood blocks with many unmanaged vacant lots result in lower residential property values. A study of property values in Philadelphia determined that derelict vacant sites caused a reduction in property values for surrounding houses of about 18%, while the clean-up and landscaping of vacant lots can increase adjacent property values by as much as 30%.[1]

Criteria for implementing holding strategies on vacant sites include:

- Site has strong development potential within the next five years.
- Property owner or community partner has the capacity to install and maintain landscape intervention.

---

1 Susan Wachter, "The Determinants of Neighborhood Transformation in Philadelphia: Identification and Analysis—The New Kensington Pilot Study," Wharton School, University of Pennsylvania, the William Penn Foundation, and the Pennsylvania Horticultural Society, 2005.

NEIGHBORHOOD STABILIZATION AND HOLDING STRATEGIES

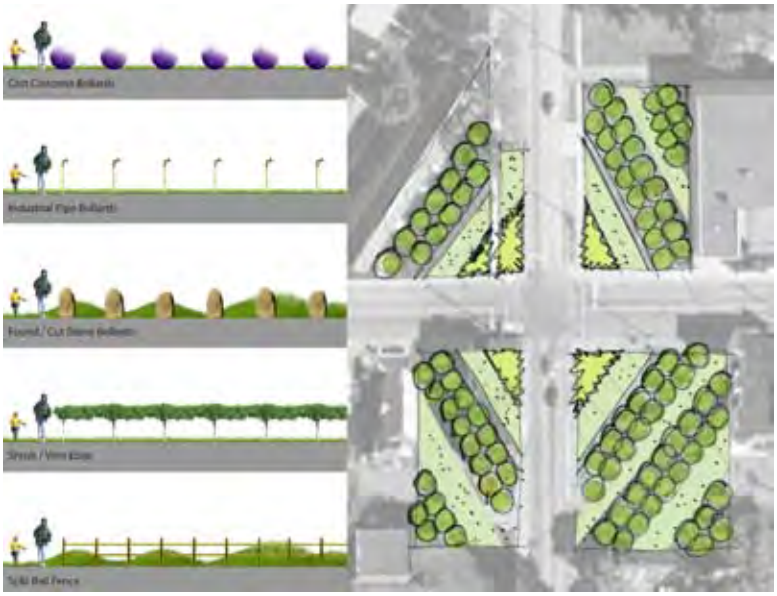


FIG 5 Trees and bollards on vacant sites enhance perceptions of maintenance and deter illegal dumping

FIG 6 Low-mow native plant materials create a patterned landscape as a holding strategy

In some neighborhoods where single vacant lots are scattered throughout residential blocks, lot consolidation and side yard expansion can be an effective way to achieve neighborhood stabilization. By encouraging existing property owners to take title to adjacent lots and become responsible for their maintenance, derelict sites are eliminated and these properties are returned to the city's tax rolls.

A variety of neighborhood stabilization and holding strategies are detailed in the *Vacant Land Pattern Book* produced by the Cleveland Urban Design Collaborative for Neighborhood Progress, Inc. These strategies include low-mow native landscapes that can be installed over large areas at a relatively low cost. Once established, low-mow landscapes require relatively little maintenance but reinforce a perception that vacant sites are being cared for. Trees can also be used as a holding strategy for vacant sites where development is anticipated. Rows of trees planted at distinct angles create a landscape that looks intentional, rather than neglected. These trees can be transplanted at the street edge when development occurs.

GREEN INFRASTRUCTURE

Green infrastructure is an interconnected network of open spaces that provides recreation resources, stormwater management, ecological benefits, and opportunities to remediate environmental toxins. Green infrastructure strategies for vacant sites in Cleveland are described below and include the expansion of the city's green space network, restoration of the city's ecosystems, and the remediation of contaminated sites.

GREEN SPACE NETWORK An abundance of vacant land and limited market demand provide opportunities throughout the city to create and enhance parks and green spaces. At the city-wide scale, vacant land can be assembled to create an integrated green space network that defines the city's physical form, preserves ecologically significant land, and makes key connections to green spaces and recreation opportunities elsewhere in the region. As vacant sites become available in the city's land bank, an assessment can be made as to whether the land is most suitable for development or whether it can best contribute to the overall green space network. Staff at the Cleveland Planning Commission have prepared a flow chart (Figure 7) to aid in making these decisions about the disposition of landbank lots. The flow chart establishes criteria to determine which sites should be preserved for a public purpose and which can be reallocated to private owners. The flowchart further distinguishes between short-term holding strategies for sites that have strong development potential, and long-term or permanent strategies for sites where development is less likely. Official adoption of this decision-making framework is the first step toward implementing a city-wide vacant land strategy.

The *Connecting Cleveland 2020 Citywide Plan* identifies locations for additional recreation and green space amenities throughout the city. The *Cuyahoga County GreenPrint* delineates a broader green space network for sites in the city and the region. These two plans are shown together in Figure 8 and they constitute a potential conservation zone for Cleveland. In the conservation zone, vacant land would be used for parks, recreation, reforestation, stormwater management, wildlife habitat, etc. Development would also be welcome in the conservation zone, but conservation easements and low-impact development strategies could be encouraged to maintain public access and protect sensitive natural resources.

Criteria for determining whether vacant land should become part of the city's parks and green space network include:

- Site is adjacent to or near an existing Cleveland Metroparks property or City of Cleveland park.
- Site is within an area designated as future green space in the 2020 Cleveland Citywide Plan and/or part of a greenway connection.
- Site contains a remaining forest stand that can provide a linkage to other areas and maintain/improve habitat migration patterns or the potential for natural habitat.
- Community partner has the capacity to install and maintain a public green space on the site.
- Neighborhood has insufficient amount of existing green space.

FIG 7 Land bank decision-making flow chart
(Cleveland City Planning Commission)

SHOULD THE SITE BE PRESERVED?

Does the site have characteristics that recommend it for a long-term green use?

decision factors

1. Culverted stream
2. Other riparian zone
3. Lack of nearby parks
4. Proximity to parks (existing or planned)
5. Land use in Citywide Plan
6. Connections to trails (existing or planned)
7. Scale

preservation strategy

yes enumerate unique characteristics
What treatment types are available for the site?

menu of treatments

1. energy generation: solar field
2. geothermal wells
3. energy generation: wind turbines
4. energy generation: ethanol production
5. clean fill cap (landfill sites)
6. storm water management: bio-retention
7. constructed wetland
8. riparian setbacks
9. green space: parks
10. green space: forest
11. green space: linkages
12. wildlife habitat
13. urban agriculture/commodity farming
14. tree nursury
15. bio-remediation, phyto-remediation, mycoremediation
16. storm water mangament: riparian setbacks, stream daylighting

choose a treatment

City, CDCs and other stakeholders conduct a qualitative review.
Make recommendations for implementing preservation strategy.

holding strategy

The new objective should be to return the vacant lot to a use that is consistent with the city's overall goals as articulated in the Citywide Plan.

no

What is the site's development potential?

[decision factors]

1. market typology
2. NPI Strategic Investment Areas
3. land bank hold areas
4. foreclosures
5. targeted demolition
6. proximity to schools and public buildings
7. proximity to core development areas
8. Who owns the property?
9. Is the land clean?
10. Has a plan been developed for the lot?
11. Has funding been commited to the project

strong development potential
(0 - 5 years)

menu of treatments

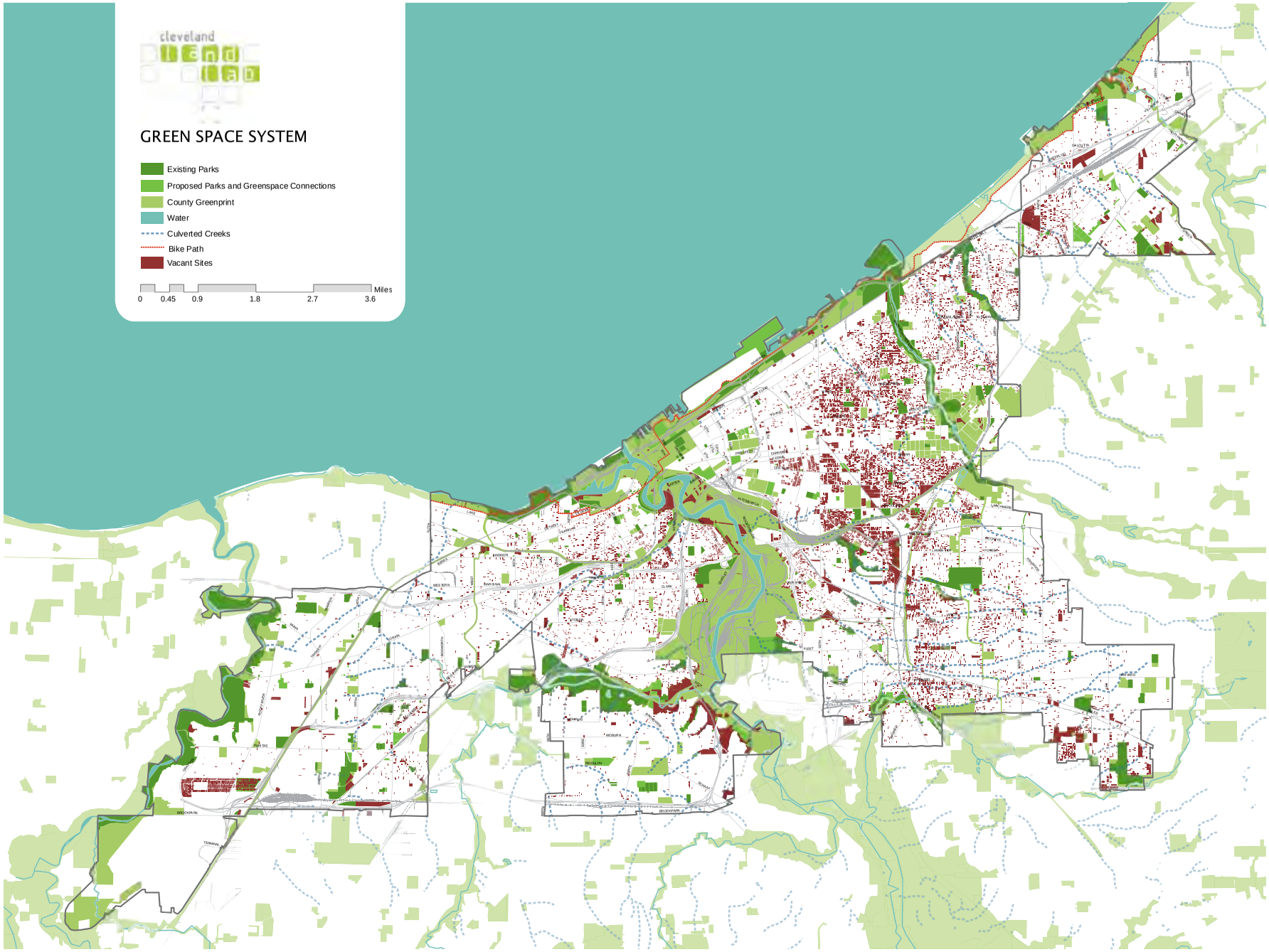
1. bio-remediation
2. landscape buffer
3. basic greening techniques

weak development potential
(5+ years)

menu of treatments

1. community garden
2. bio-remediation, phyto-remediation, myco-remediation
3. constructed wetland
4. deep tillage/pavement removal
5. basic greening techniques
6. solar field
7. urban agriculture/commodity farming
8. storm water management: riparian setbacks, stream daylighting

FIG 8 Green space system and existing vacant land



ECOSYSTEM RESTORATION/STORMWATER RETENTION Vacant land can be used to improve air and water quality, restore urban soils, increase biodiversity, and provide wildlife habitat. Urban development patterns tend to undermine local and regional ecosystems and limit the ability of nature to provide valuable services such as flood protection, air purification, climate regulation, erosion control, and biological habitat. But even in highly developed urban places like Cleveland, the functions of healthy ecosystems can be imitated and natural processes can be harnessed to provide quantifiable environmental benefits. [1]

Vacant land within the city can be used to recreate the functions of healthy ecosystems, so that natural processes are harnessed for environmental benefits. Ecosystem restoration can provide tangible benefits for the city. Water can be managed on vacant sites to imitate natural water cycling, vegetation can be introduced strategically to cool the air and filter water, and soils can be restored to support healthy vegetation and filter pollutants. For example, if trees were planted on vacant lots throughout the city, this could reduce the amount of stormwater runoff to be managed, since trees intercept rainwater and preventing it from entering the city's storm sewers. If done properly, this would reduce infrastructure costs and improve water quality.

Healthy ecosystems also contribute to the well-being of city residents. Studies show that access to nature—both the passive enjoyment of natural areas and active outdoor recreation—provide benefits such as better mental and emotional health, reduced stress, higher mental function and productivity, community cohesion and resilience, and increased safety. [2] Vacant land in Cleveland offers opportunities to integrate natural processes and human activity through the restoration of the city's ecosystems.

Soil and vegetation

Soil can take thousands of years to form but urban development often degrades soils so that they erode or are compacted. Soil ecosystems can be repaired gradually through targeted vacant land strategies.

Compaction is caused by buildings, construction equipment, and vehicular and foot traffic. Compaction damages soil structure and reduces infiltration rates, which increases runoff volume and flooding. Compaction also reduces spaces between soil particles for oxygen and water, making it difficult for vegetation to grow. Deep tillage and compost trenches can be used to reduce soil compaction on vacant sites, preparing them to support larger vegetation, accommodate agricultural uses, and increase stormwater infiltration.

Soil types and conditions vary across the city. An understanding of soil typologies should guide land use decision-making and strategies for vacant land reuse. *Hydric soils* are wetland soils; these soils developed under wet conditions and have the properties necessary to support wetland (hydrophytic) vegetation. Areas of the city with hydric soils are few, but if vacant land becomes available in these areas, they are ideal locations for constructing engineered wetlands.

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1 The Sustainable Sites Initiative, *Standards and Guidelines: Preliminary Report*. November 1, 2007.

2 Tzoulas, K., Korpela, K., Venn, S. et al., "Promoting Ecosystem and Human Health in Urban Areas Using Green Infrastructure: A Literature Review," *Landscape and Urban Planning* 81: 167-78 (2007), cited in The Sustainable Sites Initiative, *Standards and Guidelines: Preliminary Report*. November 1, 2007.

Soils are also classified by their ability to infiltrate water. Hydrologic soil types A and B offer the greatest potential for infiltration. Soil types C and D are heavier, clay soils. There are few areas in the city with A soils, but extensive areas with B soils (see Figure 9). Vacant areas with A and B soils are the most effective locations for implementing natural stormwater management practices such as bioswales and rain gardens. Soil compaction often reduces the infiltration capacity of A and B soils in urban settings, but this capacity can be restored as described above.

Vegetative cover improves soil structure and reduces sedimentation and erosion on vacant sites. Vegetation also provides wildlife habitat and increased biodiversity in urban settings. Vegetation provides shade and evapotranspiration to cool buildings and reduce energy costs. Vegetation also increases natural capacity for stormwater management and can filter pollutants from air and water. Vegetation, particularly in the form of a mature tree canopy, contributes to human health and well-being and has a measurable impact on residential property values.

Cleveland's patterns of urbanization have resulted in a significant loss of vegetation, as seen in Figure 10. Vacant land can be used to re-establish the city's tree canopy and other native vegetation (Figure 11). Design standards for new development on vacant sites can include requirements for re-establishing vegetation. And sites that have limited development potential can be used to re-establish the city's tree canopy. However, it is difficult to grow trees on compromised urban soils. Vacant land management should focus first on restoring soil structure through the planting of groundcovers and native low-mow grasses. As these plant materials become established, landscape strategies can mimic patterns of natural succession. Ground covers and low-mow grasses are a low-maintenance approach to managing short-term vacancy. Long-term vacancy can be used to recreate healthy soil ecosystems that will support trees and other larger vegetation on a permanent basis.

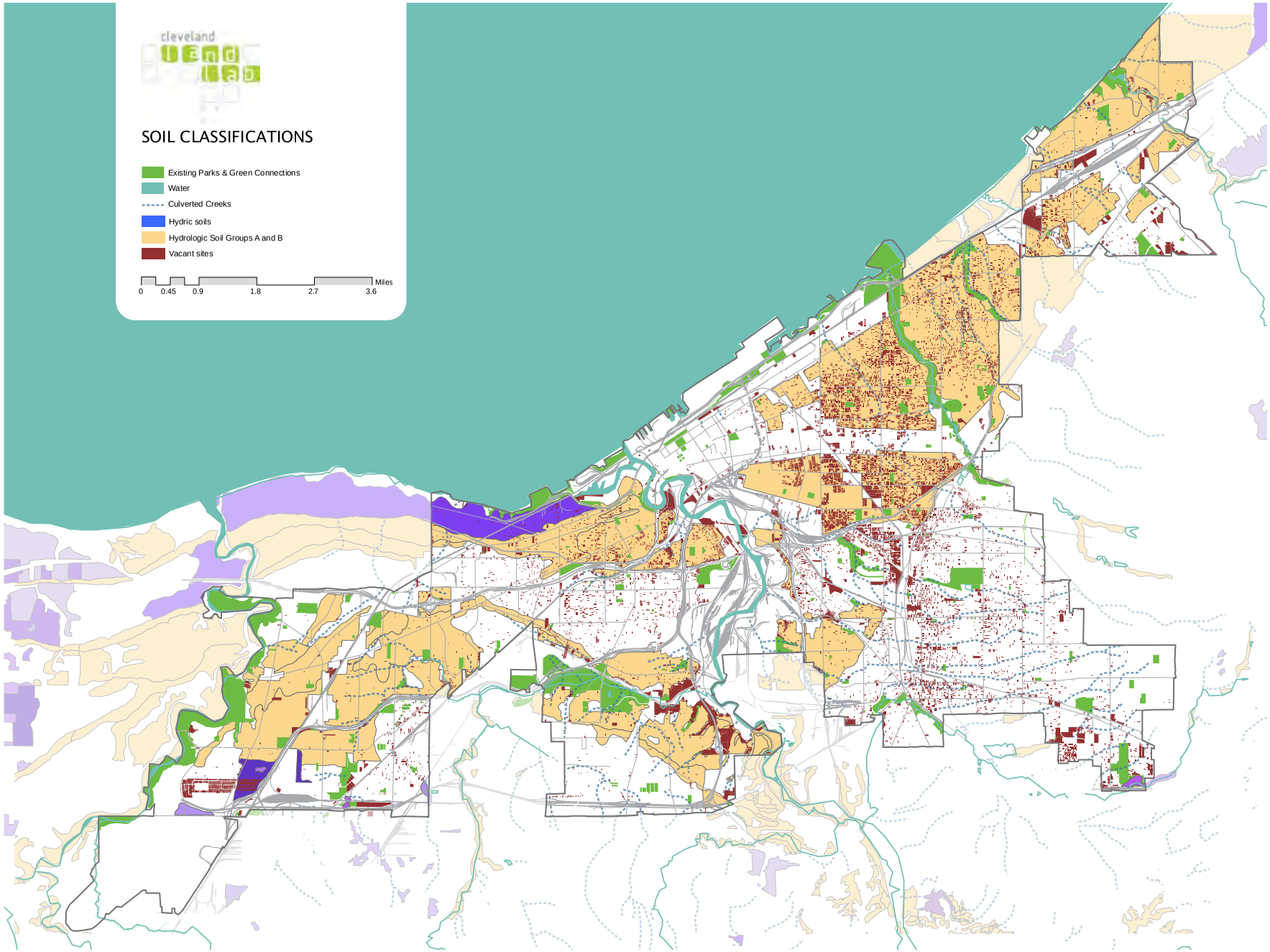
Water

Prior to urban settlement, the land in Cleveland was able to absorb much of the rain as it fell. Stormwater was absorbed and transpired by vegetation, or it slowly moved across the land and soaked into the soil. As the city grew, the percentage of impervious surfaces such as streets, sidewalks, and roofs within city limits increased dramatically. Today, much of the city's land consists of impervious surfaces. (Figure 12) This prevents the natural absorption of stormwater and results in increased runoff and compromised water quality.

As vacancy increases within the city, opportunities emerge to restore water balance by reducing impervious surfaces and restoring (or mimicking) natural hydrologic functions. The following criteria can be used to determine whether a vacant site can be used for stormwater management:

- Site is in a flood plain, an established riparian setback, or other flood-prone area and should not be developed.
- Site is identified in the Northeast Ohio Regional Sewer District's *Regional Intercommunity Drainage Evaluation* (RIDE) study as a problem area and should not be developed.
- Site is within an identified riparian area and can either be restored/conserved as open space or developed using conservation development practices.
- Site is within a headwaters area and can either be re-vegetated as open space or developed using conservation development practices.

FIG 9 Hydrologic Soil Groups



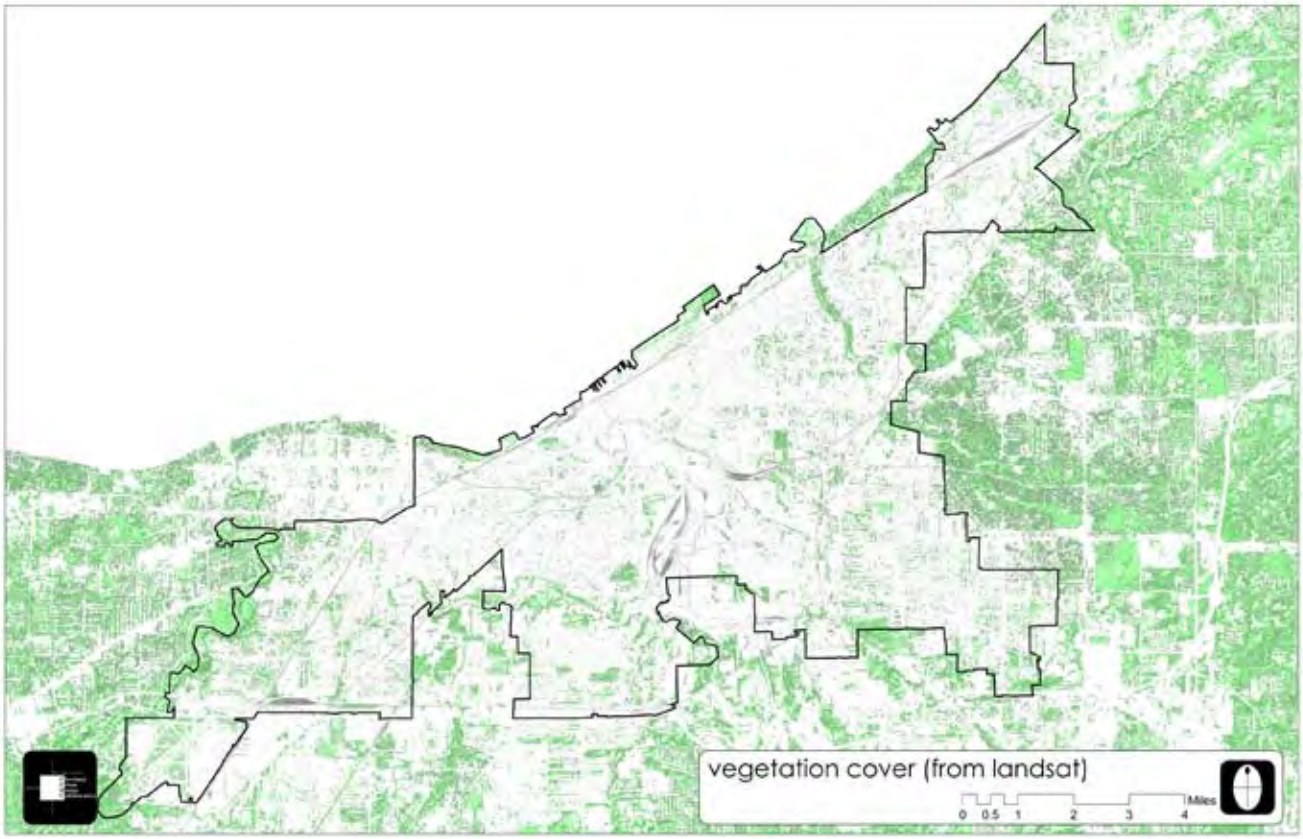


FIG 10 The tree canopy is sparse within the City of Cleveland

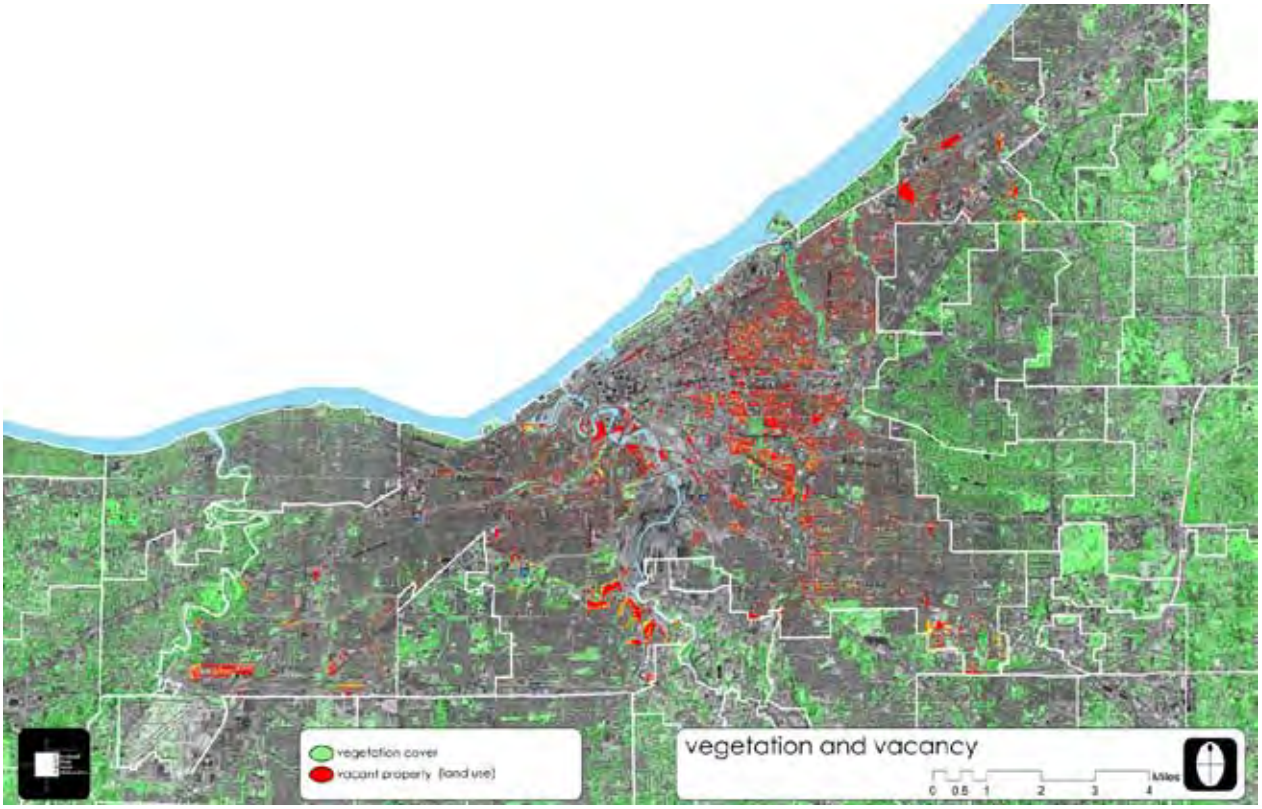


FIG 11 Vacant sites offer the potential to replenish vegetation and reestablish the tree canopy

- Site is identified in the Cuyahoga Soil and Water Conservation District's general wetland inventory of the County.
- Site can provide a linkage to other areas and maintain/improve habitat migration patterns and fish and aquatic habitats.

A more detailed and site-specific evaluation is needed to determine if vacant sites can be used to improve conditions in the following ecosystems:

Riparian Systems A riparian system is located along streams and rivers that occasionally flood and create unique ecosystems of soils, plant, and animals. In Cleveland, as in most urban areas, this system has been altered and it is not a healthy-functioning ecosystem. In many areas, streams have been culverted or completely buried and function primarily for water conveyance with marginal ecosystem value-function (See Figure 13). Vacant land can be used to establish or recreate heathy riparian systems within urban conditions. Riparian and headwaters areas for Cleveland are shown in Figure 14.

Recommended actions:

Streams: Identify opportunities to daylight buried streams, enhance existing streams, or recreate streams and their associated floodplains. Locate at existing or establish new pattern where appropriate. Ensure that system is connected and provides necessary hydrologic function (quantity and quality) to drainage area.

Riparian Corridors: Establish corridor limits using ecological principles (floodplains, soils, wetlands, slopes, and riparian vegetation). Create planning and design framework that allows either conservation or development projects within corridor.

Riparian Setbacks: Create regulations to establish minimal areas for ecosystem preservation. Determine appropriate method to define terms (setback distance, hydrologic functions, and environmental classifications) and means to administer regulations. Provide information to all stakeholders.

Conservation Design Strategies: Develop conservation guidelines integrating ecological principles into planning and design projects. Create document with goals/objectives and techniques, with monitoring/evaluation protocol.

Headwaters Systems A headwater system is located in the upper portions of a watershed and is where the drainage (surface and subsurface) patterns and processes begin for the watershed. Headwaters areas are critical for the efficient management of stormwater. Vacant land can be used to establish water quantity/quality objectives and initiate these strategies in the headwaters area. Headwaters and riparian areas for Cleveland are shown in Figure 14.

Recommended actions:

Low Impact Design-Stormwater Strategies: Establish objectives and techniques for low/minimal impacts to natural hydrologic system and existing site functions. Integrate strategies into planning and design process.

Wetland Systems: Map and document wetland criteria (hydric soils, hydrophytic vegetation, and water regime) and drainage patterns. Field verify wetlands and drainage patterns at site or local watershed level. Enhance existing lower quality, preserve existing higher quality, or create new wetland systems with appropriate vegetated buffers. Establish site design guidelines for development or conservation opportunities.

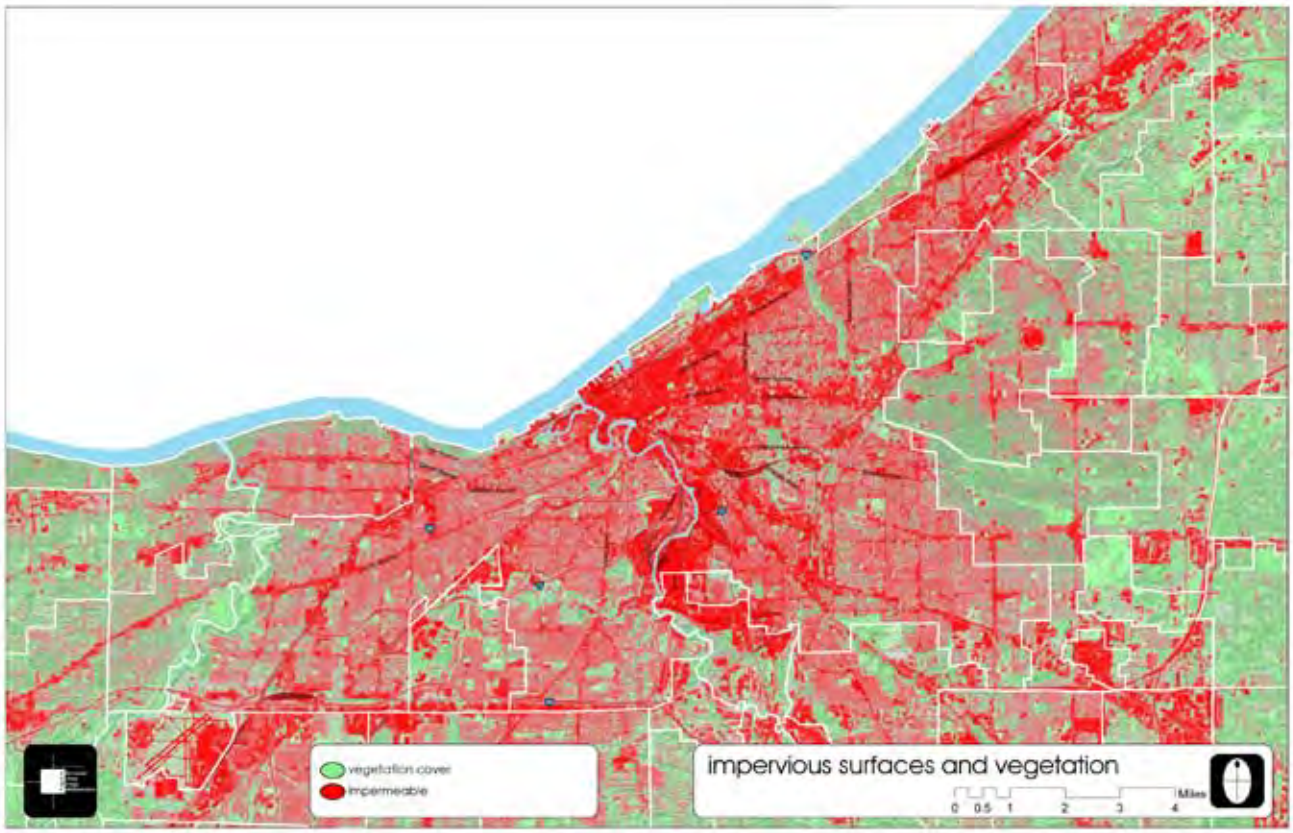


FIG 12 Impervious surfaces cover much of the land in the Cleveland.

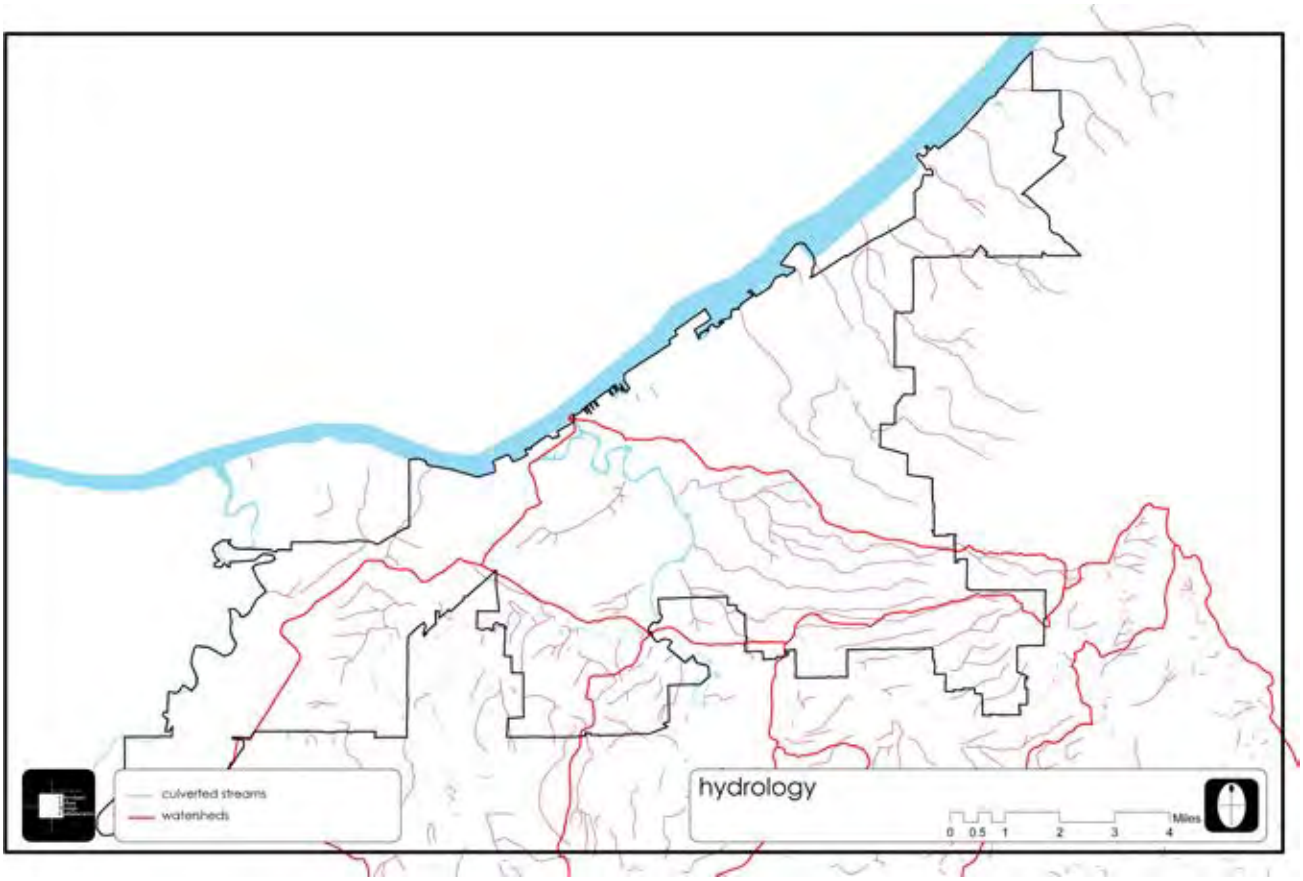


FIG 13 Creeks and streams throughout the city were culverted or buried to accommodate development.

FIG 14 Riparian and Headwaters System

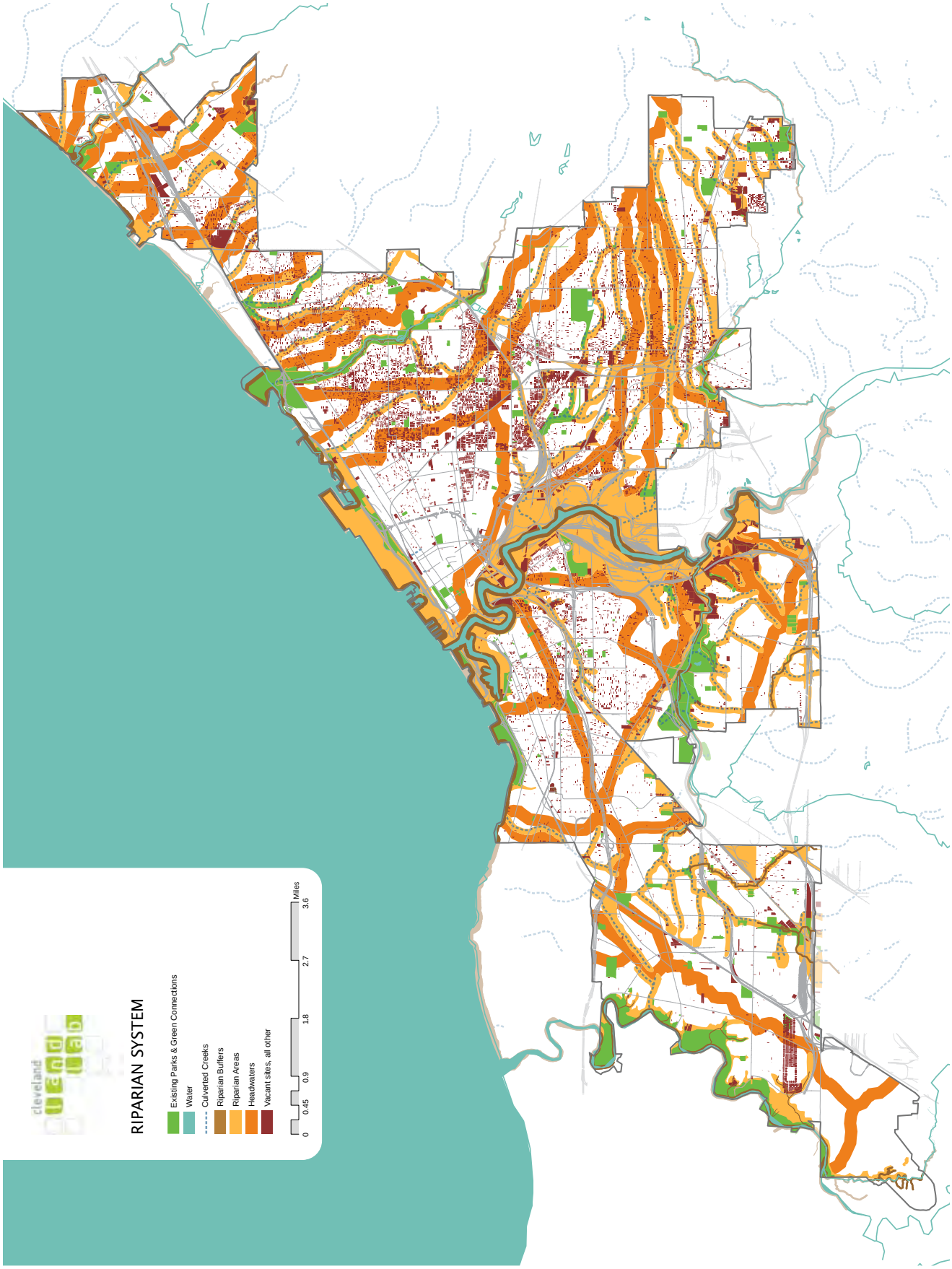


FIG 15 Low Impact Design for headwaters areas: bioretention swales

FIG 16 Swale for surface water conveyance. *Seattle Public Utilities drainage system project*

FIG 17 Rain garden for bioretention in residential areas.

Soil Systems: Map and document soil properties (HSG, water table, bedrock depth, permeability, moisture content, Ph, erosion, organic matter, and slope) from secondary sources. Field verify soil characteristics at site or neighborhood level. Establish preservation area boundaries and techniques.

Upland Vegetation Systems: Establish vegetation criteria (area, type, location, and quality), map/document relevant vegetated systems. Create guidelines for preservation, enhancement, or restoration of appropriate (native and naturalized) systems.

Engineered Naturalized Systems - Development Areas/Opportunity Sites Future development should be ecologically integrated into existing ecological systems, where this can be accomplished without excessive time or cost. The goal is to allow development as needed by the private market and incorporate ecological design principles as appropriate.

Recommended actions:

Low Impact Design – Stormwater Strategies: Establish objectives and techniques for low/minimal impacts to natural hydrologic system and existing site functions. Integrate strategies into planning and design process.

Engineered Ecosystems (streams, wetlands, riparian, upland, and managed turf systems): Establish ecosystem goals and criteria (area, type, and location) for application. Create guidelines for implementation of appropriate (native and naturalized) systems.

Hybrid Naturalized Systems–All Other Areas There will be areas within the City that are not initially designated for conservation or development. These areas can be used or altered over time as needed by local stakeholders. The important consideration should be that the changes benefit the local stakeholders and that there is a balance with conservation-development issues. These areas can be allowed to change as needed, with the application of standards and requirements in relation to the type and scale of the project.

Recommended actions:

Parcel(s) Level Hybrid Ecosystem (bioretention areas, rain gardens, upland meadows/prairie, naturalized woodlots, constructed wetlands, phytoremediation areas, low maintenance areas, and successional landscape management strategies): Establish ecosystem goals and criteria (area, type, function, and maintenance procedures) for application. Create guidelines for implementation of appropriate naturalized systems and provide evaluation standards.

FIG 18-19 Design concepts for vacant land in headwaters areas

Ecological Services

All landscapes provide ecological services (habitat, food production, air filtering, stormwater control, erosion control, and microclimate modulation). A natural or naturalized landscape can provide better and more efficient ecological services than a landscape dominated by impervious surfaces, turf, and minimal trees/shrubs. A general guideline should be to mimic natural landscape functions to the greatest extent possible, and that any additional vegetation and the more complex the ecosystem within a landscape – the more enhanced and beneficial the ecological services. To establish the planning and design framework of ecological services, six watershed scenarios were studied to determine the existing landscape functions and the potential benefits of vegetation strategies for ecosystem restoration on vacant sites. The study areas are not the only areas of the city where ecosystem restoration can occur; rather they represent a variety of urban conditions where different ecological benefits can be derived through vacant land management. Three of six study areas are included in this document.

The following land-cover descriptions were used in the watershed study areas:

- *Impervious Surfaces* Building, roads, roofs, parking areas, sidewalks, hardscape
- *Open Space – Scattered Trees (50-75% turf understory)* Active recreation parks, vacant lots (newly vacant-minimal trees), cemeteries (mostly turf)
- *Trees – Forest (native or naturalized shrub/groundcover understory)* Woods, wetlands, riparian areas
- *Trees – Grass/Turf* Passive recreation parks, cemeteries (mostly trees), wooded rear yards, wooded buffer areas, vacant lots (older vacant sites with trees, shrubs, grass)
- *Residential – Urban/Suburban (average .25 acre lot size)*

The following ecological services were modeled in each of the six study areas:

- Air Pollution Removal (carbon monoxide, ozone, nitrogen dioxide, particulate matter, sulfur dioxide)
- Carbon Storage and Sequestration
- Stormwater Control

Watershed Scenarios

St.Clair+E.105 (Figure 20)
Aggressive vegetation changes with all land-cover types. There is a variety of vacancy within the watershed so the intention is to equally apply land-cover changes in the watershed. Increase vegetation areas in all available land-covers with concentrations on vacant parcels. All of the vacant parcels were modeled for increased vegetation/re-vegetation and allowed for successional landscape changes. Predicted outcome: moderate to high increase to all ecological services in all land-cover areas.

Broadview+Harvard (Figure 21)
Vegetation changes in all land-cover types within the watershed with targeted concentrations to the existing impervious surfaces and residential areas. There are large existing vegetated vacant areas that will not be developed because of slope and soil conditions. These areas already provide ecological services so the intention was to increase these services in other land-cover areas. Predicted outcome: moderate increase to ecological services (major increase to stormwater services) in selected land-cover areas.

Harvard+Miles (Figure 22)
Vegetation changes with selected land-cover types because of smaller number and size of vacant lots available in watershed. The existing vacant lots relate more with the urban patterns than with ecosystem patterns, therefore land-cover changes dealing with vegetation will have to be designed to fit within the existing urban patterns in order to provide adequate ecological services. Predicted outcome: minor to moderate minor increases in ecological services (minor increase to stormwater services) in selected land-cover areas.

Watershed Study – Broadview+Harvard

Watershed Characteristics:

- Lower Big Creek Watershed with existing stream and culverted tributary
- Approximately 570 acres
- Majority of watershed is residential with commercial and industrial corridors of impervious surfaces
- Many areas of naturalized areas and public open spaces
- Majority of vacancy is industrial with environmental concerns and vegetated steep slopes
- Large areas of vacancy with a minimal scattered small lots

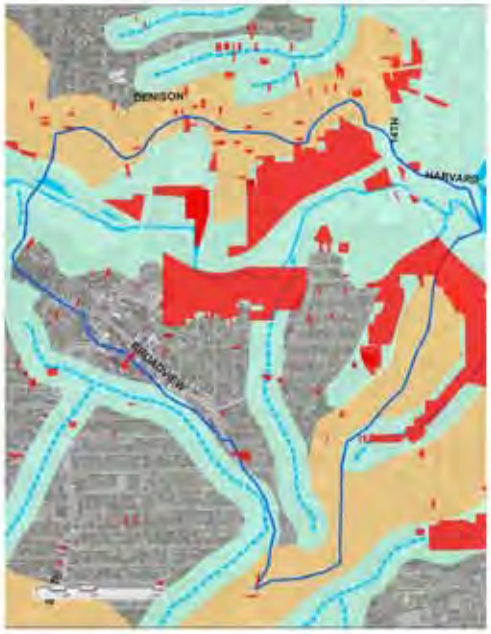
Watershed Analysis:

Current Land Cover Types

Impervious surfaces	143.3 acres (25.2 %)
Residential – medium density	233.2 acres (41.0 %)
Grass/scattered trees	26.7 acres (4.7 %)
Meadow/shrub	30.1 acres (5.3 %)
Trees/natural understory	135.6 acres (23.8 %)
Total Tree/Vegetation Canopy	135.6 acres (23.8 %)

Current Green Infrastructure Functions

- *Air Pollution Removal* *14,017 lbs removed/yr ($32,378 value)*
- *Carbon Storage & Sequestration* *5,833 total tons stored (45.41 tons annual)*
- *Stormwater – Quantity* *193,906 CF storage ($387,813 savings)*



Watershed Recommendations:

Riparian Corridor Area (100 ft buffer): Limited potential of reestablishing main tributary surface hydrology (daylight or reconstruct stream channel (750 LF possible). Reestablish urban forest in all other vacant land in area should be higher priority.

Headwaters Area (500 ft buffer): Limited opportunity to construct stormwater wetlands or other stormwater collection facilities (raingardens etc...). Higher priority should be given for other vacant land to be vegetated and maintained as a successional landscape.

Vacant Land Available (approximate)

Riparian Corridor Area	78 acres
Headwaters Area	6 acres
All others areas	6 acres
Total Vacant Land	90 acres (16 %)
Total Tree/Vegetation Canopy	177 acres (31.0 %)

Projected Green Infrastructure Functions

- *Air Pollution Removal* *18,238 lbs removed/yr ($42,128 value)*
- *Carbon Storage & Sequestration* *7,590 total tons stored (59.09 tons annual)*
- *Stormwater – Quantity* *624,648 CF storage ($1,249,296 savings)*

FIG 20 Broadview/Harvard Study Area

Watershed Study – St.Clair+E.105

Watershed Characteristics:

- Direct tributary to Lake Erie and entire watershed is culverted
- Approximately 513 acres
- Majority residential neighborhoods (240 acres) in middle and upper areas, with 2 commercial/retail corridors (St.Clair and E.105) that intersect watershed
- Minimal open space and natural areas
- Vacancy is a majority of residential parcels with commercial/retail and some industrial parcels
- Scattered vacancy with a range of medium and small lots

Watershed Analysis:

Current Land Cover Types

Impervious surfaces	150.2 acres (29.3 %)
Residential – medium density	239.8 acres (46.8 %)
Grass/scattered trees	50.1 acres (9.8 %)
Trees/grass+shrub understory	59.8 acres (11.7 %)
Trees/natural understory	12.7 acres (2.5 %)
Total Tree/Vegetation Canopy	72.5 acres (14.1 %)

Current Green Infrastructure Functions

- *Air Pollution Removal* — *7,495 lbs removed/yr ($17,312 value)*
- *Carbon Storage & Sequestration* — *3,119 total tons stored (24.28 tons annual)*
- *Stormwater – Quantity* — *85,453 CF storage ($170,907 savings)*

Watershed Recommendations:

Riparian Corridor Area (100 ft buffer): Limited potential of reestablishing main tributary surface hydrology (daylight or reconstruct stream channel (400 LF possible). Reestablish urban forest in all other vacant land in area should be higher priority.

Headwaters Area (500 ft buffer): Construct stormwater wetlands or other stormwater collection facilities (raingardens etc...) in as many areas as appropriate. All other vacant land should be vegetated and maintained as a successional landscape.

Vacant Land Available (approximate)

Riparian Corridor Area	18 acres
Headwaters Area	20 acres
All others areas	22 acres
Total Vacant Land	60 acres (12 %)
Total Tree/Vegetation Canopy	138 acres (27.0 %)

Projected Green Infrastructure Functions

- *Air Pollution Removal* — *14,313 lbs removed/yr ($33,061 value)*
- *Carbon Storage & Sequestration* — *5,956 total tons stored (46.37 tons annual)*
- *Stormwater – Quantity* — *160,085 CF storage ($320,171 savings)*

FIG 21 St. Clair and E 105 St. Study Area

Watershed Study – Harvard+Miles

Watershed Characteristics:

- Tributary to Mill Creek (Cuyahoga River) with entire watershed culverted
- Approximately 204 acres
- Majority of watershed is residential and impervious surfaces
- Minimal open space or natural areas
- Vacancy is a majority of residential parcels with minimal commercial/retail and industrial parcels
- Scattered and clustered vacancy with a range of medium and small lots

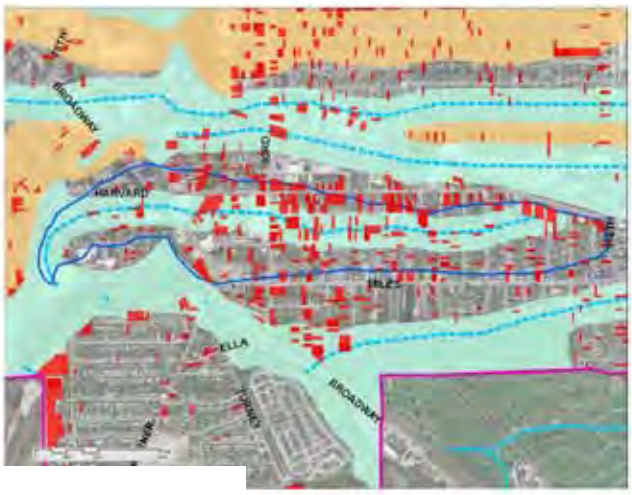
Watershed Analysis:

Current Land Cover Types

Impervious surfaces	69.2 acres (34.0 %)
Residential – medium density	74.1 acres (36.4 %)
Grass/scattered trees	22.0 acres (10.8 %)
Trees/grass+shrub understory	27.3 acres (13.4 %)
Trees/natural understory	10.8 acres (5.3 %)
Total Tree/Vegetation Canopy	38.1 acres (18.7 %)

Current Green Infrastructure Functions

- *Air Pollution Removal* — *3,941 lbs removed/yr ($9,102 value)*
- *Carbon Storage & Sequestration* — *1,640 total tons stored (12.77 tons annual)*
- *Stormwater – Quantity* — *216,402 CF storage ($432,804 savings)*



Watershed Recommendations:

Riparian Corridor Area (100 ft buffer): Potential of reestablishing main tributary surface hydrology (daylight or reconstruct stream channel (850 LF possible). Reestablish urban forest in all other vacant land in area should be higher priority.

Headwaters Area (500 ft buffer): Limited opportunity to construct stormwater wetlands or other stormwater collection facilities (raingardens etc...). Higher priority should be given for other vacant land to be vegetated and maintained as a successional landscape.

Vacant Land Available (approximate)

Riparian Corridor Area	20 acres
Headwaters Area	0 acres
All others areas	15 acres
Total Vacant Land	35 acres (17 %)
Total Tree/Vegetation Canopy	44.4 acres (21.8 %)

Projected Green Infrastructure Functions

- *Air Pollution Removal* — *4,591 lbs removed/yr ($10,605 value)*
- *Carbon Storage & Sequestration* — *1,911 total tons stored (14.87 tons annual)*
- *Stormwater – Quantity* — *50,436 CF storage ($100,872 savings)*

FIG 22 Harvard and Miles Study Area

REMEDIATION Environmental contamination is Cleveland's unfortunate legacy from the industrial era. Resources for cleaning up brownfields sites are typically tied to new development projects. This is a challenge for Cleveland, where environmental contaminants abound in places where development demand is very limited or in some cases, non-existent. Conventional brownfield clean-up, where tainted soils are removed and disposed of in toxic waste facilities, is cost-prohibitive without state and federal funding support. But this support is only available when a new development project is proposed for a polluted site, particularly a project that will create jobs or other economic development benefits.

Bio-remediation, phytoremediation, and mycoremediation are potential tools for environmental clean up in cases where conventional remediation is not feasible. Bio-remediation, phytoremediation, and mycoremediation allow natural processes to clean up harmful chemicals in the environment. With bioremediation, microscopic "bugs" or microbes that live in soil and groundwater are deployed to eat certain harmful chemicals, such as those found in gasoline and oil spills. When microbes completely digest these chemicals, they change them into water and harmless gases such as carbon dioxide. Phytoremediation and mycoremediation work in much the same way, with plants and fungi, respectively.

Sites where bio-remediation, phytoremediation, and mycoremediation techniques are most typically used include industrial and municipal landfills, agricultural fields, wood treating sites, military bases, fuel storage tank farms, gas stations, army ammunition plants, sewage treatment plants, and mining sites; the use of these techniques in residential areas is much less common. One important research project is being conducted in Portland, Maine. Dr. Samantha Langley-Turnbaugh is using spinach to extract lead from soils in city neighborhoods. The results of this works are to be published this fall.

These alternative remediation techniques take longer to work than conventional brownfield remediation. Plants, microbes, and fungi must be carefully selected and monitored in response to the specific toxins present in the soil and the condition of the soil itself. But research suggests that the following criteria can be used to identify potential sites for bio-remediation, phyto-remediation, or myco-remediation techniques:

- Sites tainted with lower levels of pollutants, contaminants, hazardous substances, petroleum products, or other wastes and debris.
- Sites that do not pose an immediate and significant hazard to adjacent residents.
- Sites that have limited short or long term development potential.
- Can be an interim or permanent solution, depending on the types of contaminants and the remediation period.

Lead is an especially pressing problem in Cleveland's neighborhoods. Vacant sites with exposed soil contribute to airborne lead levels in the city's neighborhoods, especially in the summer months. In many neighborhoods, over 30% of children test positive for lead poisoning each year (Figure 24). This is a public health crisis and a major social and economic challenge. Planting low-mow native turf grasses or other ground covers on vacant sites will reduce the amount of lead particles that become airborne and lessen the extent to which Cleveland residents are exposed to lead. These ground covers may not remediate lead through phyto-extraction, but they may help to contain lead and reduce exposure to airborne lead particles. As a singular treatment method, the usefulness of phytoremediation at a brownfield site in Cleveland is somewhat difficult to determine because there are numerous factors that could influence a contaminants bioavailability and/or the rate a hyperaccumulator can metabolize or degrade the contaminants. A site assessment will be a necessary component to predetermine if phytoremediation would benefit the site. Factors such as contaminant type, soil type, geological and hydrological conditions, weather, and site history will determine whether phytoremediation will be a constructive approach to removing soil contaminants.

FIG 23 Many properties in Cleveland have environmental contaminants

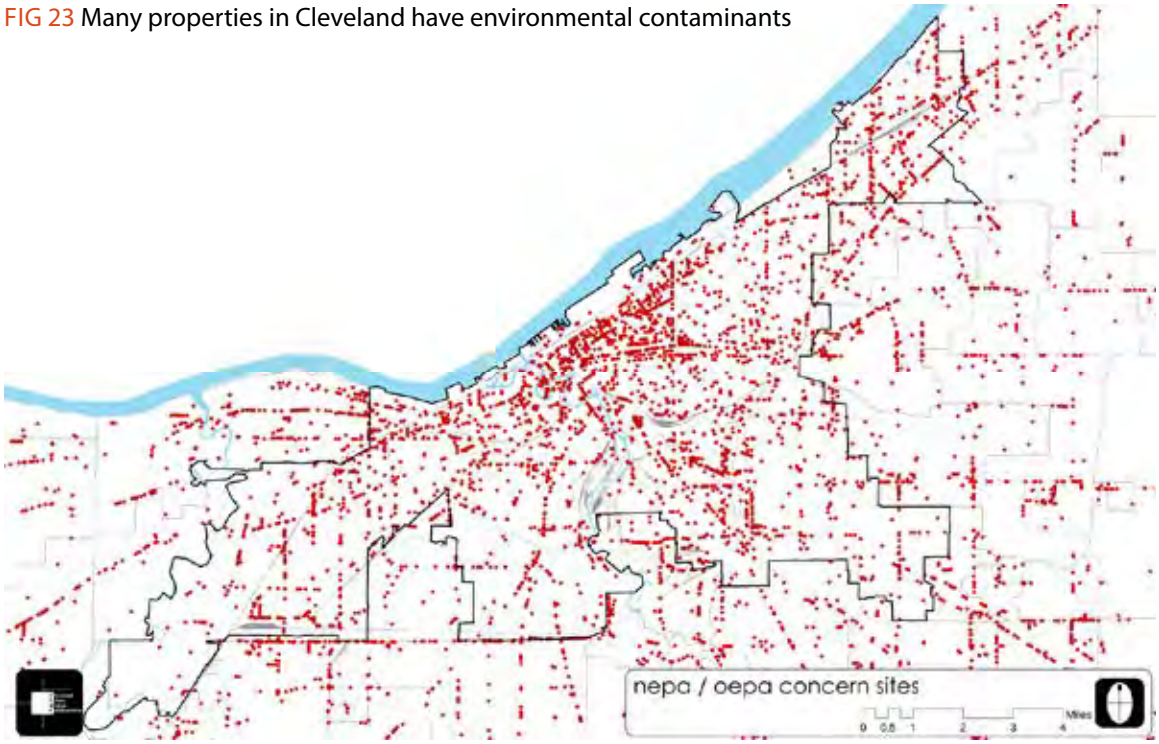
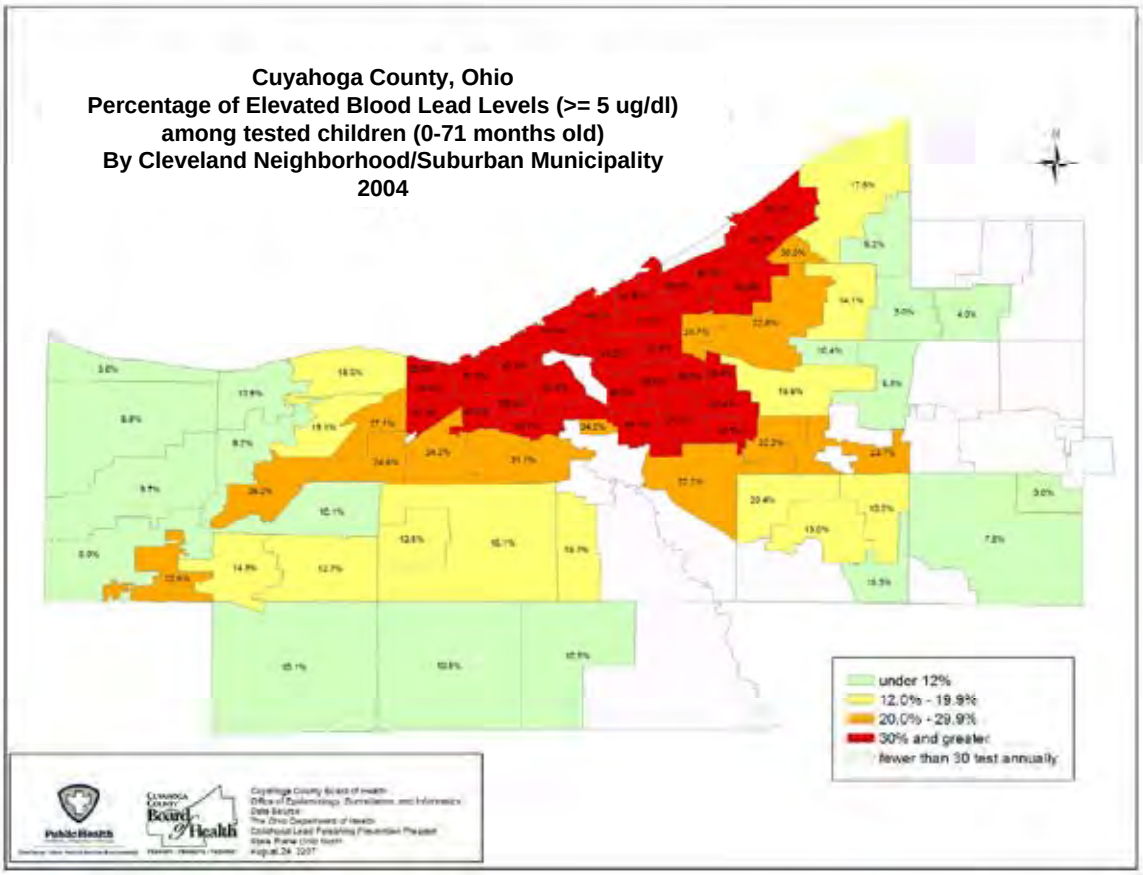


FIG 24 Lead contamination is a problem throughout the city



PRODUCTIVE LANDSCAPES Agriculture and energy generation are two ways that vacant land can be reused to generate an economic return.

Agriculture Access to fresh produce is limited in some parts of the city, as documented by the Cuyahoga County Planning Commission's recent mapping of food deserts–places where fast food restaurants are prevalent and grocery stores are few. Community gardens, market gardens, and urban farms are emerging throughout the city, providing access to affordable locally-grown produce for city residents (Figure 24).

There are more than 160 community gardens in Cleveland that engage 3,600 Cleveland residents. Community gardens increase the consumption of fruits and vegetables and they also bring neighbors together and make neighborhoods safer and more attractive. Vacant land can be used to expand this network of community gardens to provide greater access to healthy food. Seattle developed a benchmark of one community garden for every 2,500 residents. (Seattle Land Use Plan 1994). Based on Cleveland's current population this would equate to about 175 gardens in the city. A better and more ambitious standard would be to establish a community garden within a ½-mile radius of every city resident (Figure 25) or a ¼-mile radius (Figure 26). Criteria for siting community gardens include:

© Maurice Small, 2008

- Level site of approximately 4,000 square feet.
- Large trees or buildings on the north side of the plot.
- Receives 8 hours of full sun each day.
- Close to a fire hydrants for watering (on the same side of the street).
- Free of surface material (i.e. asphalt or gravel).
- Lead levels of less than 400-500 ppm (estimated total lead).
- In a residential neighborhood.
- Community support/local partner; eight to ten gardeners per garden.
- Site with limited development potential.
- Target of one community garden within a ½-mile or a ¼-mile radius of every city resident.
- Priority strategy for establishing community gardens in neighborhoods with residential density of greater than 20 households per acre, and in areas identified as food deserts in the Cuyahoga County Planning Commission's recent (2008) mapping of food availability.

Agriculture can extend beyond community gardens to include market gardens (growing produce to sell) and commercial farming operations. Commercial agriculture is a potential economic development strategy for larger areas of vacancy in the city. Criteria for commercial agriculture include:

- Site of at least one acre.
- Access to irrigation water.
- Large trees or buildings on the north side of the plot.
- Receives 8 hours of full sun each day.
- Soil tests that assess potential contamination based on location and previous use, including lead levels of less than 400-500 ppm (estimated total lead).
- Proximity to other urban agriculture sites to facilitate combined efforts in distribution and marketing and sharing of resources such as tools, water lines and water access, composting, small livestock, etc.
- Site with limited development potential (long-term use).
- Adequate due diligence, such as soil sampling and other environmental investigation activities, that assess potential contamination.

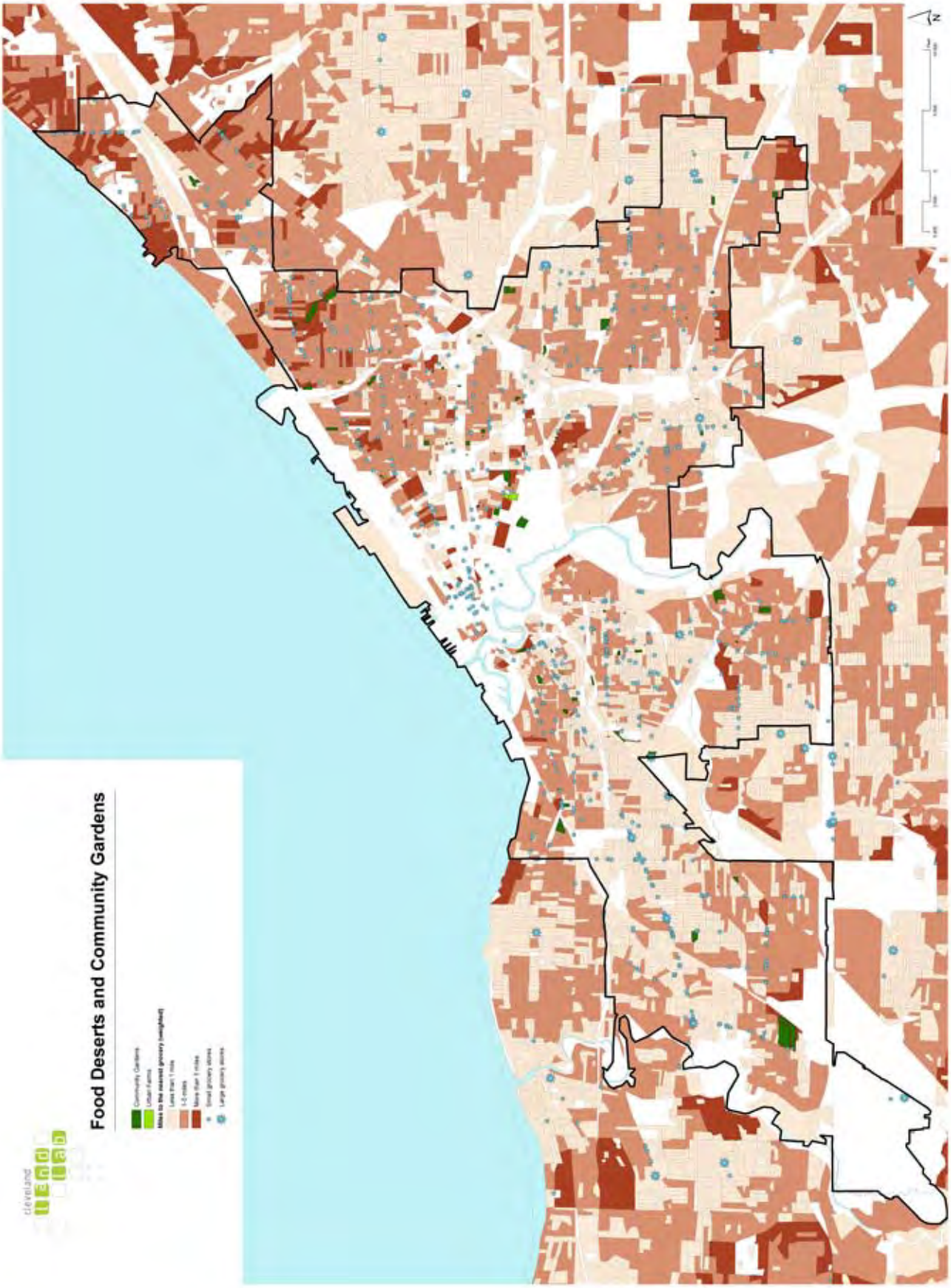


FIG 25 Community gardens and market gardens can expand food choices for residents in urban food deserts.

Note: Approximately 25% of the existing gardens are not for public use; many additional public gardens are planned for 2009.

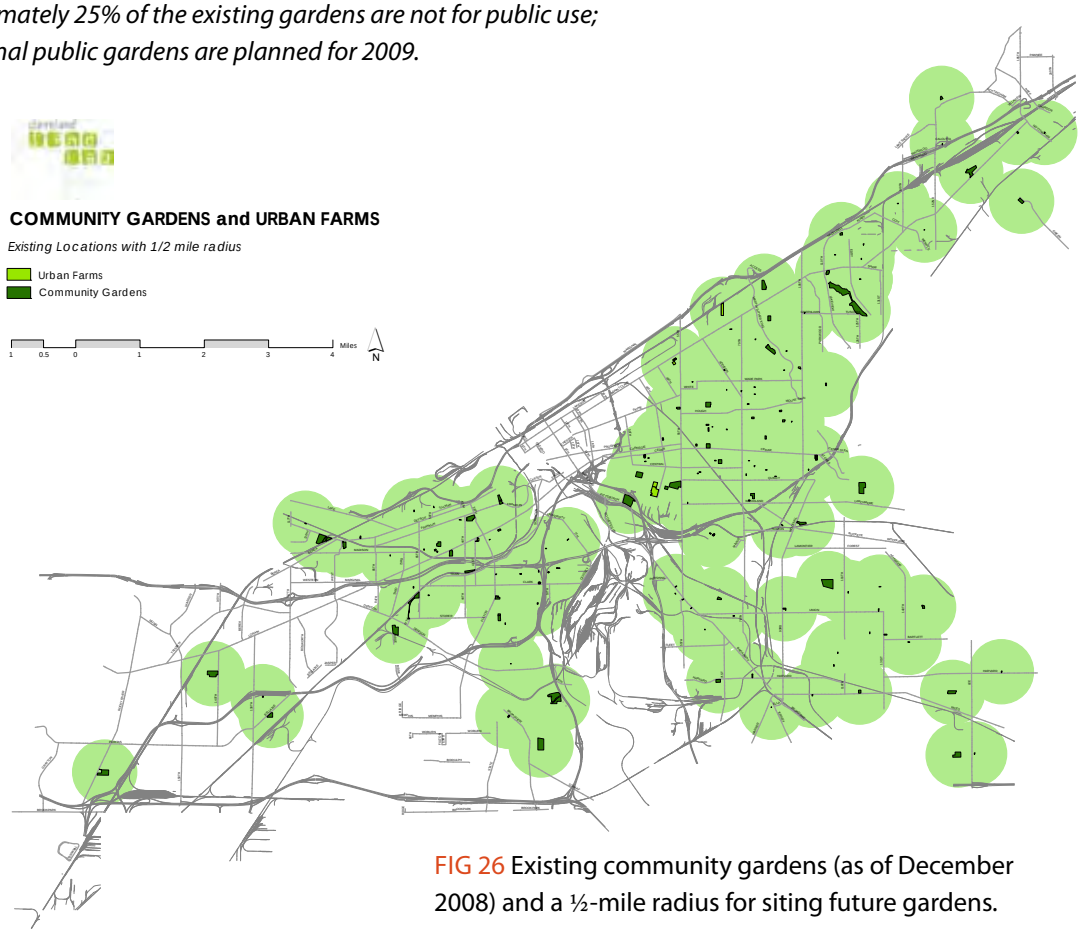


FIG 26 Existing community gardens (as of December 2008) and a ½-mile radius for siting future gardens.

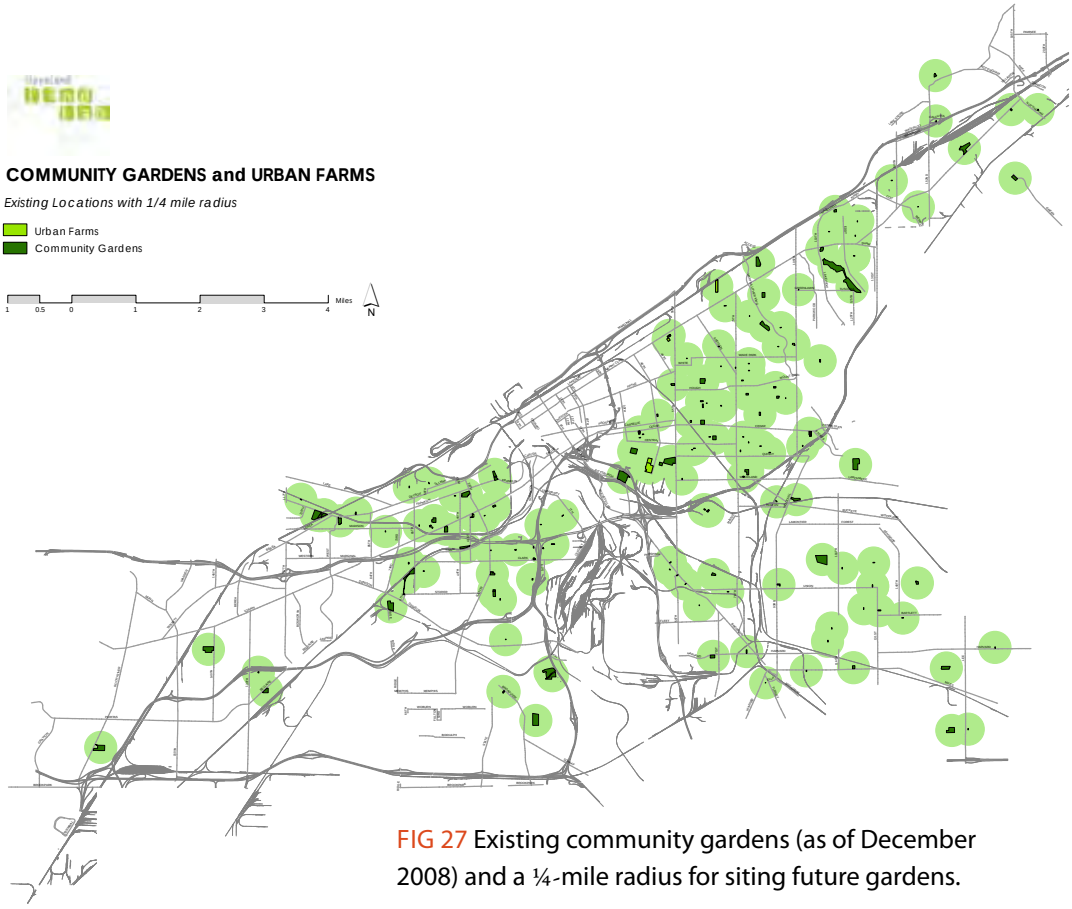


FIG 27 Existing community gardens (as of December 2008) and a ¼-mile radius for siting future gardens.

FIG 28 Blue Pike Farm established on a one-acre vacant lot in the St. Clair-Superior neighborhood *(photo by Carl Skalak)*

FIG 29 Heirloom chickens at Gather 'round Farm in the Ohio City neighborhood *(photo by Uma Kirkwood)*

FIG 30 Switchgrass, corn, or other plant materials can be converted to biodiesel through a commercial or home-based distillation process.

- Site with limited development potential (long-term use).
- Adequate due diligence, such as soil sampling and other environmental investigation activities, that assess potential contamination.

Commercial agriculture opportunities are not limited to food production. Trees and native plants can be grown be grown on vacant sites to supply wholesale or retail plant materials for new and existing development. Currently, all of the region's tree nurseries are located outside of Cuyahoga County and the nearest native plant nursery is in Hiram, Ohio. Growing plant materials on larger vacant sites in the city may prove to be a viable economic development strategy and will increase the availability of native plants that are hardy in urban conditions. Criteria for tree and plant nurseries include:

- Site of at least one acre for a native plant micro-nursery; at least 20 acres are needed for a tree nursery.
- Access to irrigation water.
- Large trees or buildings on the north side of the plot.
- Site with limited development potential (long-term use).
- Soil conditions and sun exposure conducive to the types of plants/ trees that will be grown on the site.

Additionally, there is a growing interest in including bees and chickens at community gardens and commercial agriculture sites. Cleveland City Council recently passed legislation approving this use.

ENERGY GENERATION Vacant properties also offer opportunities for the generation of alternative energy. Solar, wind, geo-thermal, and biofuel technologies can all be incorporated into urban settings where there is ample vacant land and reduced population density. For example, geothermal technology uses the earth's renewable energy, just below the surface, to heat and cool a home, and to help provide hot water. Geothermal energy is extremely cost effective and environmentally friendly. Although the cost of installing a geothermal well is higher than installing a conventional heating system, a geothermal system results in significantly lower utility costs. Geothermal wells can be installed on a vacant site to generate energy for two adjacent houses.

More research is needed to determine which energy strategies are most viable given Cleveland's dispersed pattern of vacancy, but general criteria for using vacant sites for energy generation include:

GeoThermal

- Underground utilities need to be avoided when establishing sites for geothermal energy production.
- 30 acres is an efficient size for a commercial geothermal energy plant; a smaller, neighborhood-scale plant may be feasible in some locations.
- A vacant residential lot can provide geothermal energy for two adjacent houses.

Wind Turbines

- Minimum one acre site for a residential-scale wind turbine.
- Site must have a minimum annual average wind speed of at least 11-13 mph.
- Proximity to existing transmission lines: a critical issue in keeping costs down in building a wind farm is minimizing the amount of transmission infrastructure that has to be installed availability and access to existing lines should be considered in selecting a site.
- Secure access to land: long term use.
- Is there high raptor activity in the area? Are there endangered or protected species that could be jeopardized by the presence of the facility?
- Is the site's geology suitable and appropriate for industrial development?
- Will noise and aesthetics be issues for the local community?
- Will the turbines obstruct the flight path of local air traffic?

Source: American Wind Energy Association

Ethanol Production

- 50+ acres for commercial-scale farms (including a large-scale processing facility).
- Multiple sites of 2-4 acres for neighborhood energy farms (can share a large-scale processing facility).
- Residential scale farms (on vacant lots); processing can occur in home-based processors, capable of producing 40-80 gallons of biofuel in 8-14 hours.
- Industrial hemp is a high-yielding multi-purpose fuel and fiber crop that has great potential for biomass energy. An acre of hemp yields 10 tons of biomass in four months, enough to make 1,000 gallons of methanol fuel (by pyrolytic distillation), with about 300 pounds of oil from the seed.
- Switchgrass plots produce up to 15 tons of dry biomass per acre, and five- year yields average 11.5 tons—enough to make 1,150 gallons of ethanol per acre each year.

Sources United States Department of Agriculture, National Agricultural Library

Solar Field

- Adaptable to various site sizes – the size of the photovoltaic array and installation method can be tailored to meet the site conditions. A rule of thumb is that a solar array that covers three acres can generate approximately one megawatt of power – enough for 200 homes
- Interim use option – relatively easy to move and install. An otherwise unused site could host a PV array that could later be moved to another location when the site is redeveloped.
- Compatible with diverse end uses – PV can be installed on a variety of commercial, industrial, and residential properties. PV arrays can also be installed directly on the ground on a brown-field without penetrating the surface of the property in situations where the soil should not be disturbed.
- No noise and minimal traffic generated by a PV array; can be sited near residential areas

Source: US Department of Energy

POLICY RECOMMENDATIONS for the RE-USE of VACANT PROPERTIES

LAND USE

- Establish a task force to assess and address barriers to new vacant land reutilization strategies, including zoning, building, and health codes, access to city land and water, etc. *[Cleveland City Planning Commission, Building and Housing Department, Public Service Department, Water Department, Economic Development Department]*
- Adopt land use decision-making mechanism for properties in Cleveland's land bank based on the flow chart in Figure 7, page 9. *[Cleveland City Planning Commission, Community Development Department, Economic Development Department City Council, Mayor's Office]*
- In response to the growing number of foreclosures and demolitions, determine and implement ways to streamline the disposition of properties in the city's land bank and make the process more objective; the goal would be to have a 2-3 month turnaround from when the site comes into the landbank until final disposition. *[Cleveland City Planning Commission, Community Development Department, City Council, Mayor's Office]*
- Encourage the use of hydrological data and soil characteristics as guiding factors for determining future land uses and stormwater management strategies at the city-wide level and in neighborhood master plans. *[Cleveland City Planning Commission]*

DATA

- Develop new ways to classify and geo-code vacant land in the city's GIS system to identify sites that have the strongest potential for real estate development, green space expansion, and the provision of specific ecosystem services, as well as sites that have environmental contaminants. *[Cleveland City Planning Commission, Cleveland Urban Design Collaborative]*
- Develop more detailed, parcel-based mapping of environmental contamination that distinguishes highly contaminated sites from those with lower levels of contamination; include this information in the city's GIS parcel data. *[Cleveland City Planning Commission, City and County Brownfields staff]*
- Develop parcel-level mapping of sites where children have tested positive for elevated blood-lead levels and factor this information into decision-making on building demolition. *[Cleveland Health Department, Building and Housing Department, Cleveland Urban Design Collaborative]*
- Map and document wetland criteria (hydric soils, hydrophytic vegetation, and water regime) and drainage patterns. *[Cleveland Urban Design Collaborative, Cuyahoga Soil and Water Conservation District]*
- Map and document soil properties (HSG, water table, bedrock depth, permeability, moisture content, Ph, erosion, organic matter, and slope) from secondary sources. *[Cleveland Urban Design Collaborative, Cuyahoga Soil and Water Conservation District]*
- Delineate areas of existing vegetative cover throughout the city using recent aerial photographs. *[Cleveland Urban Design Collaborative]*

GREEN INFRASTRUCTURE

- Expand the area devoted to green space and land preservation in the 2020 future land use plan to include riparian areas, headwater protection zones, and elements of the County GreenPrint; promote the use of Green Overlay District Zoning to protect these areas. *[Cleveland City Planning Commission, Cuyahoga County Planning Commission]*

- Identify one or two city-wide green infrastructure initiatives that will link neighborhoods, provide ecosystem and community benefits, and enhance Cleveland's image (e.g. inner "Emerald Necklace" of parks and trails connecting to the Cuyahoga River and the Ohio Canal Towpath Trail). *[Establish task force to explore]*.
- Adopt design guidelines and review process to establish minimal areas for ecosystem preservation in riparian and headwaters areas. Determine appropriate method to define terms (setback distance, hydrologic functions, and environmental classifications) and means to administer regulations. *[Cleveland City Planning Commission]*
- Enhance existing lower quality wetlands, preserve existing higher quality wetlands, and create new wetland systems with appropriate vegetated buffers where feasible. *[Northeast Ohio Regional Sewer District, Cleveland Metroparks. Cleveland Water Department, Office of Sustainability]*
- Encourage or mandate the use of bioswales and pervious paving for all new off street parking lots. *[Cleveland City Planning Commission, Department of Engineering and Construction, Community Development Department, Economic Development Department]*
- Encourage the creation of rain gardens on residential properties, especially side yard expansions on vacant lots. *[Cleveland City Planning Commission, Building and Housing Department, Community Development Department]*
- Link green infrastructure projects to the Cleveland Carbon Fund, where appropriate. *[Cleveland Carbon Fund, GreenCityBlueLake Institute]*

URBAN AGRICULTURE

- Provide permanent support for local food production. Prioritize agricultural land uses in the city through the creation of a new land use category for urban agriculture to aid in long-term planning and land security for urban farmers and community gardeners.; revise Urban Garden District zoning classification as appropriate. *[Cleveland City Planning Commission]*
- Establish a goal that every Cleveland resident will be within a minimum ½-mile radius of a community garden or market garden (ideally within a ¼-mile). This will increase local food security, reinforce neighborhood relationships, beautify vacant lots, and promote local entrepreneurship. *[Cleveland City Planning Commission, Ohio State University Extension, Cleveland Botanical Garden, Community Development Corporations]*
- Integrate permanent garden space in model block/neighborhood planning.
- Establish strategies for controlling use and new models for holding land (i.e. re-zone to urban garden district, transfer ownership of land to community land trust, long term land leasing with ability to fence and secure). *[Cleveland City Planning Commission, Community Development Dept., Cleveland Land Bank, Community Development Corporations]*
- Develop policies and practices within the Cleveland Water Department that streamline farmers and gardeners access to water. Establish water rates that incentivize and promote agricultural uses. *[Cleveland Water Department, Community Development Department, Economic Development Department]*
- Explore new ways of bringing water to sites including maximizing the use of rainwater runoff from adjacent building roofs, leaving water lines to properties after demolition of buildings, etc. *[Cleveland Water Department, Community Development Department, Economic Development Department]*
- Explore potential for a municipal composting facility and community composting projects. *[Community Development Department, Cleveland Office of Sustainability, Department of Parks, Recreation and Properties]*

ENERGY GENERATION

- Support the adoption of an Ohio Renewable Energy Portfolio and consider incentivizing the generation and use of renewable energy at the local level. *[Cleveland Office of Sustainability, Cuyahoga County Office of Sustainability, Green Energy Ohio]*
- Support efforts toward energy conservation and optimization, as well as energy production, at a citywide level. *[Cleveland Office of Sustainability]*

PILOT PROJECTS

Pilot projects will be prioritized based on the availability of funding and partnerships for implementation. Benchmarks need to be established for all pilot projects so that benefits can be clearly quantified and monitored. This initial list of pilot projects was developed to test the ideas put forth in this place and determine the most feasible and effective approaches for vacant land reuse. The criteria for pilot projects include:

- Projects that break new ground
- Locations near primary development areas
- Ability to attract funding
- High visibility locations
- Local constituencies and implementation partners

LAND HOLDING STRATEGIES as described in the *Vacant Land Pattern Book*, will be implemented in prime development areas and growth neighborhoods. Land holding strategies will be piloted in prime development areas and other targeted investment areas. Potential partners include all of the community development corporations.

LAND REUSE PROJECTS in urban agriculture, energy generation, bio- and phyto-remediation, stormwater management strategies, and additional recreation/green space will be piloted in low-growth neighborhoods. Potential partners include community development corporations, the Ohio State Extension, the Cleveland Botanical Garden, ParkWorks, the Northeast Ohio Sewer District, and the Cuyahoga Soil and Water Conservation District.

LAND ACQUISITION and MANAGEMENT Develop an organizational model for acquiring and maintaining vacant land and redirecting it for the uses described in the criteria section.

- Pursue land acquisition and management strategies at the watershed-scale, rather than at a neighborhood- or citywide-scale.
- Work with existing local and regional land conservation organizations to develop an urban land conservation mechanism that targets small (<10 acre) sites in the city.
- Work with the City Land Bank and the County Land Bank (when it is established) to acquire strategic parcels for conservation through the foreclosure process.

MOW-TO-OWN PROGRAM Vacant lots can be absorbed into residential neighborhoods by encouraging adjacent property owners to acquire and maintain these sites as an expansion of their own properties. Currently, the city has a program that makes landbank available to adjacent property owners. The city could expand this effort into a Mow-to-Own program in which residents earn the ownership of a neighboring or nearby property in exchange for providing good maintenance of these properties according to city-established standards. A property owner who maintains a property for one year would receive title to the property with the condition that the property continue to be maintained to the same standards. If the property owner fails to maintain the property, ownership would revert to the city's landbank. At high-profile locations in targeted parts of the city, funding could be developed to provide minimal landscaping and fencing in order to make these sites cared for and attractive.

PHYTOREMEDIATION and BIOREMEDIATION for soil restoration and lead containment/remediation of vacant sites. Even if areas must be disturbed later, preserving or establishing vegetation on vacant sites will help restore soil structure and reduce the presence of airborne led in city neighborhoods.

- Vegetation strategies can become part of the city's demolition specifications and/or a separate initiative led by local community development corporations.
- Phytoremediation and bioremediation demonstration sites can be identified from the city's landbank; this would be a site for which remediation funding is not yet available through Clean Ohio, but could be used as an experimental site for phytoremediation strategies.

Potential collaborators include the City of Cleveland Brownfields Coordinator, Cleveland Heath Department, the Ohio State Extension Office, the Greater Cleveland Lead Advisory Council, the Cleveland Botanical Garden, the Cleveland Neighborhood Development Coalition, local community development corporations.

URBAN AGRICULTURE INCUBATOR could provide land and appropriate infrastructure for urban agriculture enterprises. Aspects of this pilot project would include:

- Develop a business plan, resources for start-up, and operating partnerships.
- Identify several sites of at least two-three acres within the city that would be available for long-term use as urban farms and re-zone as an Urban Garden District; conduct environmental assessment to determine whether soil at the preferred site(s) have environmental contaminants that could affect food production.
- Develop appropriate infrastructure at the site and agreements for the management of infrastructure, including access to water, utilities, packing shed/cooler, tool storage, rototiller, security, and soil remediation.
- Once long-term use of land is secured, infrastructure developed, and the project has the support and approval of adjacent land owners, the city, and other stakeholders, ½-acre parcels would be available to agriculture entrepreneurs.

NATIVE PLANT EXPERIMENTAL PLOTS AND NURSERIES /TREE NURSERY Several large-scale public investment projects will occur in the next three to five years, including the extension of the Ohio and Erie Canal Towpath Trail into the City of Cleveland, the creation of Canal Basin Park, and improvements to Wendy Park. Native plant materials in these areas will aid in preserving riparian functions along the Cuyahoga River, improve water quality in the River and Lake Erie, and enhance biodiversity wildlife habitat within the city. Appropriate native plant materials can be expensive and difficult to find. Vacant sites within the city of Cleveland can be used to grow different varieties of plants and to conduct tests to see which plant materials are the most resilient in an urban context. Establishing series of experimental plots will allow a wide range of plant materials to become established prior to transplanting them in permanent locations in public parks and natural areas. Surplus plant materials can also be sold to institutions, residents, and businesses to increase the overall plant diversity of the city. A larger vacant site (20-acres or more) could allow for the creation of a tree nursery.

Several steps are needed to determine the feasibility of a native plant nursery:

- Identify public improvements planned for the next five years
- Calculate the quantity of native plant materials needed for these improvements and determine the acreage that would be needed to cultivate these plant materials.
- Identify land bank lots or other vacant sites that would be most suitable and accessible for plant cultivation.
- Formulate a business plan to determine if it will be financially feasible to establish native plant experimental plots, based on the cost of setting up the experimental plots and cultivating the plant materials,

and well as the revenue that would be generated (or saved) by using these locally grown plant materials for public projects.

- The costs associated with a project of this scale; and
- The environmental, economic, and social benefits of the project.

Potential collaborators include the Cleveland Metroparks, Cleveland Botanical Garden, the Cleveland Municipal School District and South High School's Horticultural Program at Washington Park, and the Cleveland Department of Parks and Recreation, the Democracy Collaborative at the University of Maryland, and the Cleveland City Forester.

NEXT STEPS/IMPLEMENTATION

Moving the ideas of *Re-imagining a More Sustainable Cleveland* forward will require new partnerships and an ongoing commitment to addressing the growing challenge of vacancy in Cleveland. Initial resources for several pilot projects in the first year are available to support this work through Neighborhood Progress, the Surdna Foundation, and the City of Cleveland's federal Neighborhood Stabilization Funds. Additional potential resources include:

- Local and national foundations
- Unexpended NatureWorks funds from the Ohio Department of Natural Resources
- USEPA CARE Program
- Living Cities National Community Development Initiative
- Federal Resources Conservation Service funding through the US Department of Agriculture
- Partnership opportunities with the Northeast Ohio Regional Sewer District, in conjunction with the implementation of a regional stormwater utility
- Research funding from the Northeast Ohio Research Consortium and other sources.
- Private sector partnerships

NPI will work with partner organizations to raise a pool of $1 million for a pilot program which could support up to 100 projects in targeted areas of the city, transforming vacant, blighted land into projects that add value to communities as opposed to being a drain on home values and quality of life. To implement this aggressive agenda, NPI recommends that local community development corporations and other specialized non-profit organizations work with grassroots organizations and individuals to implement the various strategies. These specialized organizations could include: the Cleveland Botanical Garden, Cuyahoga Community Land Trust, Cuyahoga Soil and Water Conservation District, New Agrarian Center, North East Ohio Regional Sewer District, OSU Extension, ParkWorks, Shaker Lakes Nature Center, and the Trust for Public Land.

"We know what recovery looks like. We've done it before and we'll do it again" - Councilman Anthony Brancatelli, Ward 12, City of Cleveland. For the past 20 years, Cleveland has been a national leader in community development and can become a national leader in the reutilization vacant land for productive use. The principles and projects described in this report are the beginning of a new way of thinking about development and conservation across the city. The resources and expertise are now available to support the city's recovery and transform Cleveland into an innovative, sustainable, and radiant city.

For more information on implementation of pilot projects and next steps on policy recommendations, please contact Bobbi Reichtell at Neighborhood Progress: blr@neighborhoodhoodprogress.org or 216.830.2770.

Appendix K:

Cleveland Complete and Green Streets: Typologies Plan – 8/20/2013

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Cleveland Complete and Green Streets

Typologies Plan - 8/20/2013

CITY OF CLEVELAND
Mayor Frank G. Jackson

the YMCA

alta PLANNING + DESIGN

Acknowledgements

The City of Cleveland appreciates the efforts of the stakeholders who participated in the development of this Complete and Green Streets Typologies Manual. Their creativity, energy, and commitment to a more sustainable and thriving Cleveland provided valuable input for this document and helped to shape Complete and Green Streets in Cleveland. Participation from City staff, local organizations, and Cleveland citizens, as well as generous funding from the Greater Cleveland YMCA made this project possible.

Special thanks to the members of the Cleveland Complete and Green Streets Task Force, listed below, whose continued efforts helped to guide the development of this manual.

Cleveland Complete and Green Streets Task Force

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Cover Photo: Euclid Ave in Cleveland. Steven Litt, Art and Architecture Critic at The Plain Dealer
Table of Contents Photo: Cleveland Skyline. Courtesy of Tom Baker

Table of Contents

Chapter 1 - Introduction

Euclid Ave. in Cleveland is a good example of an existing complete and green street: one that gives equal consideration to all users and addresses sustainability.

Overview

City streets serve a multitude of functions: providing access to places, goods and services, serving as public space, capturing, channeling and sometimes filtering stormwater, and serving as corridors for key utility systems. Streets are such an integral part of everyday life, it is important that we maximize their value and their safety. Because Cleveland's streets make up a large portion of the urban landscape and are the main way in which the City channels stormwater, it is also important that they are ecologically sound and energy efficient.

Cleveland's streets take several forms and serve several functions in terms of how they are used for transportation and public space. They can provide a safe, peaceful route for children to walk or bicycle to school; a way for employees to get to work by bicycle, automobile or public transit; a place for residents and visitors to shop, dine or just sit and relax; and corridors that move people and goods efficiently. When total preference is given to a particular use, this usually comes at the expense of other uses. Therefore, Cleveland's streets should be designed to give sufficient consideration to all uses.

In Cleveland, like most of the United States since the end of WWII, automobiles were given priority in the design of streets. This means that streets are primarily designed for cars and not for walking, bicycling and transit, or the natural environment. By contrast, the concept of Complete and Green Streets takes into consideration context, roadway users and environmental concerns to ensure that streets are designed to reasonably balance the needs of all roadway users and uses. There are additional benefits of increased health, safety, and environmental improvements.

The purpose of the Cleveland Complete and Green Streets Typologies Manual is to provide a framework and guide for Cleveland to use in its efforts towards developing a network of Complete and Green Streets throughout the City, for the benefit of all residents and visitors.

Definition of Complete and Green Streets: *Complete Streets are streets for everyone. They are designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists, and public transportation users of all ages and abilities are able to safely move along and across a complete street. Complete Streets make it easy to cross the street, walk to shops, and bicycle to work. They allow buses to run on time and make it safe for people to walk to and from train stations.*

Many elements of street design, construction, and operation can work in favor of achieving both Complete Streets that work for all travelers and 'green' streets that serve environmental sustainability. Of particular concern are drainage and stormwater runoff issues too common in traditional streets. Optimal stormwater management looks beyond simply removing rainfall as quickly as possible, which risks negative environmental impacts associated with both stormwater quality and quantity, like polluted runoff, sedimentation, and bank erosion. Instead it focuses on efforts to retain and treat – or even eliminate – runoff at the source through cost-effective green infrastructure, improving water quality and complementing Complete Streets efforts.[1]

This Plan is presented in the following chapters:

Chapter 1 provides background information about the Typologies and the planning process that contributed to the development of this Plan.

Chapter 2 provides an overview of what the City, planners and developers should consider when planning a Complete Street and the different treatments that can be applied to Cleveland's streets to make a street more "complete."

Chapter 3 presents the street typologies developed for Cleveland and potential treatments appropriate for each. This section also presents maps that show Complete Streets typologies applied to the entire Cleveland street network.

Project Background

The City of Cleveland is committed to becoming a more bicycle and pedestrian-friendly community, while reducing its ecological footprint. These commitments, combined with world-class service provided by the Greater Cleveland RTA, are putting Cleveland on a path to a sustainable transportation network.

In September 2011, the City of Cleveland passed Ordinance 798-11 which states that the City of Cleveland is committed to the creation of a network of Complete and Green Streets that will improve the economic, environmental and social well-being of its citizens. Cleveland's network of Complete and Green Streets will provide safe and desirable travel for users of all ages and abilities by promoting alternative modes of transportation to accommodate pedestrians, cyclists, motorists and transit while also creating opportunities for the development of sustainable solutions and their application to urban streets in accordance with best management practices in green infrastructure.

The ordinance was crafted by the Complete and Green Streets Task Force (CGST). This same Task Force initiated the Typologies project to create an agreed-upon framework for decision making in the right-of-way that is in compliance with the City's Complete and Green Streets Ordinance. This guiding document will allow the City and other stakeholders to understand the preferred designs and the criteria for implementing those designs in the right-of-way.

In addition to the Complete and Green Streets Ordinance, City Council passed a bicycle transportation safety ordinance in June 2012 to help protect cyclists on the road. Among other features, the policy requires motorists overtaking a bicycle proceeding in the same direction to leave a safe distance, not less than 3 feet, when passing (commercial vehicles required to leave at least 6 feet).

As one sign of progress, the League of American Bicyclists has recognized Cleveland as a Bronze level Bicycle Friendly Community (BFC). The Bronze BFC award highlights our community's commitment to improving conditions for bicycling through investment in bicycling promotion, education programs, infrastructure and pro-bicycling policies.

Cleveland Complete and Green Streets Typologies Goals

The primary goals of the Cleveland Complete and Green Streets Typologies are as follows:

"Two-thirds of adults and one-third of children are overweight or obese. Left unchecked, obesity's effects on health, health care costs, and our productivity as a nation could become catastrophic".

In May 2012, the Institute of Medicine committee released Accelerating Progress in Obesity Prevention and offered five recommendations along with strategies for implementation.

"Recommendation 1: Communities, transportation officials, community planners, health professionals, and governments should make promotion of physical activity a priority by substantially increasing access to places and opportunities for such activity. "

"Strategy 1-1: Enhance the physical and built environment." (Institute of Medicine, 2012)[2]

- Build upon the vision and requirements contained in the Complete and Green Streets Ordinance.
- Provide a practical, cost-effective, guide to roadway infrastructure investments that provide safety, convenience and comfort for all transportation modes and users.
- Create approaches tailored to existing conditions in Cleveland and to community objectives; and provide a catalogue of best practices for Complete and Green Streets design that builds upon current Cleveland practices with nationally accepted best practices.
- Build consensus and remove barriers between City government departments and external stakeholders in implementing Complete and Green Streets in Cleveland.
- Serve as a tool for the efficient pre-planning of roadways, a guide that sets internal and external expectations for Cleveland's roads.

The Need for Complete Streets

The benefits of Complete Streets within communities are numerous and have been documented by planners, engineers, state legislatures, non-profit coalitions, state and county health departments, and others. The National Complete Streets Coalition (www.complete streets.com) has published fact sheets on the many direct and indirect benefits Complete Streets provide. Some of the benefits that Cleveland can expect to realize in the implementation of the Complete Streets Plan and Ordinance include the following:

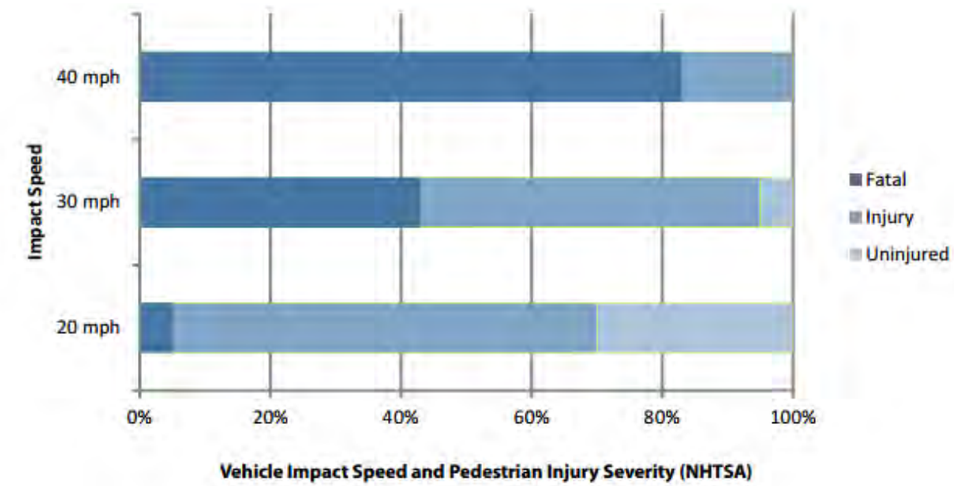
Healthy and Livable Communities

Today, many local governments and businesses are facing a crisis as they attempt to cope with the growing healthcare costs associated with chronic diseases, many of which are preventable. Obesity and sedentary lifestyles are major contributors to chronic disease for both adults and children.

The public health community recognizes that nonmotorized or "active" travel helps citizens meet recommended levels of physical activity, thereby reducing the risk of chronic disease and associated health care costs.[3] In 2009, the Centers for Disease Control and Prevention (CDC) released Recommended Community Strategies and Measurements to Prevent Obesity in the United States, a report recommending Complete Streets policy adoption as a strategy for obesity prevention.[4] Complete Streets are a way of providing an environment that will encourage and promote healthier, more active lifestyles for residents.

Air Quality

Reducing congestion along a roadway results in less vehicle idle times, thus reducing smog and ground level ozone, which are both large contributors of greenhouse gases. Complete Streets-designed corridors improve traffic flow by lessening the stop-and-go pace of vehicular traffic, help regulate vehicle speeds to appropriate levels for the corridor's function, and reduce the number of cars on the road as some motorists become choice pedestrians, bicyclists, and transit riders.



Improved Safety

A recent review of bicyclist safety studies found that the addition of well-designed bicycle-specific infrastructure tends to reduce injury and crash risk. On-road bicycle lanes reduced these rates by about 50%.[5]

Streets without safe places to walk, cross, catch a bus, or bicycle put people at risk. The National Complete Streets Coalition publishes some sobering national statistics:[5]

"Pedestrian crashes are more than twice as likely to occur in places without sidewalks; streets with sidewalks on both sides have the fewest crashes. Of pedestrians killed in 2007 and 2008, more than 50% died on arterial roadways, typically designed to be wide and fast. More than 40% of pedestrian fatalities occurred where no crosswalk was available...Speed reduction has a dramatic impact on pedestrian fatalities. **Eighty percent of pedestrians struck by a car going 40 mph will die; at 30 mph the likelihood of death is 40 percent. At 20 mph, the fatality rate drops to just 5 percent."**

Roadway design and engineering approaches commonly found in complete streets create long-lasting speed reduction. Such methods include enlarging sidewalks, installing medians, and adding bike lanes. All road users - motorists, pedestrians and bicyclists - benefit from slower speeds.

Improved Access

Access to jobs, education, grocery shopping, healthcare, and other destinations is vital in our urban areas. In Cleveland, about 25% of households do not own a car. In addition, many seniors and disabled Clevelanders are limited in their ability to drive. Creating safe streets allows access and travel by pedestrians, wheelchair users, cyclists, transit users and builds a more livable, accessible community for people of all ages, abilities, and income levels.[6]

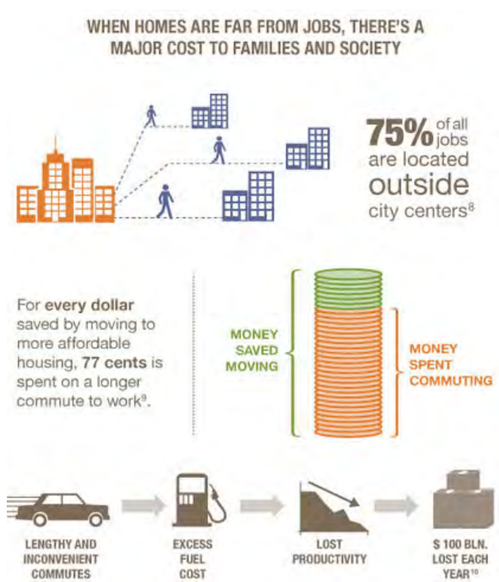
Changing demographics

America's young people, including the 'Generation Y' and the maturing 'Millennials', are decreasing the amount they drive and increasing their use of transportation alternatives.[7] National Household Transportation Survey Data

The estimated replacement cost of Portland's entire 300+ mile bikeway network—acknowledged as the best in North America—is approximately $60 million (in 2008 dollars), which is roughly the cost of one mile of four-lane urban freeway.

The monetary investment on bicycle specific infrastructure represents just less than one percent of the funding the metropolitan area spent on transportation between 1995 and 2010.[8]

compared between 2001 and 2009 has shown that America's 16-34 year olds are driving less and walking, bicycling and taking transit more. Downtown Cleveland's population grew 96% over the last 20 years with residential totals increasing from 4,651 to 9,098. Downtown residential occupancy rates now stand over 95% and developers are eagerly looking to meet residential demand. The majority of the population increase is made up of 22 to 24-year olds (51%). Closely followed by 25 to 34-year olds.[9]



Graphic Source: Robert Wood Johnson Foundation (www.newpublichealth.org)

Young people's transportation priorities and preferences differ from those of older generations. Preferences for living in places where they can easily walk, bike or take public transportation are clearly exhibited by a recent study by the National Association of Realtors. Environmental consciousness is also becoming more evident with nearly twice as many 18 to 34 year olds stating that they drive less to protect the environment than older generations (16 percent versus 9 percent). The trend toward reduced driving among young people is likely to persist as a result of technological advancements that reduce the need to travel and increased legal and financial barriers to driving.

Economic Development

In Cleveland, Euclid Avenue and its Healthline is a Complete and Green Street which includes Bus Rapid Transit, bicycle lanes, hundreds of trees and green medians, and enhanced pedestrian infrastructure. The HealthLine's role in Euclid Avenue's revitalization has been demonstrated in a first year ridership increase of 46 percent over the previous year's bus service, moving 3.8 million people. Ridership has consistently increased ever since. Even before starting operations, the Healthline helped spur $4.3 billion in development projects in the corridor. Key accomplishments include the following:

- The $200 million investment in the HealthLine BRT project attracted at least $4.3 billion in development investment.
- Development activity along Euclid Avenue resulted in the clean-up and redevelopment of numerous vacant and abandoned properties and infrastructure.
- The Institute for Transportation and Development Policy rated the HealthLine as the best BRT line in the country based on service planning, infrastructure, station design, quality of service, and access.
- Between 2002 and 2009, $1.9 billion in development occurred in the University Circle district on Euclid Avenue, including the addition of 22,000 square feet of retail space.
- It has also spurred the creation of 5,000 jobs since 2005.

Intent and Use of the Guide

The Cleveland Complete and Green Streets Guidelines will provide a toolbox for those who design, build and maintain streets, as well as citizens who live and travel on those streets.

For designers, the typologies and guidelines presented in this Plan do not dictate rigid standards for roadway design; rather, they provide examples of appropriate design elements and dimensions used in unison, depending on the location of the roadway, its function and the nature of the surrounding area. **The typologies presented in this plan do not necessarily show what treatments *should* be applied to a particular roadway, but rather what treatments *can* be applied to a particular roadway. Further planning studies, engineering studies and outreach should be conducted to weigh all available options and the desired balance of transportation modes.**

The Complete Streets elements presented in this document are compliant with nationally accepted best practices such as the *AASHTO Guide for the Development of Bicycle Facilities* (2012), the *NACTO Urban Bikeway Design Guide* (2012), the *AASHTO Guide for the Planning, Design and Operation of Pedestrian Facilities (2004)* , *ITE and CNU's Designing Walkable Urban Thoroughfares: A Context Sensitive Approach (2010),* and the *Manual on Uniform Traffic Control Devices* (2009)

For citizens, the Complete Streets Guidelines are intended to be an accessible and easy to understand document that show potential improvements that can be applied to Cleveland's streets to make them more "complete. and green." These guidelines will allow designers and citizens to use a common language while working together to create roadways that meet the current and future needs of Cleveland's communities.

Future Considerations

The typologies developed for this document are intended to show what improvements can be made to Cleveland's streets with a focus on the near future. Typologies show what treatments can be applied to Cleveland's streets without changing the curb-to curb width of the street, making it feasible that many of the improvements shown in this Plan can be included as a part of roadway resurfacing or restriping projects. Roadway resurfacing projects provide a quick and relatively inexpensive means of implementing changes to the roadway; roadway re-engineering projects such as those that widen or add lanes tend to be more costly and occur less frequently.

However, roadway contexts and uses change over time, as well as accepted best practices. For example, the City may see it necessary in the future to recommend making changes to the overall width of some of its roadways due to changes in context.

The City may update this document to ensure that guidelines remain relevant especially if changes are made to the Bikeway Master Plan, and other citywide planning documents.

Cleveland Complete and Green Streets January Stakeholder Workshop

Planning Process

The Cleveland Complete and Green Streets Task Force with the consulting guidance of the Alta Planning + Design team led to the development of the Typologies. The planning effort kicked off with a stakeholder workshop in January 2013, which included members of the Complete and Green Streets Task Force as well as local, regional, and state stakeholders.

Stakeholder Workshop

The workshop in January brought together key stakeholders from the Cleveland region and throughout the State to provide input on the development of the typologies. Stakeholders included representatives from:

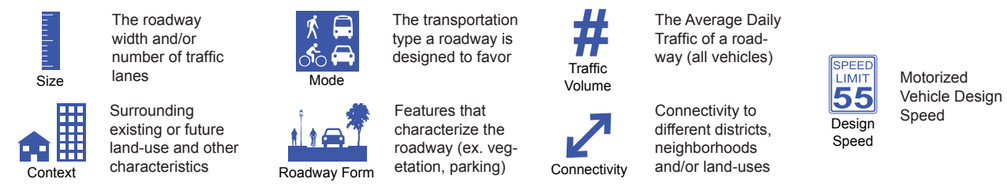
- The Cleveland Urban Design Collaborative
- LAND Studio
- The Northeast Ohio Regional Sewer District
- The Downtown Cleveland Alliance
- The GreenCityBlueLake Institute
- YMCA of Greater Cleveland
- The City of Cleveland Department of Aging
- The Northeast Ohio Areawide Coordinating Agency
- Cuyahoga County
- Ohio Department of Transportation
- The Greater Cleveland Regional Transit Authority
- Metroparks
- Cleveland City Council
- University Circle Incorporated

The workshop began with an overview that showed the need for Complete and Green Streets in Cleveland, showed how other cities are addressing Complete Streets and presented possible treatments that can be applied to roadways to help balance user needs and address context.

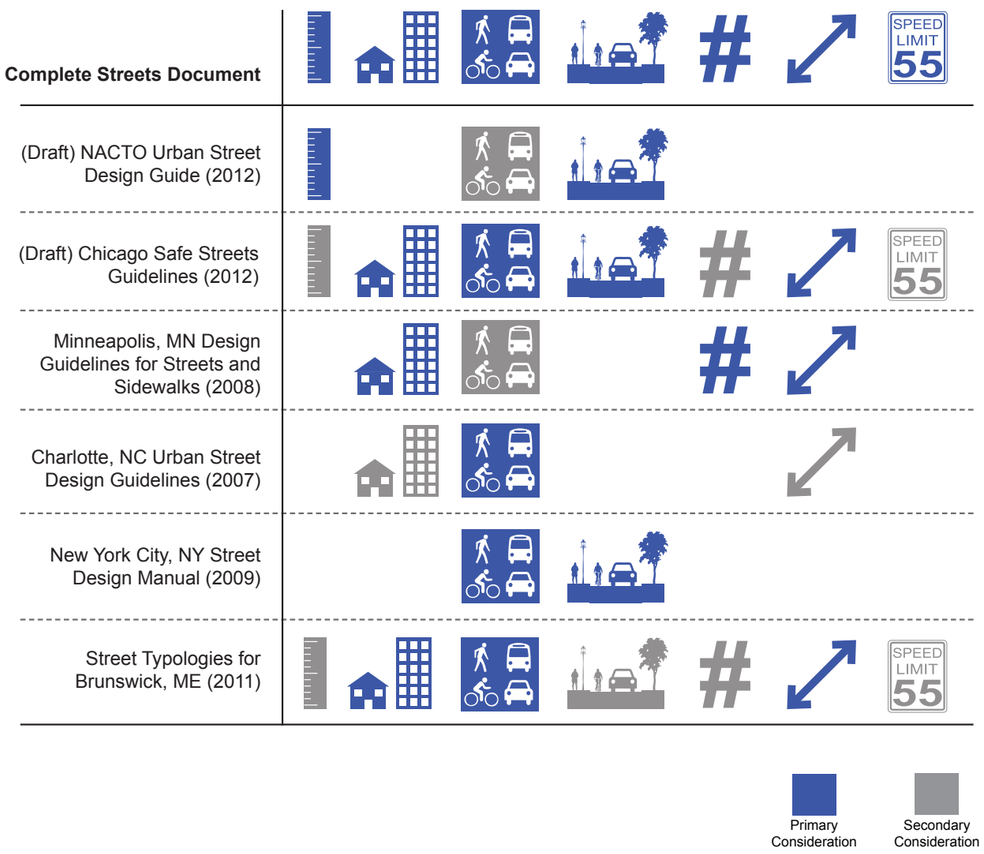
After this presentation, the participants were divided into groups and asked to develop Complete Streets Typologies for Cleveland and then select the traffic calming treatments they most preferred for each of these typologies. The results of these exercises were used to help generate typology names and determine potential Complete and Green Streets treatments.

***Figure 1.1** - Review of Street Characteristics Considered in Complete Streets Typologies of Peer Cities*

Street Typology Characteristics



Characteristics Included in Complete Streets Guidelines



A detailed summary of the January Stakeholder Workshop can be found in Appendix A.

Complete Streets Plan Peer Review

To help with the development of Cleveland's typologies, the Alta team conducted a review of Complete Streets Plans, mostly those of cities with similar land use, weather or socio-economic characteristics of Cleveland. These plans included:

- (Draft) *The NACTO Urban Street Design Guide* (2012)
- (Draft) *Chicago Safe Streets Guidelines* (2012)
- *Minneapolis, MN Design Guidelines for Streets and Sidewalks* (2008)
- *Charlotte, NC Urban Street Design Guidelines* (2007)
- *New York City, NY Street Design Manual* (2009)
- *Street Typologies for Brunswick, ME* (2011)

These documents were compared to see what elements defined roadway typologies. Seven principal characteristics were used to define complete streets typologies throughout the documents, although different plans emphasized different characteristics. These characteristics include:

- Roadway Size
- Roadway Context
- Transportation Mode
- Roadway Form
- Traffic Volume
- Connectivity, and
- Design Speed

A graphic summarizing the results of this review can be seen in **Figure 1.1**. The results of this review influenced the definition of Cleveland's typologies, which are explained in Chapter

Chapter 1 Endnotes

1. IOM (Institute of Medicine), Accelerating Progress in Obesity Prevention: Solving the Weight of the Nation. Washington, DC: the National Academies Press (2012).

2. Robert Wood Johnson Foundation. Active transportation: making the link from transportation to physical activity and obesity, Active Living Research (2009).

3. Safe Routes to School National Partnership, Quick Facts (2012). http://www.saferoutespartnership.org/resourcecenter/quick-facts.

4. Keener, D., Goodman, K., Lowry, A., Zaro, S., & Kettel Khan, L. Recommended community strategies and measurements to prevent obesity in the United States: Implementation and measurement guide. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. http://www.cdc.gov/obesity/downloads/community_strategies_guide.pdf

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6. Cromartie & Nelson, Baby Boom Migration and Its Impact on Rural America, United States Department of Agriculture, Economic Research Service, Economic Research Report No. (ERR-79) (2009). http://www.ers.usda.gov/publications/err79/

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8. Geller, Roger, Build it and they will come, City of Portland (2011). http://www.portlandoregon.gov/transportation/article/370893

9. Piiparinen, Richey. Not Dead Yet: The Infill of Cleveland's Urban Core. http://www.metrotrends.org/spotlight/Cleveland_Spotlight.cfm)

10. Partnership for Sustainable Communities. Transit as Transformation: The Euclid Corridor in Cleveland (2012). http://www.sustainablecommunities.gov/pdf/studies/cleveland-euclid-corridor.pdf)

Euclid Avenue

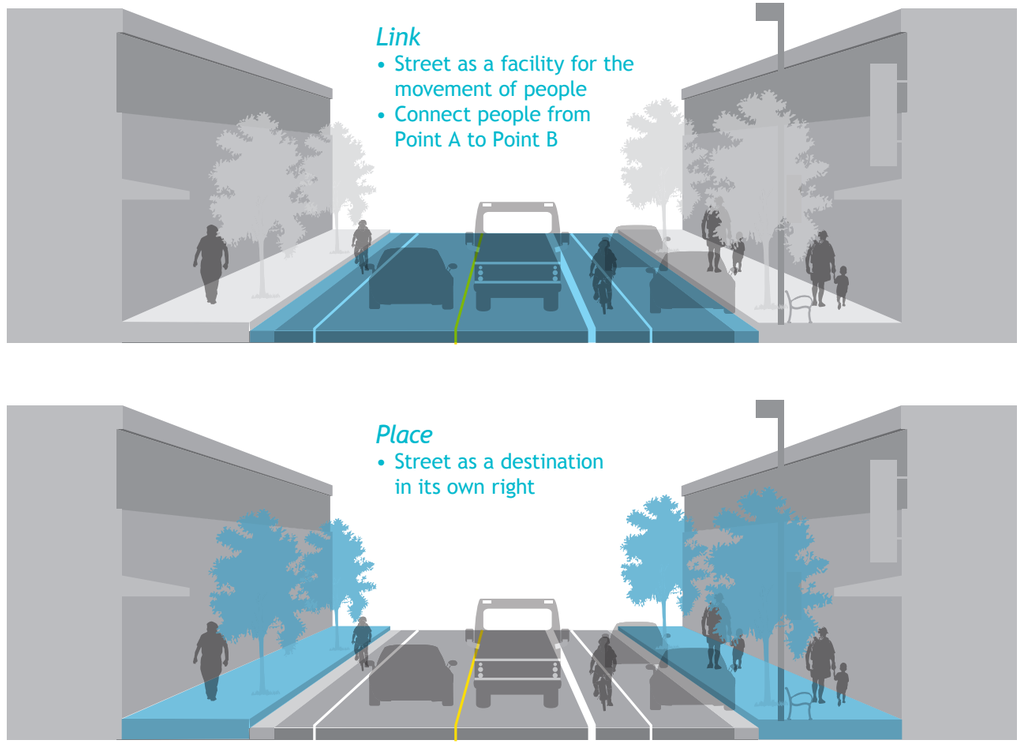
Chapter 2 - Complete and Green Streets Design

Overview

There are many considerations that factor into the design of a Complete and Green Street. This chapter explains the elements that comprise a Complete and Green Street, as well as explain how considerations such as land use, expected users, and connectivity can affect the overall design of the roadway.

A street serves as a **place** and as a **link**. In the United States following WWII, most roadways have been designed with the primary focus being to connect destinations via automobile. Roadways designed in this fashion typically function as a link that is designed only to connect point A to point B in a manner that facilitates quick motor vehicle travel. However, roadways also function as a social space and have a relationship with the places where people live, work and play. Treating streets simply as links often ignores the other important contexts and functions that streets should address. The Complete Streets design philosophy is a shift to use both link and place concepts in designing roadways. Designing for all modes with both link and place considerations has the potential to add value to Cleveland's roadway system. This will help the city transition to a network that is more sustainable and safe, while providing public spaces that are inviting for people and businesses.

Figure 2.1 - *The Street as a Link and a Place*



Since ample guidelines exist on the accommodation of automobiles along roadways, and Cleveland roadways are, for the most part, designed to give these users priority, this guide is intended to focus on the design considerations for bicyclists, pedestrians and transit users.

Design for Pedestrians

The transportation network should accommodate pedestrians with a variety of needs, abilities, and possible impairments. Age is one major factor that affects pedestrians' physical characteristics, walking speed, and environmental perception. Children have low eye height and walk at slower speeds than adults. They also perceive the environment differently at various stages of their cognitive development. Older adults walk more slowly and may require assistive devices for walking stability, sight, and hearing.

The Manual of Uniform Traffic Control Devices (MUTCD) recommends a normal walking speed of three and a half feet per second when calculating the pedestrian clearance interval at traffic signals. Typical walking speeds can drop to three feet per second in areas with older populations and persons with mobility impairments. While the type and degree of mobility impairment varies greatly across the population, the transportation system should accommodate these users to the greatest reasonable extent.

Sidewalks

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel that is separated from vehicle traffic. Sidewalks are typically constructed of concrete and are separated from the roadway by a curb and gutter and preferably a landscaped planting strip area. Sidewalks are a common application in both urban and suburban environments. Attributes of well-designed sidewalks include the following:

Sidewalks should be more than areas to travel; they should provide places for people to interact. There should be places for standing, visiting, and sitting. Sidewalks should contribute to the character of neighborhoods and business districts, strengthen their identity, and be an area where adults and children can safely participate in public life.

Accessibility: A network of sidewalks should be accessible to all users. Roadway crossing distances and distances between crossings should be minimized to accommodate and encourage pedestrian travel.

Adequate width: Two people should be able to walk side-by-side. Different walking speeds should be possible. In areas of intense pedestrian use, sidewalks should accommodate the high volume of walkers.

Safety: Design features of the sidewalk should allow pedestrians to have a sense of security and predictability. Sidewalk users should not feel they are at risk due to the presence of adjacent traffic.

Continuity: Walking routes should be obvious and should not require pedestrians to travel out of their way unnecessarily.

Landscaping: Plantings and street trees should contribute to the overall psychological and visual comfort of sidewalk users, and be designed in a manner that contributes to the safety of people.

Drainage: Sidewalks and curb ramps should be designed so that standing water is minimized.

Social space: There should be places for standing, visiting, and sitting. The sidewalk area should be a place where adults and children can safely participate in public life.

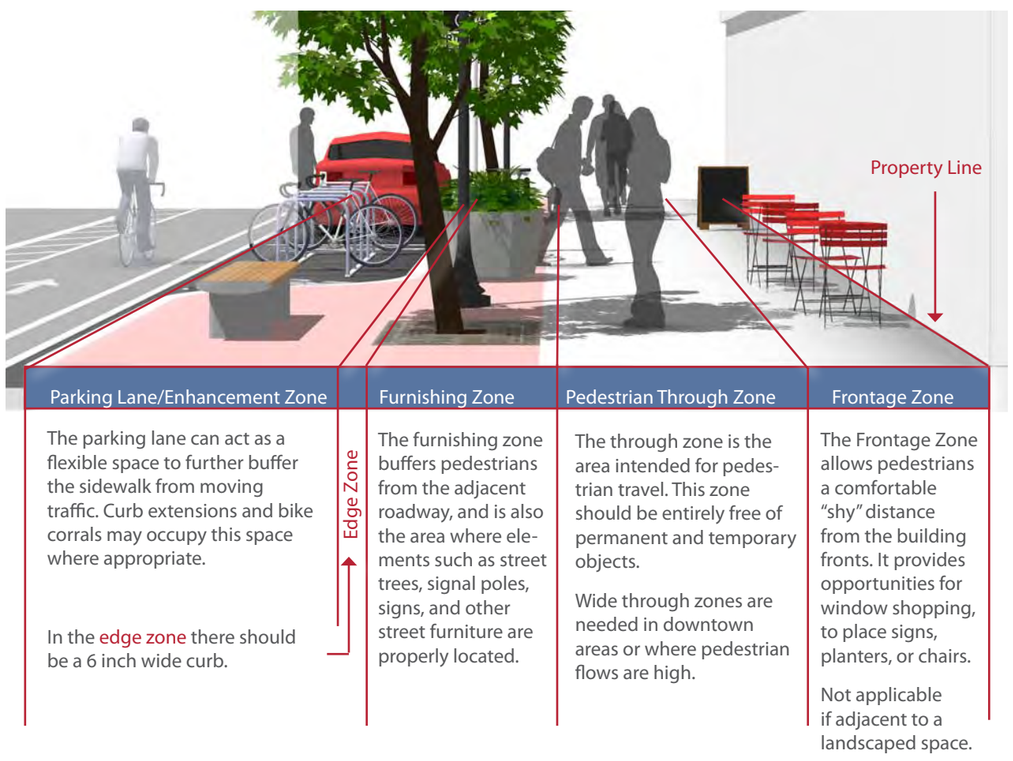
Quality of place: Sidewalks should contribute to the character of neighborhoods and business districts.

Sidewalk Zones

The sidewalk area can be broken down into four distinct zones as seen in **Figure 2.2** below. The concept of sidewalk zones should be strictly followed for a sidewalk to function properly and provide safe passage for all users. This is especially important for users with visual or physical impairments to be able to effectively navigate the corridor.

Other considerations such as sidewalk obstructions, driveways, width and access through construction areas are important to consider as well. More guidance on these topics will be included in the companion Complete and Green Streets Design Guidelines to come at a later date.

Figure 2.2 - *Elements of the Sidewalk Corridor*



Intersections

Intersections are also an important piece of the pedestrian realm. Attributes of pedestrian-friendly intersection design include:

Clear Space: Corners should be clear of obstructions. They should also have enough room for curb ramps, for transit stops where appropriate, and for street conversations where pedestrians might congregate.

Visibility: It is critical that pedestrians on the corner have a good view of vehicle travel lanes and that motorists in the travel lanes can easily see waiting pedestrians.

Legibility: Symbols, markings, and signs used at corners should clearly indicate what actions the pedestrian should take.

Accessibility: All corner features, such as curb ramps, landings, call buttons, signs, symbols, markings, and textures, should meet accessibility standards and follow universal design principles.

Separation from Traffic: Corner design and construction should be effective in discouraging turning vehicles from driving over the pedestrian area. Crossing distances should be minimized.

Lighting: Good lighting is an important aspect of visibility, legibility, and accessibility.

These attributes will vary with context but should be considered in all design processes. For example, more remote intersections may have limited or no signing. However, legibility regarding appropriate pedestrian movements should still be taken into account during design.

Design for Bicyclists

Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers. Bicyclists lack the protection from the elements and roadway hazards provided by an automobile's structure and safety features. By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The design of a bikeway should consider reasonably expected bicycle types on the facility and utilize the appropriate dimensions.

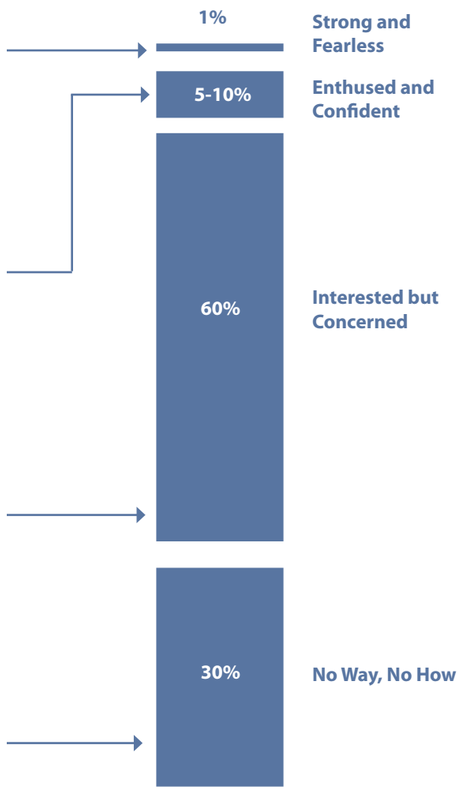
Mayfield Rd. in Little Italy is a popular street for pedestrians and bicyclists. The concept of Complete Streets looks at the principles that make streets like this one pleasant and accessible for all roadway users, builds upon these principles and applies them to all streets.

It is important to consider bicyclists of all skill levels when creating a non-motorized plan or project. Bicyclist skill level greatly influences expected speeds and behavior, both in separated bikeways and on shared roadways. Bicycle infrastructure should accommodate as many user types as possible, with decisions for separate or parallel facilities based on providing a comfortable experience for the greatest number of people.

The bicycle planning and engineering professions currently use several systems to classify the population, which can assist in understanding the characteristics and infrastructure preferences of different bicyclists. The most conventional framework classifies the "design cyclist" as *Advanced*, *Basic*, or *Child*.[1] A more detailed understanding of the US population as a whole is illustrated in **Figure 2.3**. Developed by planners in Portland, OR[2] and supported by

1 Selecting Roadway Design Treatments to Accommodate Bicycles. (1994). Publication No. FHWA-RD-92-073
2 Four Types of Cyclists. (2009). Roger Geller, City of Portland

Figure 2.3 - *Four Types of Cyclists*



data collected nationally since 2005, this classification provides the following alternative categories to address varying attitudes towards bicycling in the US:

- **Strong and Fearless** (approximately 1% of population) – Characterized by bicyclists that will typically ride anywhere regardless of roadway conditions or weather. These bicyclists can ride faster than other user types, prefer direct routes and will typically choose roadway connections -- even if shared with vehicles -- over separate bicycle facilities such as shared use paths.

- **Enthused and Confident** (5-10% of population) - This user group encompasses bicyclists who are fairly comfortable riding on all types of bikeways but usually choose low traffic streets or shared use paths when available. These bicyclists may deviate from a more direct route in favor of a preferred facility type. This group includes all kinds of bicyclists such as commuters, recreationalists, racers and utilitarian bicyclists.

- **Interested but Concerned** (approximately 60% of population) – This user type comprises the bulk of the cycling population and represents bicyclists who typically only ride a bicycle on low traffic streets or multi-use trails under favorable weather conditions. These bicyclists perceive significant barriers to their increased use of cycling, specifically traffic and other safety issues. These people may become "Enthused & Confident" with encouragement, education and experience and higher level facilities, such as buffered and protected bike lanes.

- **No Way, No How** (approximately 30% of population) – Persons in this category are not bicyclists, and perceive severe safety issues with riding in traffic. Some people in this group may eventually become regular cyclists with time and education. A significant portion of these people will not ride a bicycle under any circumstances.

Bicycle Facility Types

Consistent with bicycle facility classifications throughout the nation, the facility types presented in the figures below identify classes of facilities by degree of separation from motor vehicle traffic. In general, the wider the roadway, the higher the traffic volume, and the greater the traffic speed, the more separation is necessary to provide safe and comfortable riding conditions for bicyclists. The most common bicycle facility types are as follows:

Shared Roadways are bikeways where bicyclists and cars operate within the same travel lane, either side by side or in single file depending on roadway configuration. The most basic type of bikeway is a signed shared roadway. This facility provides continuity with other bicycle facilities (usually bike lanes), or designates preferred routes through high-demand corridors.

Shared Roadways with Pavement Markings Shared roadways may also be designated by pavement markings, signage and other treatments including directional signage, traffic diverters, chicanes, chokers and /or other traffic calming devices to reduce vehicle speeds or volumes. Such treatments often are associated with **Neighborhood Greenways** (also known as Bicycle Boulevards).

Separated Bikeways, such as bike lanes and buffered bike lanes, use signage and striping to delineate the right-of-way assigned to bicyclists and motorists. Bike lanes encourage predictable movements by both bicyclists and motorists.

Cycle Tracks are exclusive bike facilities that combine the user experience of a separated path with the on-street infrastructure of conventional bike lanes. These are also referred to as protected bicycle lanes.

Shared Use Paths are facilities separated from roadways for use by bicyclists and pedestrians. Sidepaths usually refer to shared use paths immediately adjacent to the roadway.

Bicycle Parking

Bicyclists expect a safe, convenient place to secure their bicycle when they reach their destination. This may be short-term parking of two hours or less, or long-term parking for employees, students, residents, and commuters. In order to encourage bicycling in Cleveland, plentiful, convenient and attractive bicycle parking must be provided.

Transit Design

According to the South Florida East Coast Corridor (SFECC) *Transit Analysis: Station Design Guidelines*[3], successful transit design depends on 6 elements. These include:

- **Integration into the contextual fabric** - ensuring that transit stops are coherent with surrounding visual themes and that

Bureau of Transportation. http://www.portlandonline.com/transportation/index.cfm?&a=237507

3 http://www.sfeccstudy.com/draft_docs/(3.4.1.2)Station%20Design%20Guidelines%20Final%20122309.pdf

transit stops serve transit-compatible land uses such as day-cares, shopping areas, employment areas and schools.

- **Accessibility via multiple modes -** making sure that transit stations and routes connect other modes such as pedestrians, bicyclists, park and ride centers, and airports.
- **Functional simplicity -** Transit stops should provide users with clear and informative system information and provide easy access and payment options.
- **Security -** Transit stops and systems should look, feel and be clean and secure. This can be accomplished through a number of methods including call boxes and lighting.
- **Comprehensive systems sustainability -** The design of transit should be environmentally conscious and be a tool to promote sustainable development.
- **Articulation of form and identity -** Transit stops should respond to public art or community landmarks; or local, relevant art should be incorporated into the stops and stations themselves.
- **The incorporation of arts in transit -** Incorporating art and design into all aspects of the transit system.

In most cases, transit shelters and waiting platforms should be placed in the Enhancement or Furnishing Zone (see **Figure 2.2**). Transit stops can be incorporated into curb extensions where appropriate. It is important to also consider the accommodation of bicycles at transit stops. Designs that reduce bicycle travel/bus stop conflict, include secure bicycle parking, and provide ample loading space for bicycles on bus-mounted bicycle racks are all part of bicycle-friendly transit system design.

The location and design of transit stops along a block is also an important consideration. Where feasible, transit stops should be located immediately after the intersection to reduce conflict with turning vehicles and resolve sight line issues at the intersection. Bus stops should be designed so that busses can pull out of the vehicular travel lane when stopping to preserve traffic flow, especially on major streets.

Traffic Calming Treatments

Motor vehicle speeds affect the frequency at which automobiles pass bicyclists as well as the severity of bicycle and pedestrian crashes that can occur on a roadway. Slower vehicular speeds also improve motorists' ability to see and react to non-motorized users, minimize conflicts at driveways and other turning locations and in many cases can improve vehicular throughput. Maintaining slower motor vehicle speeds and reducing traffic in areas where pedestrian and bicycle traffic is regularly expected greatly improves comfort and safety for non-motorized users on a street.

This section presents an overview of traffic calming treatments that can be applied to Cleveland's roadways. Traffic calming treatments can be divided into two different types:

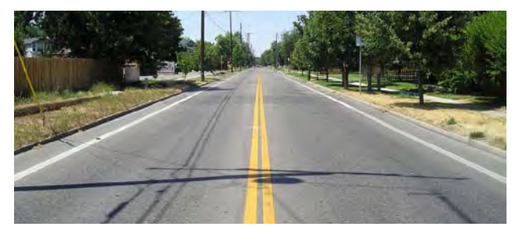
- **"Hard" traffic calming** are engineering measures taken with the sole intent of slowing traffic and reducing conflict.
- **"Soft" traffic calming** includes placemaking design measures that have the added effect of traffic calming**,** as well as educational and enforcement measures.

Not all treatments listed here are appropriate for all roadways. **Figure 3.1** shows a matrix of which treatments are appropriate for certain roadway typologies. The treatments are as follows:

Hard Traffic Calming Treatments

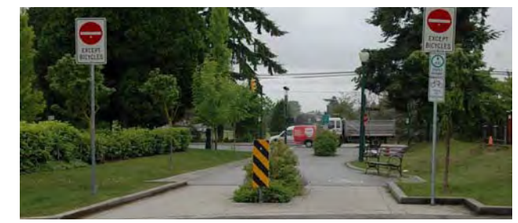
Speed limit reduction - A reduction in speed limit is a simple way to make the roadway a safer place for pedestrians and bicyclists. Statistically, eighty percent of pedestrians struck by a car going 40 mph will die; at 30 mph the likelihood of death is 40 percent. At 20 mph, the fatality rate drops to just 5 percent (The National Highway Traffic Safety Administration)

Road diet - Road diets are a reduction in the number of lanes along a roadway. Typically, these are four lane roads reduced to three lanes (although larger road diets are done as well), often with the addition of bike lanes. This not only improves conditions for bicyclists, but it enhances the pedestrian environment and often improves traffic flow and vehicle-on-vehicle collision rates as well.



Lane narrowing - Lane narrowing is when an excessively large lane is reduced through the striping of a shoulder or the addition of bike lanes. This helps reduce traffic speed and adds dedicated space for bicyclists.

Speed humps/Speed tables - Speed humps are raised areas usually placed in a series across both travel lanes. Longer humps reduce impacts to emergency vehicles. Some speed hump designs can be challenging for bicyclists, however gaps can be provided in the center or by the curb for bicyclists and to improve drainage. Speed humps can also be offset to accommodate emergency vehicles as seen in the image above. The City currently has not approved a policy for the installation of these devices, although their use is common in US cities with similar climates and street types such as Chicago and Minneapolis. The use of speed humps in Cleveland warrants further discussion.



Traffic Diversion - Motor vehicle traffic volumes affect comfort for bicyclists and pedestrians on local streets. Higher vehicle volumes reduce bicycle and pedestrian comfort and can result in more conflicts. Traffic diversion treatments reduce motor vehicle volumes by completely or partially restricting through traffic on select neighborhood streets such as bicycle boulevards.

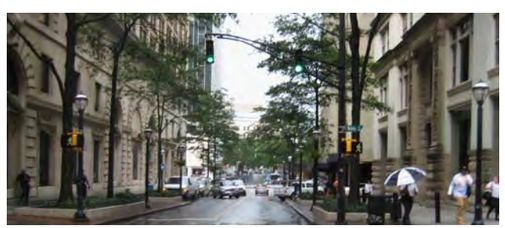
Pinchpoints/neckdowns - These are curb extensions placed on both sides of the street, narrowing the travel lane and encouraging all road users to slow down. When placed at intersections, pinchpoints are known as chokers or neckdowns. They reduce curb radii and further lower motor vehicle speeds.

Chicanes - Chicanes are essentially curb extensions arranged in an alternating pattern that require cars to oscillate along a roadway to avoid them. These are effective on long-straight neighborhood streets where speeding is an issue.

Soft Traffic Calming Treatments

Image: www.planetizen.com

Setback reduction - Large setbacks in roadside development are a result of car-oriented development practices which typically locate a large parking lot in the front of the building. Redeveling these properties with little or no setback creates a sense of enclosure, adds visual stimuli, and creates a seemingly pedestrian environment, all of which help to slow traffic.



Street trees, landscaping and other aesthetic elements - Street trees, landscaping and other aesthetic elements such as art or banners produce a feeling of enclosure and add visual stimuli along a roadway corridor. Green elements often have added environmental benefits as well.

Street material - Textured street material, such as the use of pavers, creates visual stimuli and a feeling of a special district or pedestrian-oriented area which can help to calm traffic.

Appropriately scaled street lighting - Appropriately scaled street lighting can provide a safer, more inviting and more visible environment for all roadway users. Pedsetrian-scaled street lighting along with other improvements such as street trees can alert motorists to a potential presence of pedestrians and bicycles, slowing down traffic in these areas.

Enforcement and awareness measures - Enforcement and awareness measures such as signage, speed traps and educational programs can help to reduce speeding in problem areas. However, the effectiveness of these programs depends adequate frequency and duration.

Intersection Improvements

Minimize curb radius - The size of a curb's radius can have a significant impact on pedestrian comfort and safety. A smaller curb radius provides more pedestrian area at the corner, allows more flexibility in the placement of curb ramps, results in a shorter crossing distance and requires vehicles to slow more on the intersection approach. During the design phase, the chosen radius should be the smallest possible for the circumstances. One effective way of minimizing the curb ramp radius is by adding curb extensions.

High-visibility crosswalks - A marked crosswalk signals to motorists that they must stop for pedestrians and encourages pedestrians to cross at designated locations. Installing crosswalks alone will not necessarily make crossings safer, especially on multi-lane roadways. However, high-visibility crosswalks make crossings more visible to motorists and add a sense of security for pedestrians. High-visibility crosswalks should be combined with advanced stop bars and other tools to increase safety. At mid-block locations, crosswalks can be marked where there is a demand for crossing and there are no nearby marked crosswalks.

Median pedestrian refuge: intersections - Median pedestrian refuges at intersections provide pedestrians with a secure place to stand in case they are unable to walk the entire distance of the crossing in one movement. This is especially important for young, elderly and disabled users in areas where crossing distances are great.

Raised crosswalks and intersections - A raised crosswalk or intersection can eliminate grade changes from the pedestrian path and give pedestrians greater prominence as they cross the street. Raised crosswalks should be used where a special emphasis on pedestrians is desired.

Traffic circles - Traffic circles are a type of Horizontal Traffic Calming that can be used at minor street intersections. Traffic circles reduce conflict potential and severity while providing traffic calming to the corridor.

Bicycle intersection treatments - Designs for intersections with bicycle facilities should reduce conflict between bicyclists (and other vulnerable road users) and vehicles by heightening the level of visibility, denoting clear right-of-way and facilitating eye contact and awareness with other modes. Intersection treatments can improve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals.

The configuration of a safe intersection for bicyclists may include elements such as color, signage, medians, signal detection and pavement markings. Intersection design should take into consideration existing and anticipated bicyclist, pedestrian and motorist movements. In all cases, the degree of mixing or separation between bicyclists and other modes is intended to reduce the risk of crashes and increase bicyclist comfort. The level of treatment required for bicyclists at an intersection will depend on the bicycle facility type used, whether bicycle facilities are intersecting, and the adjacent street function and land use.

Curb extensions/bulbouts - Curb extensions minimize pedestrian exposure during crossing by shortening crossing distance and giving pedestrians a better chance to see and be seen before committing to crossing. They are appropriate for any crosswalk where it is desirable to shorten the crossing distance and there is a parking lane adjacent to the curb.

Intersection parking control - Parking control involves restricting or reducing on-street parking near intersections with high pedestrian activity. Locating parking away from the intersection improves motorist's visibility on the approach to the intersection and crosswalk. Improved sight lines at intersections reduces conflicts between motorists and pedestrians. This can be accomplished in part through the use of bulbouts.

ADA compliant curb ramps - Curb ramps are the design elements that allow all users to make the transition from the street to the sidewalk. There are a number of factors to be considered in the design and placement of curb ramps at corners. Properly designed curb ramps ensure that the sidewalk is accessible from the roadway. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access.

Mid-block Crossing Treatments

Median pedestrian refuge: island - Median refuge islands are located at the mid-point of a marked crossing and help improve pedestrian safety by allowing pedestrians to cross one direction of traffic at a time. Refuge islands minimize pedestrian exposure by shortening crossing distance and increasing the number of available gaps for crossing. These can be combined with curb extensions for added traffic calming.

Active warning beacons - Active warning beacons are pedestrian or bicyclist actuated illuminated devices designed to increase motor vehicle yielding compliance at crossings of multi lane or high volume roadways.

Types of active warning beacons include conventional circular yellow flashing beacons, in-roadway warning lights, or Rectangular Rapid Flash Beacons (RRFB).

In-street pedestrian crossing signs - In-street pedestrian crossing signs reinforce the presence of crosswalks and remind motorists of their legal obligation to yield for pedestrians in marked or unmarked crosswalks. This signage is often placed at high-volume pedestrian crossings that are not signalized. This is a low-cost treatment that has shown significant improvements to driver slowing and yielding rates at crosswalks.

Bicycle and Pedestrian Signalized Crossings

Countdown pedestrian signals - Pedestrian signal indicators demonstrate to pedestrians when to cross at a signalized crosswalk. Ideally, all traffic signals should be equipped with pedestrian signal indications except where pedestrian crossing is prohibited by signage.

Countdown pedestrian signals are particularly valuable for pedestrians, as they indicate whether a pedestrian has time to cross the street before the signal phase ends. Countdown signals should be used at all signalized intersections. Designers should allow greater signal timing for crossing along large roadways, areas with a high frequency of pedestrian crossing and areas where seniors or disabled persons are expected.

Accessible pedestrian signals should be used in locations where visual or hearing impaired individuals can be expected. Also consider utilizing a leading pedestrian interval, where pedestrians are allowed in the intersection 3 seconds in advance of vehicles, in areas with frequent motor vehicle and pedestrian traffic

Hybrid Beacons - A hybrid beacon, previously known as a High-intensity Activated CrosswalK (HAWK), consists of a signal-head with two red lenses over a single yellow lens on the major

street, and pedestrian and/or bicycle signal heads for the minor street.

Hybrid beacons are primarily applied at mid-block pedestrian or trail crossings where non-motorized crossing volumes and crossing distance and/or motorized traffic volumes and speeds raise significant safety and accessibility concerns. Hybrid Beacons are also sometimes used to improve non-motorized crossings of major streets at intersections where side-street volumes do not support installation of a conventional traffic signal (or where there are concerns that a conventional signal will encourage additional motor vehicle traffic on the minor street).

Green Infrastructure for the Right of Way

A Contributing factor for including "Green" into the city's Complete and Green Streets ordinance is the Consent Decree between the Northeast Ohio Regional Sewer District (NEORSD) and the Environmental Protection Agency in 2010. A large amount of contaminated stormwater was entering Cleveland's surrounding water bodies as a result of stress on the combined sewer overflow sewer system (CSO) within the city. For that reason, NEORSD has a duty to eliminate or treat 98% of the sewage that exits the CSO system into the surrounding waterways.

Large amounts of impervious surfaces are the main cause of the overburden on the CSO sewer system. Impervious surfaces are those that water cannot freely pass through. These include any surfaces covered by traditional asphalt or concrete such as roadways, parking lots, or buildings. Therefore, reducing the amount of impervious surfaces in Cleveland and increasing opportunities for stormwater infiltration into underlying soils are simple solutions that will help address this problem.

Green infrastructure is an emerging suite of strategies for cleaning polluted runoff and managing stormwater in the urban environment by mimicking the way water acts in a natural environment: soaking into the ground, being filtered by aquifers or trees and then returning to the water cycle.

During the process of urbanization, the land's natural cycle is broken due to the loss of pervious, vegetated ecosystems – the oak-hickory forests that blanketed northern Ohio and their replacement by impervious surfaces like pavements and rooftops. These surfaces increase the rate and volume of water that flows into creeks, rivers and lakes, harming aquatic habitat. Streets, in particular, create water-borne pollution due to the various oil and petroleum products that drip on them and heavy metals that fall from vehicles during routine operations like braking.

Additionally, for much of Cleveland the stormwater system and the sewer system are combined into the same pipes. During normal operations, both types of water are cleaned at a treatment plant before entering Lake Erie. However, during extreme weather events, the system overflows due to the high volume of stormwater runoff. These combined sewer overflows (CSOs) discharge raw sewage into Lake Erie.

Consequently, streets are one of the best places to invest in green infrastructure since they can play an outsized role in preventing polluted runoff from entering Lake Erie. Since streets are one of the largest types of impervious surfaces in the City, streetside green infrastructure can help diminish peak stormwater runoff volumes and can treat and infiltrate stormwater before it ever enters the piped system.

The first steps to creating a greener stormwater strategy are a connected street grid, which Cleveland already has to a large degree, and reducing lane widths for automobiles. There are also significant opportunities to increase the right-of-way performance by reducing stormwater runoff through a series of small-scale green infrastructure facilities that complement the mobility concerns of the Cleveland's Complete Streets Guidelines. These include: amended soils, street trees, sheet flow dispersion, bioretention systems and pervious pavements.

In addition to stormwater benefits, streets can also be greened to save energy and reduce greenhouse gas emissions through use of efficient street lighting, recycled construction materials, green construction practices and tree planting.

Amended Soils

Healthy soil provides important stormwater functions: it helps clean pollutants from runoff, supports the growth of trees that contribute to the urban forest and slows the release of stormwater into urban waterways. By protecting and creating healthy soils, Cleveland can do much to protect it's streamsides and lakeshores. In the urban environment, soil health can be damaged by excavation, clearing, grubbing and the use of heavy equipment can cause erosion, remove topsoil and compact soil, killing soil microorganisms, removing nutrients, and compressing the voids within soil structure that retain air and water. As streets are constructed preventing such damage during construction can be the most cost-effective way of managing soil quality on-site.

Where construction damage cannot be avoided or existing soils need revitalization, rototilling compost, organic waste, gravelly sand and/or other amendments into existing soils can restore permeability, increase infiltration capacity and improve soil health. Soil amendments can be tailored to provide optimum growing conditions for particular plant communities or to meet different stormwater management goals. Restoring disturbed soils can improve fertility and support vigorous plant growth, allow biofiltration of urban pollutants and reduce irrigation needs.

Amended Soils: Amended soils are placed in a bioretention swale (top). Compost amended soils are prepared for shrub (middle) and tree (bottom) planting.

Street Trees

A robust tree canopy is one of the great contributors to a healthy and livable urban landscape. Trees provide many benefits in terms of stormwater flow regulation and water quality treatment. Mechanisms for these benefits include interception, transpiration, and increased infiltration. Additional benefits provided by trees include enhancing the visual and spatial character of a place; improving air quality; reducing noise and light pollution; traffic-calming and reducing the heat island effect. Trees provide numerous habitat benefits, including refuge from predators, food and nesting resources and habitat patches. Trees enhance the quality of open space and provide visual relief within the urban environment, leading to stress reduction and other health benefits. A healthy urban forest also increases property values. Because

trees can take fifteen years or more to develop a full canopy, preserving healthy existing trees wherever practicable is a cost effective and efficient way to obtain the most value from trees.

Street Trees: As part of the urban forest, street trees are incredibly important assets for stormwater capture and storage.

Sheet Flow Dispersion

Using sheet flow dispersion, paved surfaces are graded to evenly spread flows across the entire surface rather than concentrating them. As a result, only a narrow layer of vegetation is needed to further attenuate flows. This technique works well where there are continuous vegetated surfaces adjoining impervious areas.

Sheet Flow Dispersion: The impervious surface is sloped to direct runoff to the side of the street where runoff is treated/infiltrated by the adjacent vegetated surface.

Bioretention

Bioretention facilities use amended soils and vegetation to absorb, hold, evaporate and clean polluted runoff from the streets. By reducing the peak rate and the total runoff volume, these facilities decrease the negative downstream or downslope impacts of storm events. With the right underlying geologic conditions, bioretention systems can be designed to clean stormwater then allow it to infiltrate, thus decreasing transport of some pollutants and recharging groundwater supply. In the right-of-way, bioretention systems can be integrated into site design as linear features (e.g. bioretention swales) or as cells (e.g. rain gardens and stormwater planters). Additional community benefits from bioretention facilities can include improved property values, increased habitat, a better environment for walking, and traffic calming.

Opportunity areas for using bioretention systems in streets include within traffic calming curb bulbouts, in roadside bioswales, and in place of standard landscape plantings on streets.

Bioretention Cells: Bioretention cells are used to treat stormwater and serve as a traffic-calming device , by narrowing travel lanes and reducing pedestrian crossing distances.

Bioretention Cells/Bioretention Swales

Bioretention cells are shallow planted depressions that utilize climate-appropriate plants and soils to retain and treat stormwater. Bioretention cells promote transpiration of stormwater through the vegetation; detention of stormwater in the pores of amended and native soils; cleansing of stormwater through various mechanisms that include sedimentation, filtration, adsorption, and phytoremediation; and retention of stormwater via infiltration into native soils.

Bioretention cells may have underdrains to help convey excess water below the soil surface. Conveyance may be a secondary, but not the primary purpose for bioretention cells. All bioswales perform some amount of conveyance, but those considered to be bioretention systems also allow infiltration of stormwater into surrounding soils.

Bioswales have been shown to remove 70% of total suspended solids, 30% of total phosphorus, 25% of total nitrogen, 50-90% of certain metals, and 67-93% of oil and grease pollutants in stormwater (Davis & McCuen 2005, p. 236). Bioswales are recommended for use adjacent to drive lanes, in place of conventional in-road features (such as curbs and gutters) and as vegetated buffers vehicular and pedestrian areas.

Rain gardens are typically designed with a ponding depth of less than 18" in order to meet small scale flow control and water quality requirements and may be formed in any shape. An overflow, either piped or natural, is typically included to manage higher flows and convey runoff to a public storm drain, channel or natural outlet. The area of a rain garden is generally sized to equal 5% of the area being treated. They can be particularly effective at heavy metal removal; reductions of up to 95% of lead, copper and zinc, and 70-85% of total phosphorus and nitrogen have been noted (Davis & McCuen 2005, p. 241). Rain gardens are useful strategies for managing stormwater in areas adjacent to parking, such as within tree islands, along pedestrian zones, in center roadway medians, and in unused open space, including front yards.

Bioretention Swale: Water flows off of the street and is treated in this streetside bioretention swale.

Bioretention Planter: Polluted runoff from the street runs into these stormwater planters. If there is too much water, it overflows back onto the curb and continues down the gutter line.

Bioretention Planters

Bioretention planters are similar in design and function to rain gardens, but have a more defined shape and vertical sides, and may employ an impermeable bottom layer or enclosure. The planters are often constructed of concrete, making them well-suited for urban applications where water needs to be directed away from building foundations. Stormwater planters consist of a planter box made of sturdy material, amended soils, a gravel drainage layer, and plants. An overflow is incorporated to manage higher flows and convey runoff to the public storm drain system, either via a perforated pipe or via surface flow. Although stormwater planters can be designed without a bottom to allow infiltration, they are typically designed to focus on flow control and attenuation to the public storm drain system. They are particularly effective at handling low intensity storms.

In the right-of-way, stormwater planters are recommended adjacent to buildings, sidewalks and pedestrian plazas where flow control is a significant concern and space is at a premium. Planters can also be designed to serve a conveyance function in the right of way where there is insufficient width to provide sloped sides (i.e., a swale) or the grade would be too steep. Stormwater planters provide aesthetic benefits and, depending on plant selection and design, can provide water, food and nesting materials for birds.

Pervious Paving

Pervious paving technologies provide hard surfaces for walking and driving while allowing stormwater runoff to percolate into an underlying soil or reservoir base where it can infiltrate into native soil or be conveyed off-site via an overflow drainage system. Pervious paving is largely made up of the same components as conventional paving material, but includes more void space to allow runoff to percolate through the pavement section. Void spaces within these pavements trap oils, grease, and other roadway pollutants and create opportunities for micro-organisms to break them down. Additional benefits include reducing impervious surface area, which in turn, reduces stormwater flows off-site.

Pervious paving systems may be used in place of conventional impervious paving in many locations. They are typically used on low-traffic streets, such as residential streets and pedestrian corridors, and are especially appropriate for parking areas, driveways, alleys and sidewalks.

Pervious Concrete: A close-up view of the structure of porous concrete.

Pervious Concrete: A porous concrete street.

Pervious Concrete

Porous cement concrete generally has a narrower distribution of coarse aggregate and contains less fines than standard concrete. The porous concrete layer is placed atop a 6" to 12" permeable base course that serves as a reservoir, assisting with flow through. This base course can be sized to provide detention, and provides strength for the travel lane. Proper installation of porous cement concrete requires the talents of experienced craftsmen.

Porous cement concrete can often be identified by the "popcorn" or "rice krispie" look of its surface. This surface finish can be mitigated by using smaller aggregate sizes to provide a smoother, more traditional finish. Aggregate sizing can range from as small as 1/4" all the way up to 1".

Porous Asphalt

Porous asphalt is a variation of the standard hot mix asphalt used as a road surface. Porous asphalt omits the fine sand and dust, creating void content of about 18-22% compared to the 2-3% void content of traditional asphalt mixes. This top course is installed as a 2-4" thick layer placed atop a course of coarse aggregate designed to rapidly filter and store water in addition to providing stability. Porous asphalt is slightly easier to install than porous concrete; however, product life tends to be shorter (about 10-12 years) in roadway applications.

In appearance, porous asphalt has a similar finish to standard asphalt. It is generally smoother than porous concrete, making it ideal for bicycle and pedestrian surfaces. Porous asphalt h–as been shown to reduce runoff by 60-98% (Legret and Colandini 1999) and can reduce total suspended solids in runoff and their associated pollutants by more than 80% (Barrett 2008). It can also increase road safety by reducing splash and spray, providing better visibility and traction, and reducing hydroplaning. Porous asphalt also reduces road noise.

Porous Asphalt: Water soaks into the wearing coarse of a porous asphalt installation.

Permeable Pavers

Porous pavers are made for a wide variety of uses, from patios, paths and walkways, to driveways, parking areas and roadways. They come in many shapes, sizes and finishes, ranging from open grid systems with grass or gravel to interlocking porous blocks. Porous pavers tend to be easier and faster to install than porous concrete or porous asphalt, but require more long-term maintenance. They have been shown to reduce virtually all runoff and to substantially reduce runoff pollutant loads, particularly zinc and copper. (Dietz 2007).

Porous Pavers are installed in a residential alley setting.

Recycled Roadway Surface

The use of recycled materials is becoming increasingly commonplace in roadway reconstruction and resurfacing projects across the country. Using materials such as reclaimed asphalt pavement, recycled asphalt shingles, and ground tire rubber in the mixing of the asphalt aggregate can have both great environmental and economical impacts.

For example, the recent resurfacing of Michigan Avenue in Chicago consists of 45 percent recycled content. The project utilized asphalt shingles from about 130 houses, 2,200 recycled car tires and 24 truckloads of reclaimed pavement. It is estimated to be approximately 40 percent less expensive than non-recycled roadway resurfacing projects and has noise dampening benefits on account of the rubber.[4]

4 McMahon, Jeff. Taking Recycling To The Street: Chicago Recycles Michigan Ave. Forbes Magazine. http://www.forbes.com/sites/jeffmcmahon/2012/07/31/taking-recycling-to-the-street-chicago-recycles-michigan-avenue/

Euclid Avenue Bus Rapid Transit Station

Chapter 3 - Complete and Green Streets Typologies

Overview

As described in Chapter 1, Cleveland's Complete and Green Street Typologies classify the City's roadways into logical categories based on similar physical and contextual characteristics. In order to best accomplish this, streets are classified based on a two tier system.

Tier One classifies streets by their curb to curb width. Classification breaks were set based on the number of vehicular lanes a street currently has. The classifications in this tier are:

- **Very Large -** > 70' pavement width
- **Large -** 69'-48' pavement width
- **Medium -** 48'-30' Pavement Width
- **Small -** < 30' Pavement Width

The **Transit Spine Overlay** and **Access/Alleyways** categories don't fall under a specific tier one classification. The Transit Spine Overlay and the Bicycle Overlay are intended to be applied to different classifications as an overlay. In general, access streets and alleyways in Cleveland vary greatly in width, therefore a particular tier one classification is not appropriate for this typology category.

Tier Two classifies roadways based on context, function and connectivity. These classifications are as follows:

- **Commuter Street -** The current, primary function of these roadways is the efficient movement of motor vehicles. Sufficient accommodations should be made for pedestrians, bicyclists and transit users along these routes where they are expected so as not to deter or discourage use by non-motorized roadway users. Truck traffic should be a consideration.
- **Commercial Street -** These streets have a significant transportation connectivity function and serve as a destination for commercial activity. Roadway priorities should be balanced among motor vehicles, transit, bicyclists and pedestrians. Truck traffic should be a consideration.
- **Neighborhood Street -** These roadways have a significant transportation connectivity function serving residential areas. Roadway priorities should be balanced among motor vehicles, transit, bicyclists and pedestrians.
- **Industrial Street -** These roadways have a significant transportation connectivity function serving industrial areas. The accommodation of large trucks should be a design consideration. Surrounding land use is primarily industrial but may become increasingly business-oriented or commercial, especially as Cleveland land uses change in accordance with the Connecting Cleveland 2020 Citywide Plan. For this reason, pedestrian and bicycle traffic should be expected and provided for and these roadways should be designed with transitioning land use as a major contextual consideration.
- **Neighborhood Street -** These roadways have a local connectivity function serving residential areas. Roadway priorities should be given to pedestrians and bicyclists and providing good access to transit. Providing on-street parking should be a consideration.
- **Commercial Street/Pedestrian Shopping Street -** These roadways have a local connectivity function serving commercial areas. Roadway priorities should be given to pedestrians and bicyclists and providing good access to transit. Providing on-street parking should be a consideration. Truck access should be a consideration.
- **Transit Spine Overlay -** These are roadways that have been identified as future express bus or Bus Rapid Transit corridors by the Cleveland Regional Transit Authority. However, Transit Spine Overlay treatments may be warranted on Medium to Very Large streets that serve a significant transit function and have excess vehicular capacity. Warrants for the Transit Spine Overlay typology will be discussed in the *Cleveland Complete and Green Streets Design Guide*. It is important to coordinate bicycle and pedestrian accommodations with transit design to ensure access for transit customers.
- **Priority Bikeway Overlay -** While all typologies include accommodations for bicyclists, the Priority Bikeway Overlay uses additional treatments that give roadway priority to bicycle users. These treatments are intended to improve safety, comfort and convenience for bicyclists and encourage them to utilize these routes as much as possible for trips. The Priority Bikeway Overlay is applied to corridors that are identified in the Cleveland Bikeway Master Plan. Additionally, the Priority Bikeway Overlay can be applied to roadways that meet the warrants described in the future *Cleveland Complete and Green Streets Design Guide*.
- **Alleyway/Access -** These roadways have a local access function serving commercial or industrial areas. Roadway priorities should be given to loading vehicles, trucks and possibly pedestrians and bicyclists where good non-motorized connections can be made.

A table of prototypical Cleveland streets that were used in developing the typologies can be found in **Appendix B**

Typology Examples

Typology Cutsheets

The following pages present information on the Complete and Green Steets Typologies developed for the City of Cleveland. These cutsheets depict **potential** improvement options for each of the typology types based on different transportation mode and green treatment priorities. Due to the large palette of different traffic calming and greening techniques and differences in street designs, it is impossible to show all the potential configurations for each typology.

These cutsheets were developed primarily as illustrative examples and should not take the place of the design and engineering process

Not all improvements presented in Chapter 2 are applicable across all typologies. **Figures 3.1, 3.2** and **3.3** on the following pages show which treatments can be applied to each of the Complete and Green Street Typologies. The Priority Bikeway Overlay classification is excluded from these figures since this overlay can be applied to any typology.

Typology Maps

Following the development of the typologies, Cleveland's street network was classified based on the new typology categories. The classification methodology looked primarily at existing and future land-use and zoning along street corridors, street width, connectivity function (what land uses a street corridor connects and whether it facilitates local or regional connections) and current and future transit. Maps depicting the Complete and Green Streets Typologies applied to Cleveland's street network can be seen following the typology cutsheets.

It is possible that some roadways can be classified according to multiple typologies. It is also possible that changing land uses over time will cause some typologies depicted in the map to change. Typologies shown on the maps are a starting point for roadway classification, but may not always be used for the selection of design elements.

The graphic to the right presents an overview of the roadway typologies shown in the cutsheets presented in the following section. The graphic shows the existing primary and secondary users of the corridor and how the application of the treatments proposed in the typology cutsheets will affect current user priorities.

Very Large, Commuter Street
Proposed Users: Primary Secondary
Existing Users: Primary Secondary

Very Large, Commercial Connector
Proposed Users: Primary Secondary
Existing Users: Primary Secondary

Very Large, Transit/Priority Bikeway Overlay
Proposed Users: Primary
Existing Users: Primary Secondary

Large, Commercial Connector
Proposed Users: Primary Secondary
Existing Users: Primary Secondary

Large, Neighborhood Connector
Proposed Users: Primary
Existing Users: Primary Secondary

Large, Industrial Connector
Proposed Users: Primary Secondary
Existing Users: Primary Secondary

Large, Transit/Priority Bikeway Overlay
Proposed Users: Primary Secondary
Existing Users: Primary and Secondary Users Vary

Medium, Neighborhood Street
Proposed Users: Primary
Existing Users: Primary Secondary

Medium, Commercial Street
Proposed Users: Primary Secondary
Existing Users: Primary Secondary

Medium, Industrial Street
Proposed Users: Primary Secondary (Transit not typical)
Existing Users: Primary Secondary

Medium, Transit/Priority Bikeway Overlay
Proposed Users: Primary
Existing Users: Primary Secondary

Small, Neighborhood Street
Proposed Users: Primary Secondary (Transit not typical)
Existing Users: Primary Secondary

Small, Commercial Street
Proposed Users: Primary Secondary
Existing Users: Primary Secondary

Alleyway/Access Street
Proposed Users: Primary Secondary (Transit not typical)
Existing Users: Primary Secondary

Figure 3.1 - Traffic Calming Appropriateness Per Complete Streets Typologies

Legend

- Appropriate in Most Cases
- Appropriate in Some Cases
- Not Recommended

** The Priority Bikeway Overlay can be applied to any typology without affecting what traffic calming treatments are appropriate for that classification.*

	Very Large, Commuter Street	Very Large, Commercial Connector	Large, Commercial Connector	Large, Neighborhood Connector	Large, Industrial Connector	Medium, Neighborhood Street	Medium, Commercial Street	Medium, Industrial Street	Small, Neighborhood Street	Small, Commercial Street/Pedestrian Shopping Street	Transit Spine Overlay	Alleyway/Access Street
Roadway Designed to Target Speed	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some
Road Diet	Some	Some	Some	Some	Some	Not	Not	Not	Not	Not	Most	Not
Lane Narrowing	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some
Chicanes	Not	Not	Not	Not	Not	Not	Not	Not	Most	Not	Not	Not
Access Management	Some	Some	Some	Some	Some	Some	Some	Some	Not	Not	Some	Not
Pinchpoints	Not	Not	Not	Not	Not	Not	Not	Not	Most	Most	Not	Most
Diverters	Not	Not	Not	Not	Not	Some	Not	Not	Most	Most	Not	Not
Setback Reduction	Some	Most	Most	Some	Most	Some	Most	Most	Some	Most	Most	Not
Street Trees + Aesthetic Elements	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
Street Material	Not	Not	Not	Not	Not	Some	Some	Not	Most	Most	Not	Most
Street Lighting	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
Enforcement and Awareness	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
Parking Control (Cleveland-specific term for peak-hour parking prohibitions)	Most	Most	Most	Most	Most	Some	Some	Some	Not	Not	Not	Not

Figure 3.2 - Intersection Improvement Appropriateness Per Complete Streets Typologies

Legend

- Appropriate in Most Cases
- Appropriate in Some Cases
- Not Recommended

** The Priority Bikeway Overlay can be applied to any typology without affecting what intersection improvement treatments are appropriate for that classification.*

	Very Large, Commuter Street	Very Large, Commercial Connector	Large, Commercial Connector	Large, Neighborhood Connector	Large, Industrial Connector	Medium, Neighborhood Street	Medium, Commercial Street	Medium, Industrial Street	Small, Neighborhood Street	Small, Commercial Street/Pedestrian Shopping Street	Transit Spine Overlay	Alleyway/Access Street
Curb Radius Reduction	Some	Some	Some	Some	Some	Some	Some	Some	Most	Most	Some	Most
High-visibility Crosswalks	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
Raised Crosswalks/Intersections	Not	Not	Not	Not	Not	Not	Not	Not	Some	Some	Not	Not
Traffic Circles	Not	Not	Not	Not	Not	Not	Not	Not	Most	Most	Not	Not
Bicycle Intersection Treatments (along Priority Bikeways only, includes bike signalization)	Most	Most	Most	Most	Most	Some	Some	Some	Not	Not	Most	Not
Curb Extensions/Bulbouts	Not	Some	Some	Some	Some	Some	Some	Some	Most	Most	Some	Most
Intersection Parking Control	Not	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
ADA Compliant Curb Ramps	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
Median Pedestrian Refuge	Most	Most	Most	Most	Most	Some	Some	Some	Not	Not	Most	Not
Active Warning Beacons	Not	Not	Some	Some	Some	Most	Most	Most	Not	Not	Not	Not
Countdown Pedestrian Signals	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most	Most
Pedestrian Hybrid Beacons	Most	Most	Most	Most	Most	Some	Some	Some	Not	Not	Most	Not

Figure 3.3 - Green Treatment Appropriateness Per Complete Streets Typologies

Legend

- Appropriate in Most Cases
- Appropriate in Some Cases
- Not Recommended

** The Priority Bikeway Overlay can be applied to any typology without affecting what green treatments are appropriate for that classification.*

Very Large, Commuter Street > 70' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- 4-6 lanes with dedicated turn lanes
- Target speed: 35mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Median stormwater infiltration
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Pedestrian crossing refuge
- Native and/or drought tolerant plantings
- Bicycle parking
- Reduced impervious surfaces
- Recycled roadway surface
- Median street trees and planting
- Street trees

Option A (higher bus/bike priority)

- Curbside stormwater swales
- Shared bus/bike lane

Option B

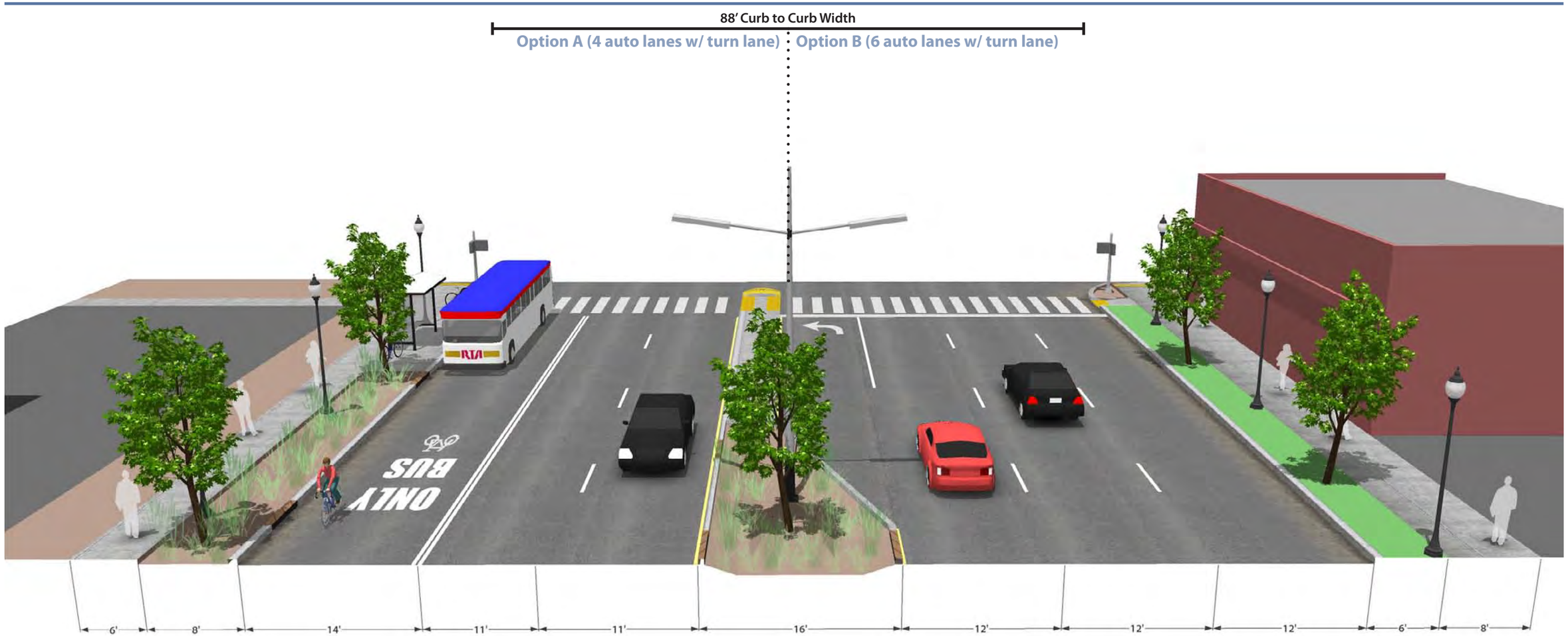
- Bicycle facilities on parallel street
- Minimum 8' sidewalk or sidepath

Example Existing Conditions

Curb to Curb Width: 88ft
Right-of-Way: 120ft
Land Use: Commercial/Residential
Connectivity: High
Lanes: 7
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary Secondary

Existing Users: Primary Secondary



Very Large, Commercial Street > 70' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 4-5, target speed: 30mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Street trees
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Native and/or drought tolerant plantings
- Bicycle parking (including bike corrals)
- Recycled roadway surface
- Curbside bioretention planters

Option A (higher bike/stormwater priority)

- 4 lanes
- Standard or buffered bike lanes
- Permeable pavement
- Curbside continuous bioretention
- Bulbouts with bioretention cells

Option B

- 4 lanes with a planted median/turn lane
- Shared lane markings

Example Existing Conditions

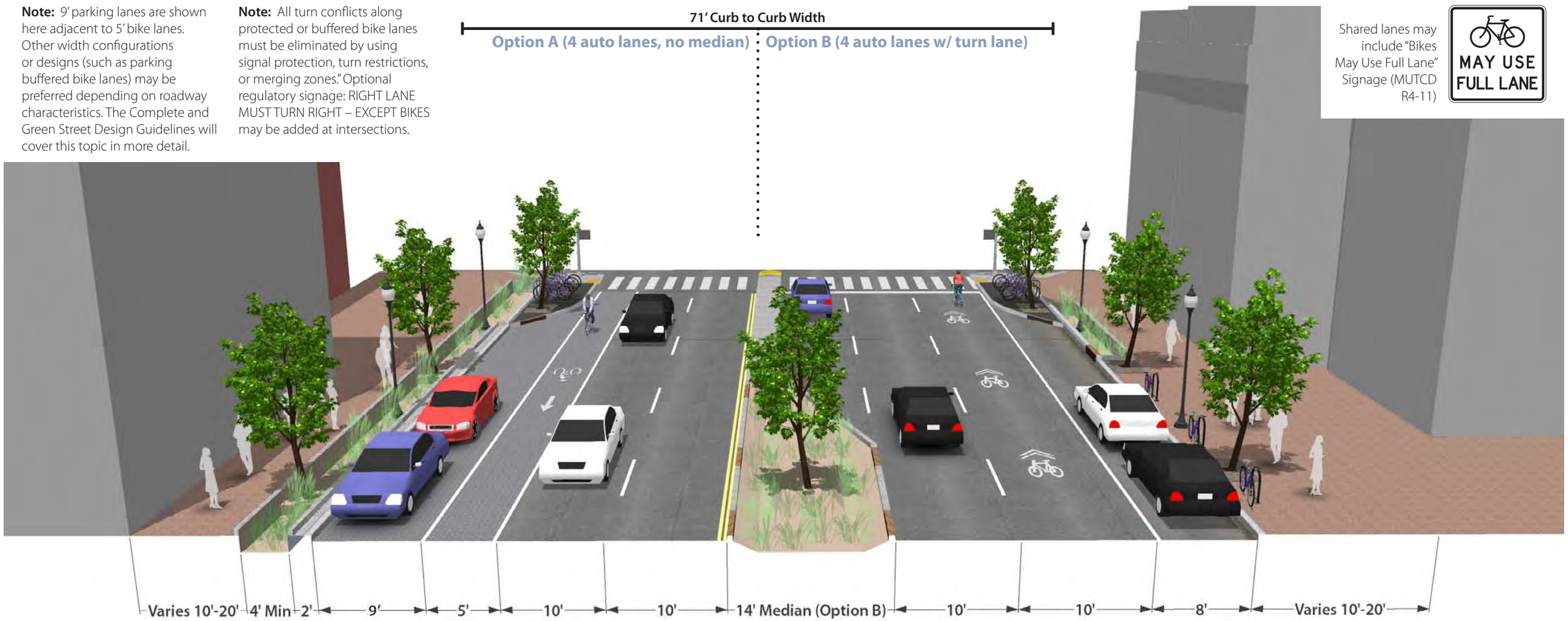
Curb to Curb Width: 71ft
Right-of-Way: 100ft
Land Use: Commercial
Connectivity: Medium
Lanes: 7
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary Secondary

Existing Users: Primary Secondary

Note: 9' parking lanes are shown here adjacent to 5' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.

Note: All turn conflicts along protected or buffered bike lanes must be eliminated by using signal protection, turn restrictions, or merging zones." Optional regulatory signage: RIGHT LANE MUST TURN RIGHT – EXCEPT BIKES may be added at intersections.



Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)

Very Large, Transit/Priority Bikeway Overlay > 70' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- 4 auto lanes with dedicated turn lanes
- Target speed: 35mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Median stormwater infiltration
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Pedestrian crossing refuge
- Native and/or drought tolerant plantings
- Bicycle parking
- Reduced impervious surfaces
- Recycled roadway surface
- Median stormwater swale
- Street trees

Option A (Transit Overlay)

- Curbside stormwater swales
- Wide shared bike-bus lane (16' preferred)

Option B (Priority Bikeway Overlay)

- Protected or curb-separated bikeway

Example Existing Conditions

Curb to Curb Width: 88ft
Right-of-Way: 120ft
Land Use: Commercial/Residential
Connectivity: High
Lanes: 7
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary Secondary

Existing Users: Primary Secondary

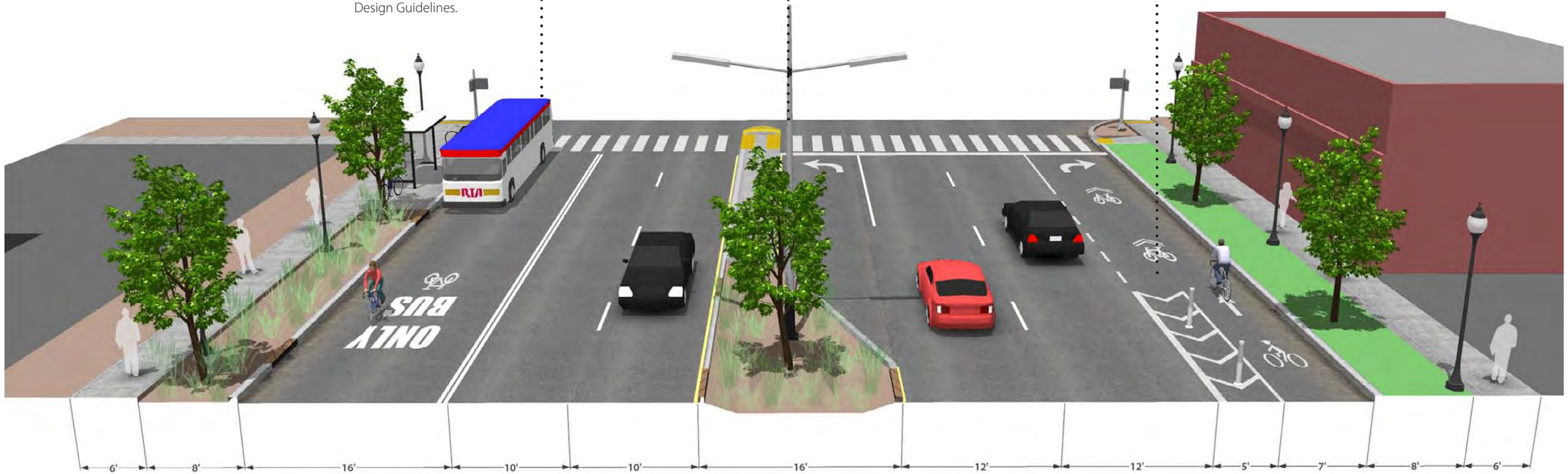
Note: All turn conflicts along protected or buffered bike lanes must be eliminated by using signal protection, turn restrictions, or merging zones." Optional regulatory signage: RIGHT LANE MUST TURN RIGHT – EXCEPT BIKES may be added at intersections.

Bicycle and bus lane configuration will vary depending on conditions (for example, Bus Rapid Transit lanes and loading platforms along Euclid Ave are located in the center of the roadway). Different design options will be presented in the Complete and Green Streets Design Guidelines.

88' Curb to Curb Width

Option A | Option B

Protected or buffered bike lanes are the preferred treatment option on Priority Bikeway Overlay streets. Design options for buffered and protected lanes will be covered in the Design Guidelines.



Large, Commercial Street 69'-48' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- 4 lanes with dedicated left turn lanes
- Target speed: 35mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Bicycle parking
- Recycled roadway surface
- Native and/or drought tolerant plantings
- Reduced impervious surfaces
- Street trees

Option A (higher bike priority)

- Buffered bike lanes
- Curbside bioretention cells

Option B (higher green infrastructure priority)

- Curbside stormwater swales
- On-street parking
- Bulb-outs with bioretention cells
- Shared lane markings

Example Existing Conditions

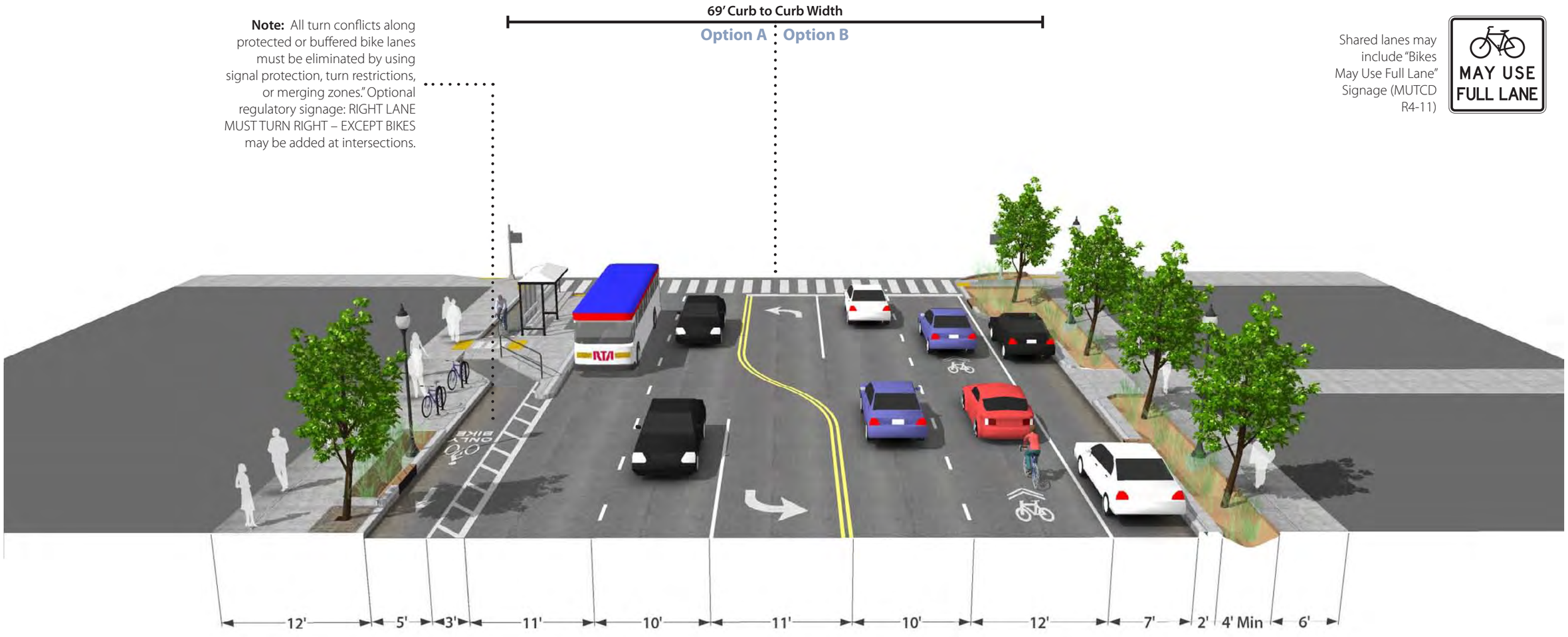
Curb to Curb Width: 69ft
Right-of-Way: 96ft
Land Use: Commercial/Residential
Connectivity: High
Lanes: 6
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary Secondary

Existing Users: Primary Secondary

Note: All turn conflicts along protected or buffered bike lanes must be eliminated by using signal protection, turn restrictions, or merging zones." Optional regulatory signage: RIGHT LANE MUST TURN RIGHT – EXCEPT BIKES may be added at intersections.

Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)



Large, Neighborhood Street 69'-49' Pavement Width

= green infrastructure treatment

Example Improved Characteristics

- Lanes: 3-4 lanes
- Target speed: 25mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Accessible Pedestrian Signals
- ADA compliant curb ramps and sidewalks
- Recycled roadway surface
- Street trees
- Native and/or drought tolerant plantings
- Reduced impervious surfaces
- On-street parking

Option A (higher bike priority)

- Bike Lanes
- Planted median
- Bulbouts with bioretention
- Retain existing street trees

Option B (higher stormwater priority)

- Shared lane markings
- Curbside bioretention cells/swales

Example Existing Conditions

Curb to Curb Width: 60ft
Right-of-Way: 100ft
Land Use: Residential
Connectivity: High
Lanes: 4
Speed Limit: 25
Transit: Bus
Traffic Calming: None

Proposed Users: Primary

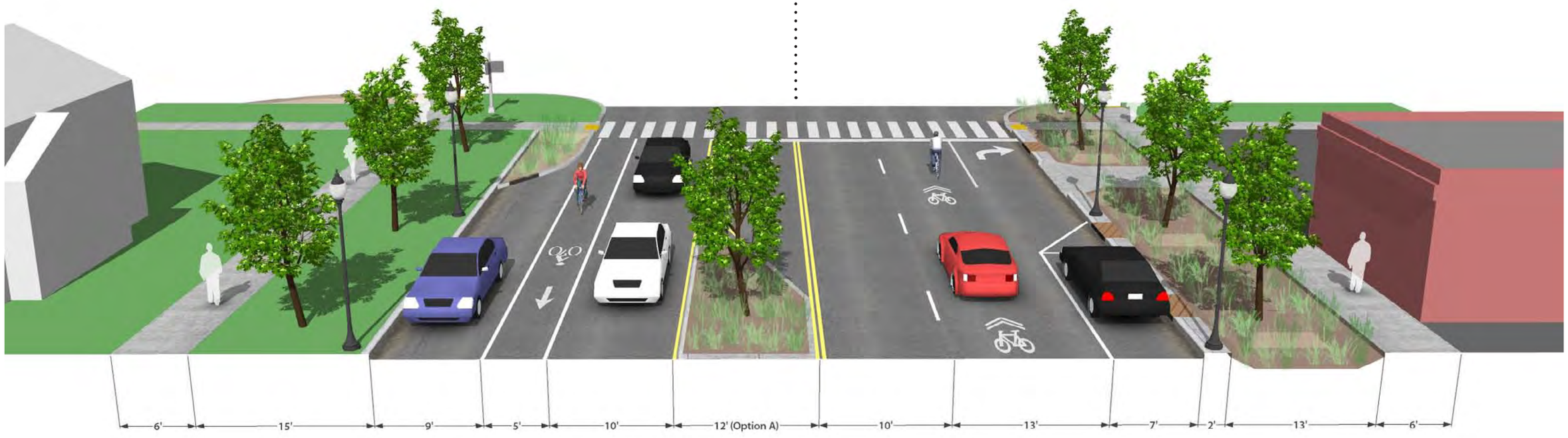
Existing Users: Primary Secondary

Note: 9' parking lanes are shown here adjacent to 5' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.

60' Curb to Curb Width

Option A (2 auto lanes w/turn lane) | Option B (4 auto lanes, no median)

Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)



Large, Industrial Street 69'-48' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 2 with center turn lane
- Target speed: 30mph
- High-visibility crosswalks
- Street lighting
- Accessible Pedestrian Signals
- ADA compliant curb ramps and sidewalks
- Curbside stormwater retention
- Native and/or drought tolerant plantings
- Recycled roadway surface
- Street trees
- Planted median (where feasible)
- Reduced impervious surfaces

Option A (higher bike priority)

- Bike lanes
- Planted median
- Truck compatible bulb-outs with bioretention

Option B

- Pedestrian-scaled street lighting
- Shared lane markings

Example Existing Conditions

Curb to Curb Width: 61ft
Right-of-Way: 85ft
Land Use: Industrial/Office
Connectivity: Medium
Lanes: 4
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary Secondary

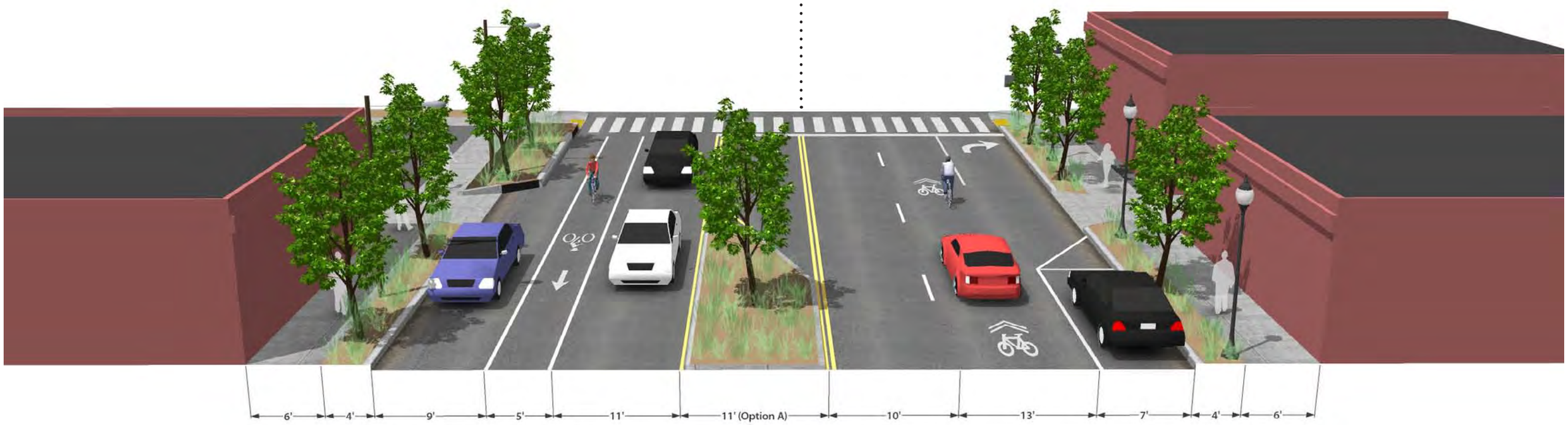
Existing Users: Primary Secondary

Note: 9' parking lanes are shown here adjacent to 5' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.

61' Curb to Curb Width

Option A (2 auto lanes w/turn lane) | Option B (4 auto lanes, no median)

Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)



Large, Transit/Priority Bikeway Overlay 69'-49' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- High-visibility crosswalks
- Pedestrian-scaled street lighting
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Native and/or drought tolerant plantings
- Bicycle parking
- Recycled roadway surface
- Curbside stormwater swales
- Reduced impervious surfaces
- Street trees
- Median with pedestrian refuge (planted where feasible)

Option A (Transit Overlay)

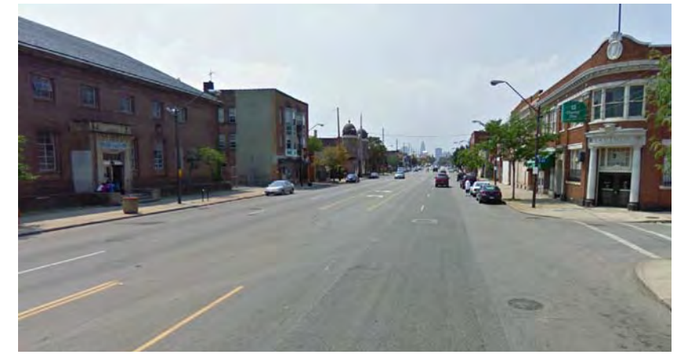
- Dedicated bus lane
- Advanced bus stops
- Protected or buffered bike lane

Option B (Priority Bikeway Overlay)

- Protected or buffered bike lane

Example Existing Conditions

Curb to Curb Width: 73ft
Right-of-Way: 100ft
Land Use: Commercial/Industrial
Connectivity: High
Lanes: 5
Speed Limit: 35
Transit: Bus
Traffic Calming: None



Proposed Users: Primary Secondary

Existing Users: Primary and Secondary Users Vary

Note: All turn conflicts along protected or buffered bike lanes must be eliminated by using signal protection, turn restrictions, or merging zones." Optional regulatory signage: RIGHT LANE MUST TURN RIGHT – EXCEPT BIKES may be added at intersections.

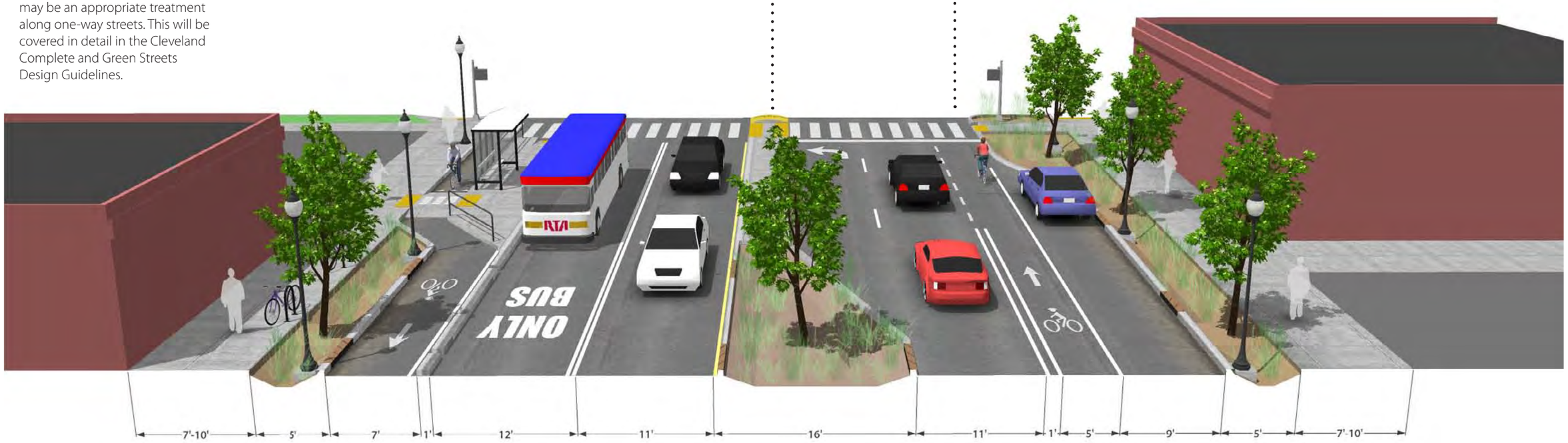
Note: Contra-flow bicycle lanes may be an appropriate treatment along one-way streets. This will be covered in detail in the Cleveland Complete and Green Streets Design Guidelines.

73' Curb to Curb Width

Option A | Option B

Protected or buffered bike lanes are the preferred treatment option on Priority Bikeway Overlay streets. Appropriate design options for buffered and protected lanes will be covered in the Design Guidelines.

Note: 9' parking lanes are shown here adjacent to 6' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.



Medium, Neighborhood Street 48'-30' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 2
- Target speed: 25mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Accessible Pedestrian Signals
- ADA compliant curb ramps and sidewalks
- Recycled roadway surface
- Street trees
- Native and/or drought tolerant plantings
- Reduced impervious surfaces

Option A (higher bike priority)

- Permeable pavement
- Parking, one side of street
- Bike lanes

Option B

- Parking, both sides of street
- Shared lane markings
- Bulbouts with bioretention
- Mid-block bioretention bulbouts (may include mid-block pedestrian crossings)

Example Existing Conditions

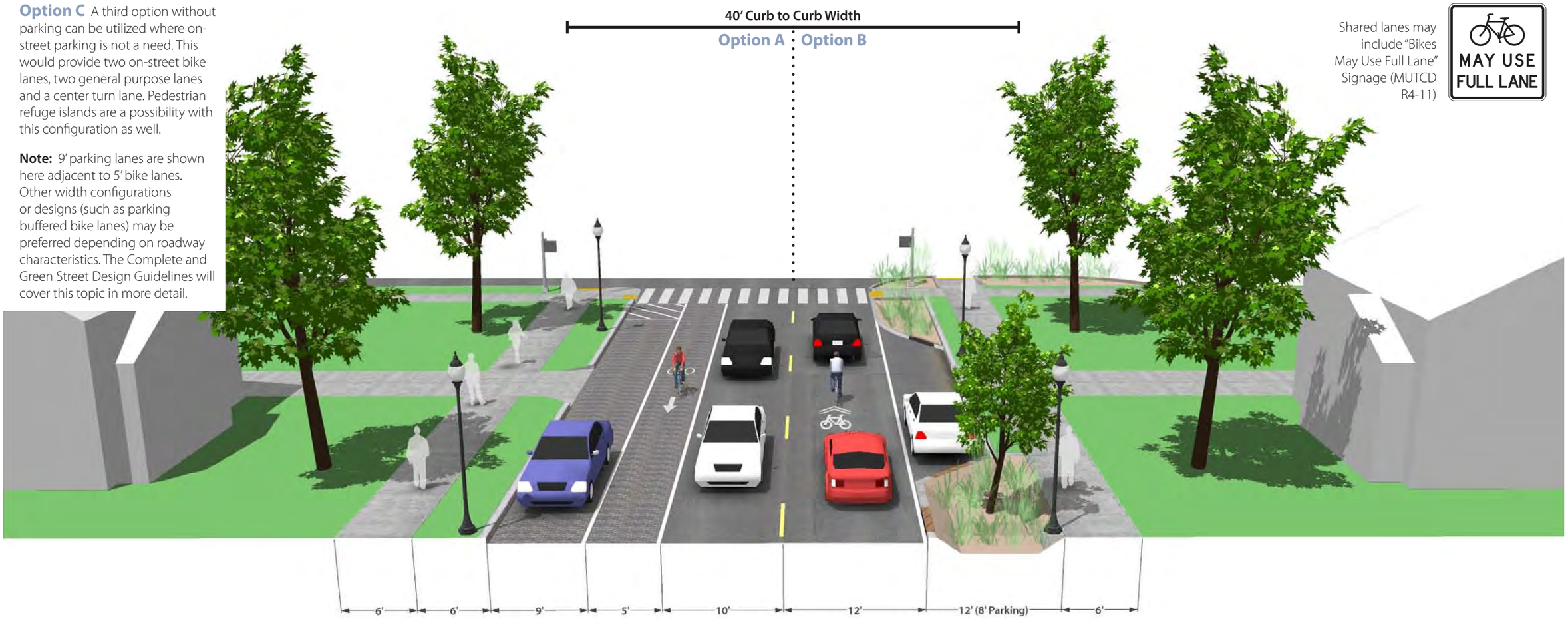
Curb to Curb Width: 40ft
Right-of-Way: 75ft
Land Use: Residential
Connectivity: Medium
Lanes: 2
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary

Existing Users: Primary Secondary

Option C A third option without parking can be utilized where on-street parking is not a need. This would provide two on-street bike lanes, two general purpose lanes and a center turn lane. Pedestrian refuge islands are a possibility with this configuration as well.

Note: 9' parking lanes are shown here adjacent to 5' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.



Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)

Medium, Commercial Street 48'-30' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 2-3, Target speed: 25 mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Native and/or drought tolerant plantings
- Parking/loading lane
- Sidewalk furniture
- Street trees
- Bicycle parking (including bike corrals)
- Reduced impervious surfaces

Option A

- Curbside bioretention cells

Option B

- Shared lane markings
- Curbside continuous bioretention
- Bulb-outs with bioretention cells
- Permeable pavement

Example Existing Conditions

Curb to Curb Width: 40ft
Right-of-Way: 75ft
Land Use: Residential
Connectivity: Medium
Lanes: 2
Speed Limit: 35
Transit: Bus
Traffic Calming: None

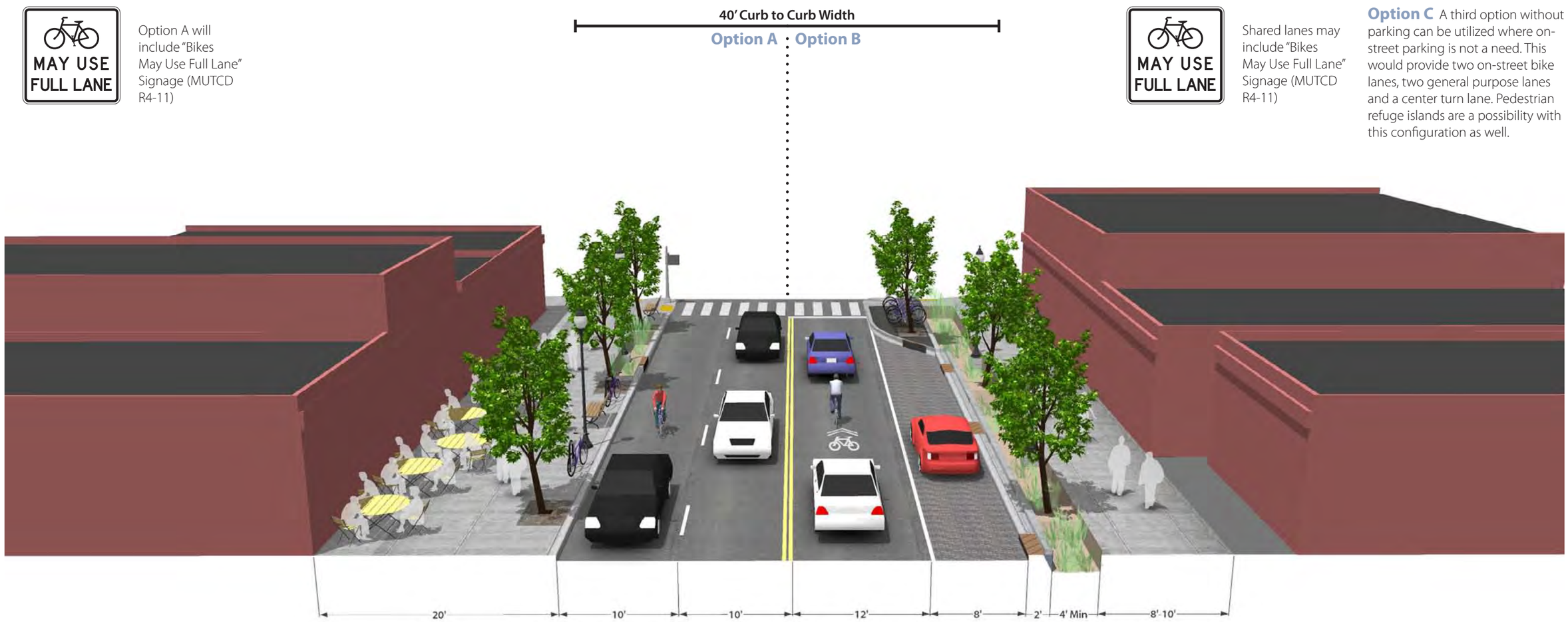
Proposed Users: Primary Secondary

Existing Users: Primary Secondary

Option A will include "Bikes May Use Full Lane" Signage (MUTCD R4-11)

Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)

Option C A third option without parking can be utilized where on-street parking is not a need. This would provide two on-street bike lanes, two general purpose lanes and a center turn lane. Pedestrian refuge islands are a possibility with this configuration as well.



Medium, Industrial Street 48'-30' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 2
- Target speed: 25 mph
- High-visibility crosswalks
- Street lighting
- Accessible Pedestrian Signals
- ADA compliant curb ramps and sidewalks
- Bicycle parking (includes bike corrals)
- Native and/or drought tolerant plantings
- Recycled roadway surface
- Street trees
- Reduced impervious surfaces

Option A

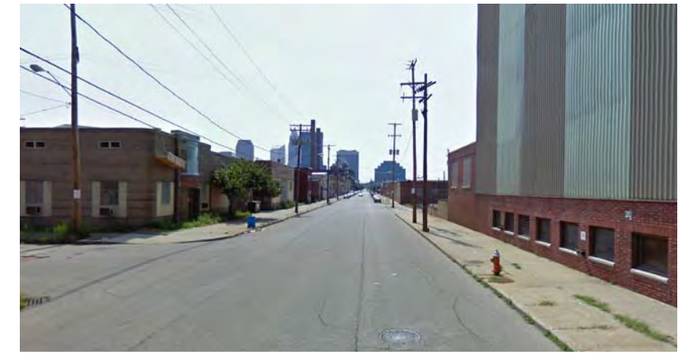
- Parking/loading both sides of street
- Shared lane markings

Option B (higher bike priority)

- Truck compatible bulb-outs with bioretention
- Parking/loading one side of street
- Bike lanes
- Mid-block bioretention bulb-outs

Example Existing Conditions

Curb to Curb Width: 40ft
Right-of-Way: 66ft
Land Use: Industrial/Office
Connectivity: Medium
Lanes: 2
Speed Limit: 35
Transit: None
Traffic Calming: None

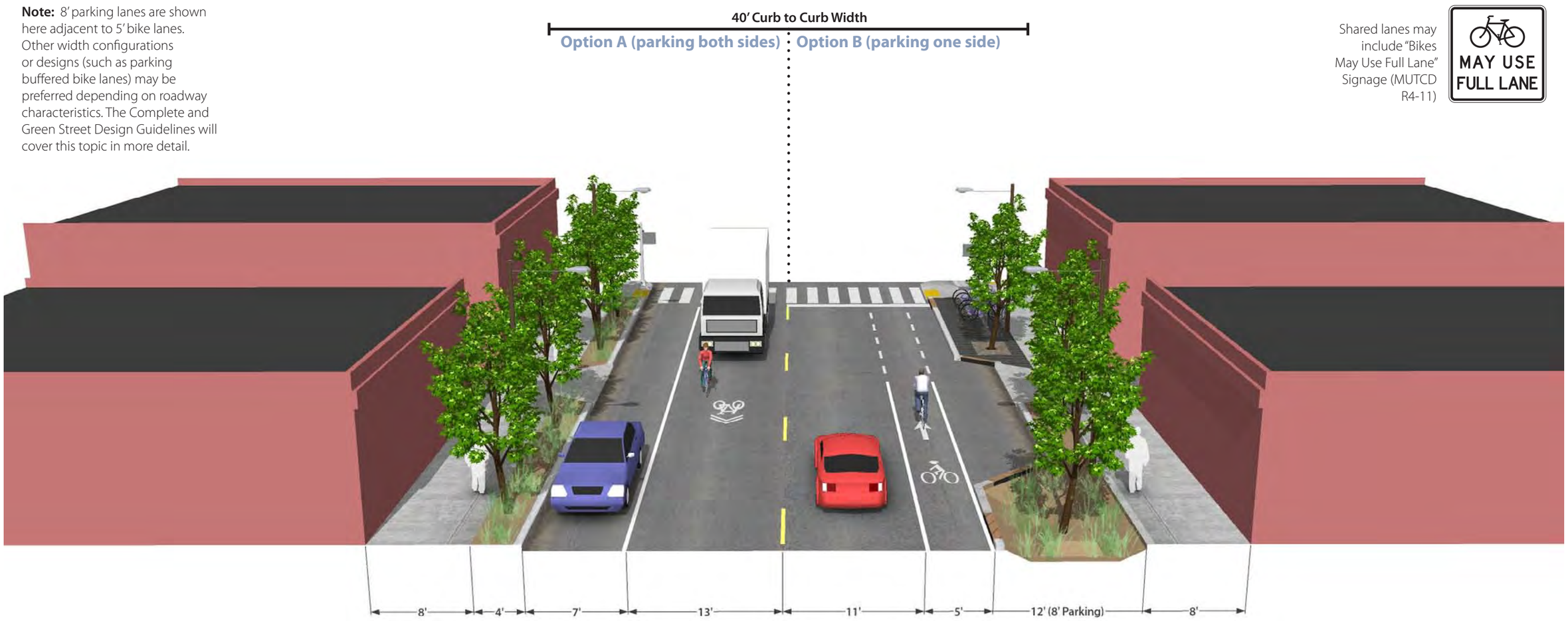


Proposed Users: Primary Secondary (Transit not typical)

Existing Users: Primary Secondary

Note: 8' parking lanes are shown here adjacent to 5' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.

Shared lanes may include "Bikes May Use Full Lane" Signage (MUTCD R4-11)



Medium, Transit/Priority Bikeway Overlay 48'-30' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 2
- Target speed: 25mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Accessible Pedestrian Signals
- ADA compliant curb ramps and sidewalks
- Recycled roadway surface
- Street trees
- Native and/or drought tolerant plantings
- Reduced impervious surfaces

Option A (Transit Overlay)

- Dedicated bus pull-offs and waiting areas
- Parking, one side of street
- Bike lanes

Option B (Priority Bikeway Overlay)

- Bulb-outs with bioretention cells
- Mid-block bioretention bulbouts (may include mid-block pedestrian crossing)
- Parking, one side of street
- Bike lanes

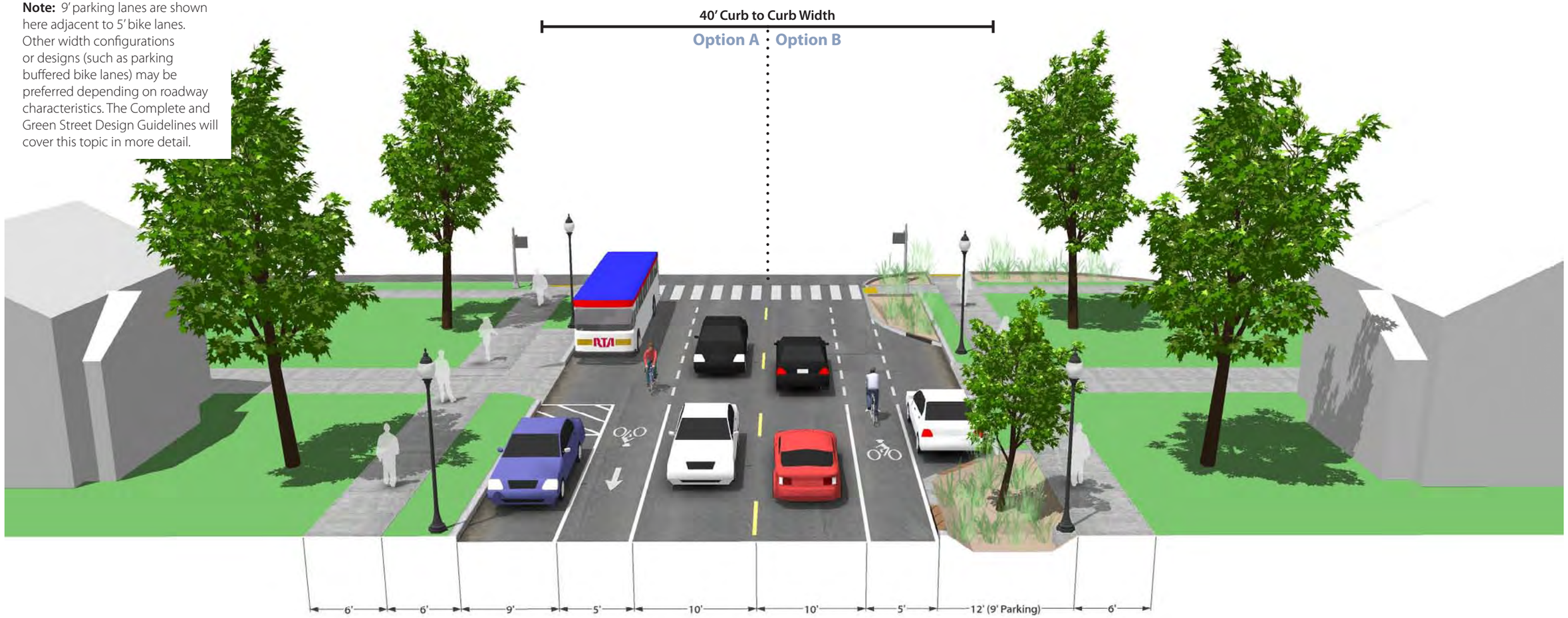
Example Existing Conditions

Curb to Curb Width: 40ft
Right-of-Way: 75ft
Land Use: Residential
Connectivity: Medium
Lanes: 2
Speed Limit: 35
Transit: Bus
Traffic Calming: None

Proposed Users: Primary

Existing Users: Primary Secondary

Note: 9' parking lanes are shown here adjacent to 5' bike lanes. Other width configurations or designs (such as parking buffered bike lanes) may be preferred depending on roadway characteristics. The Complete and Green Street Design Guidelines will cover this topic in more detail.



Small, Neighborhood Street < 30' Pavement Width

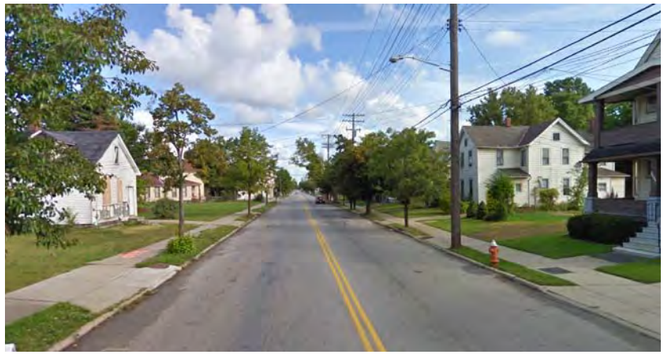
= green infrastructure strategies

Example Improved Characteristics

- Lanes: 1-2
- Target speed: 20 mph
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Bulb-outs with bioretention cells
- ADA compliant curb ramps and sidewalks
- Recycled roadway surface
- Street trees
- Native and/or drought tolerant plantings
- Curbside bioretention cells
- On street parking
- Intersection traffic calming treatments
- Reduced impervious surfaces

Example Existing Conditions

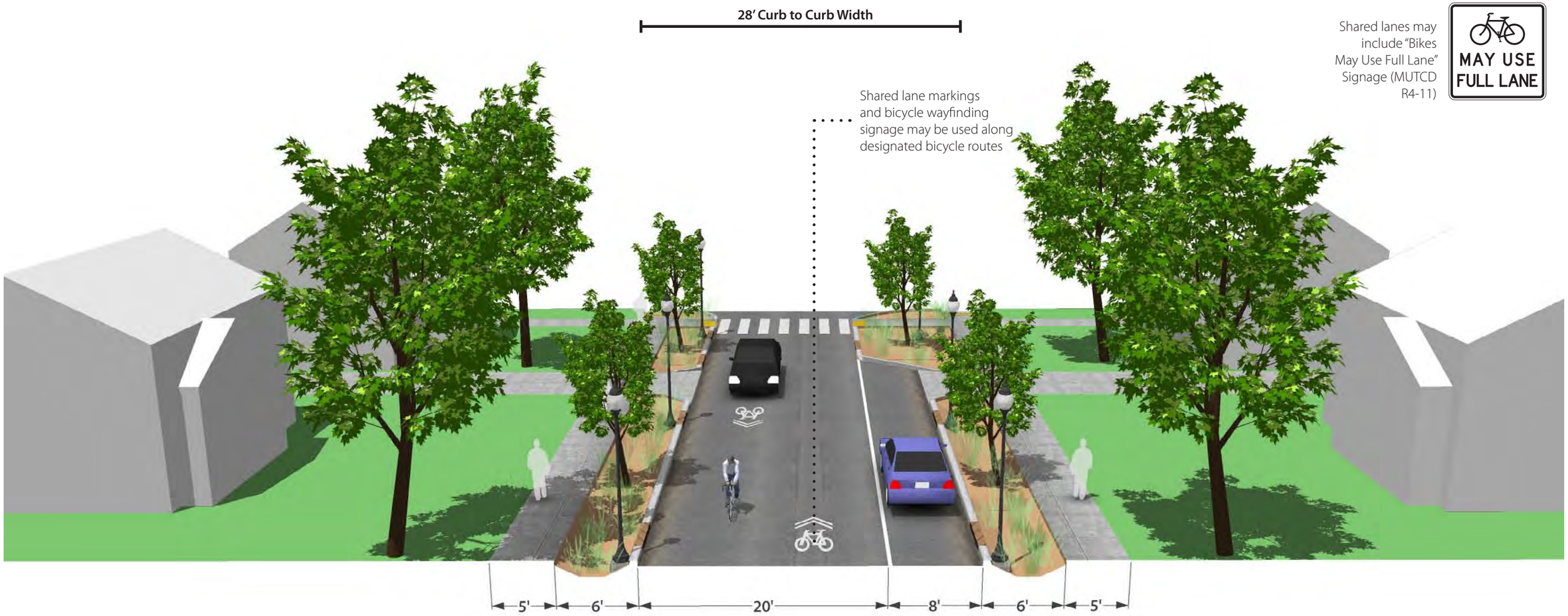
Curb to Curb Width: 28ft
Right-of-Way: 48ft
Land Use: Residential
Connectivity: Medium
Lanes: 2
Speed Limit: 25
Transit: None
Traffic Calming: None



Transit not typical

Proposed Users: Primary Secondary

Existing Users: Primary Secondary



Small, Commercial Street < 30' Pavement Width

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 1
- High-visibility crosswalks
- Pedestrian-scaled street lighting
- Bulb-outs with Bioretention cells
- ADA compliant curb ramps and sidewalks
- Accessible Pedestrian Signals
- Permeable pavement
- Reduced impervious surfaces
- Native and/or drought tolerant plantings
- Parking/loading lane
- Bicycle parking (including bike corrals)
- Sidewalk furniture
- Street trees

Option A

- Curbside continuous bioretention

Option B

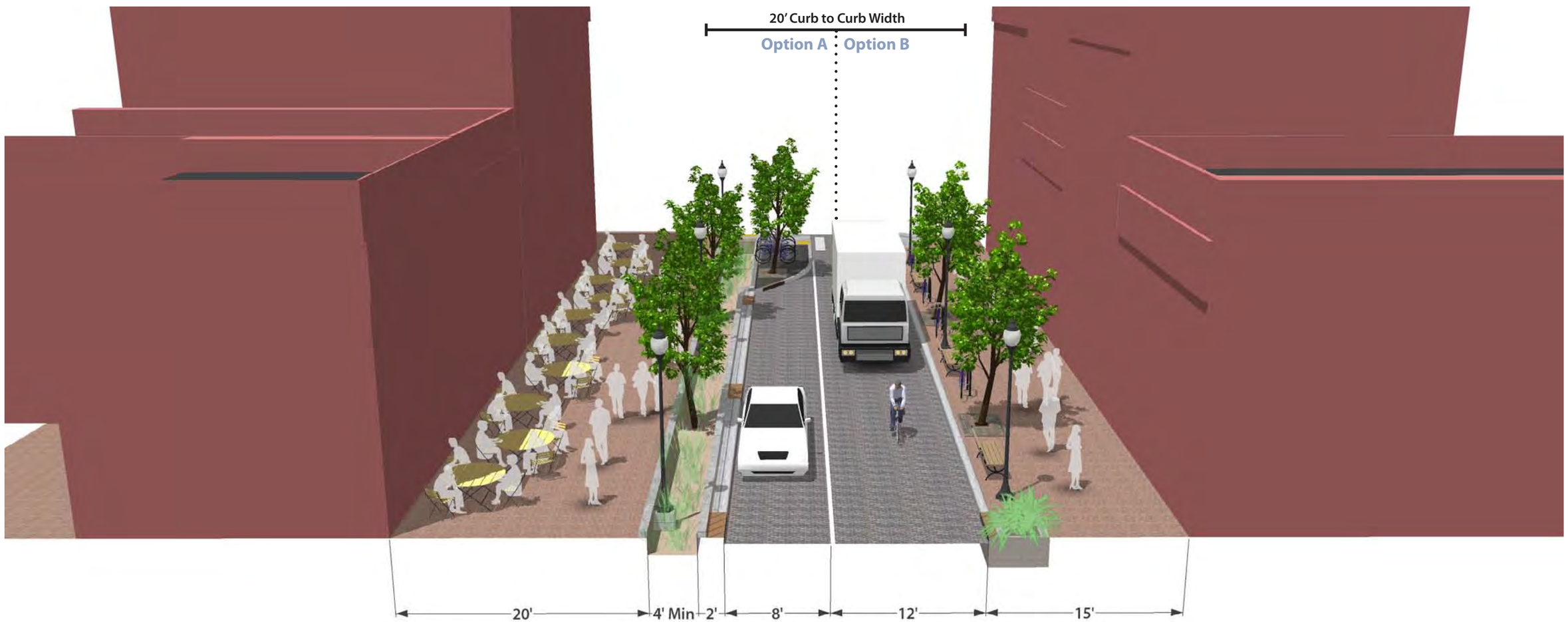
- *Filterra* or similar stormwater treatment

Example Existing Conditions

Curb to Curb Width: 20ft
Right-of-Way: 60ft
Land Use: Commercial
Connectivity: Low
Lanes: 1
Speed Limit: n/a
Transit: None
Traffic Calming: Several types

Proposed Users: Primary Secondary

Existing Users: Primary Secondary



Alleyways/Access Pavement Width Varies

= green infrastructure strategies

Example Improved Characteristics

- Lanes: 1
- Target speed: 20 mph
- High-visibility crosswalks
- Street lighting
- Accessible Pedestrian Signals
- ADA compliant curb ramps and sidewalks
- Permeable asphalt/concrete or pavers
- Reduced impervious surfaces

Option A (higher parking priority)

- One-way shared lane
- Parking/loading one side of street
- Add tree boxes in parking lane

Option B (higher bike priority)

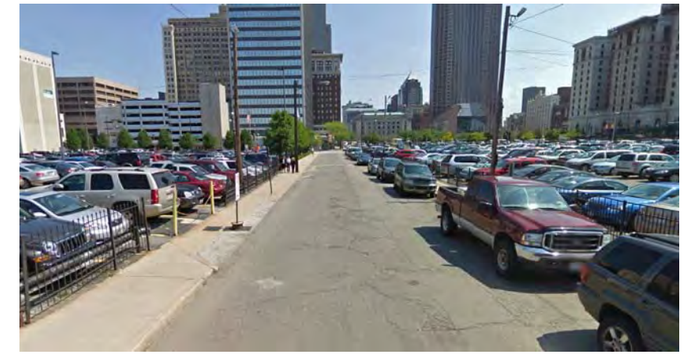
- No parking, loading zone only
- One-way motor vehicle traffic, two-way bike travel (contra-flow bike lane)

Option C (create linear park)

- Prohibit vehicular access
- Permeable grass pavers or natural surface
- Add pedestrian-scaled lighting

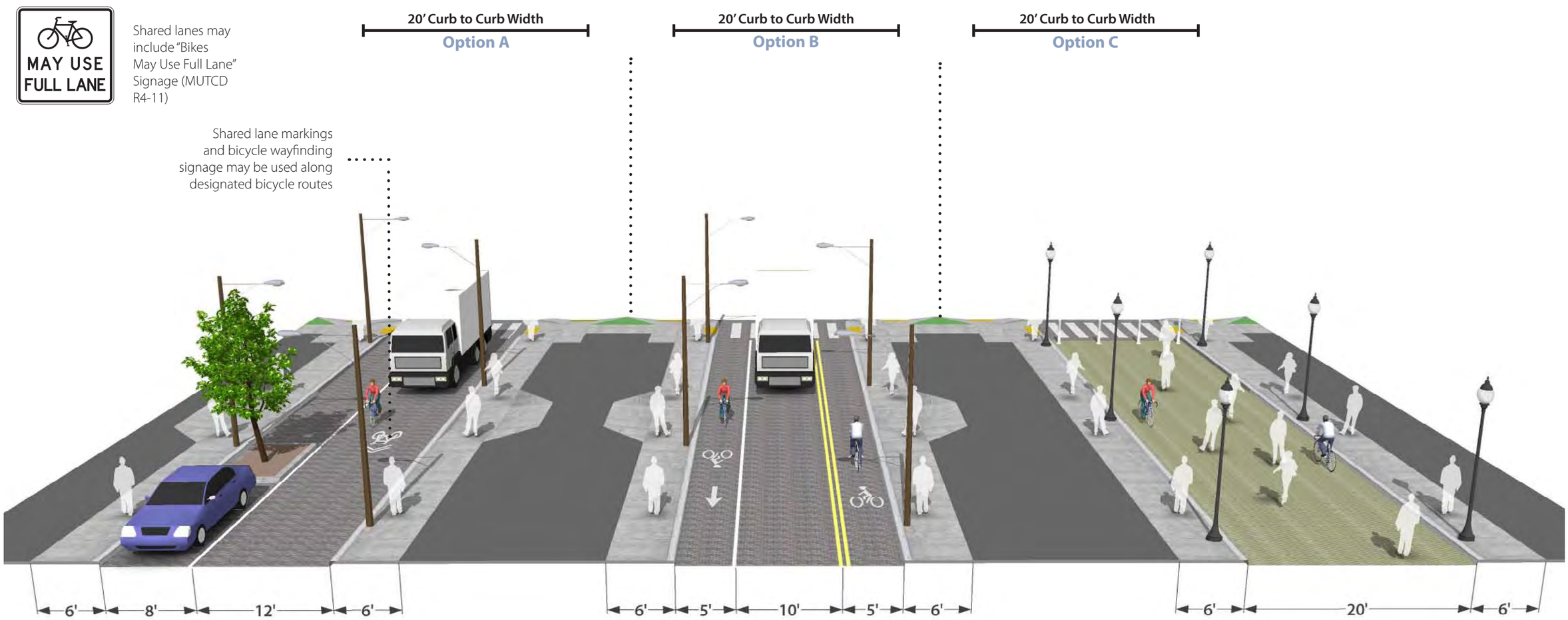
Example Existing Conditions

Curb to Curb Width: 20ft
Right-of-Way: 40ft
Land Use: Access
Connectivity: Low
Lanes: 1
Speed Limit: 25
Transit: None
Traffic Calming: None



Proposed Users: Primary Secondary (Transit not typical)

Existing Users: Primary Secondary

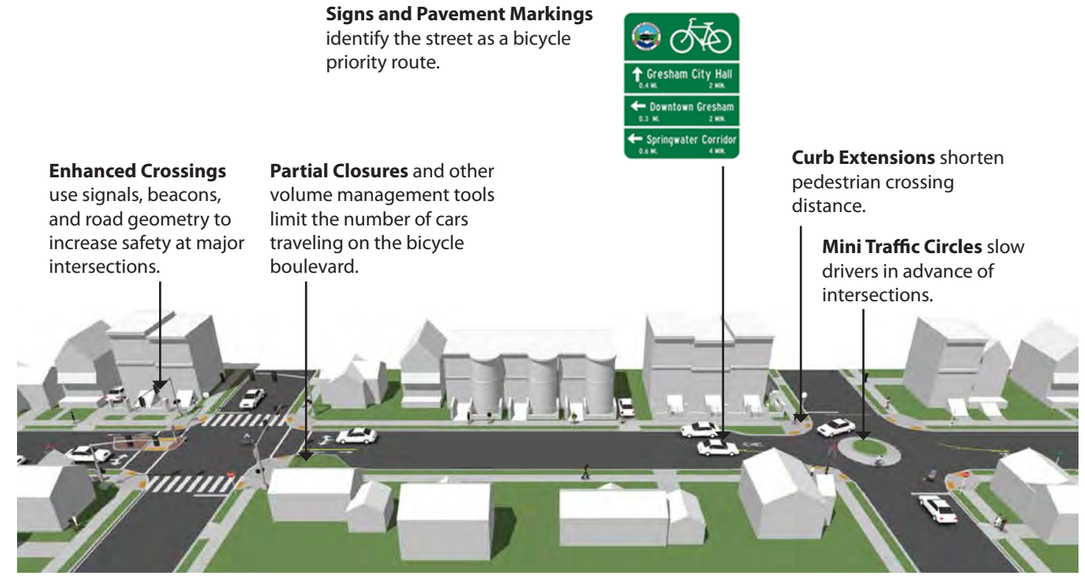


Priority Bikeway Overlay Potential Treatments

Priority Bikeway Overlay - While all typologies include considerations for bicyclists, the Priority Bikeway Overlay uses additional treatments that give roadway priority to bicycle users. These treatments are intended to improve safety, comfort and convenience for bicyclists and encourage them to utilize these routes as much as possible for trips. The Priority Bikeway Overlay may be applied to corridors that are identified in the Cleveland Bikeway Master Plan. Additionally, the Priority Bikeway Overlay may be applied to roadways that meet the warrants described in the future Cleveland Complete and Green Streets Design Guide.

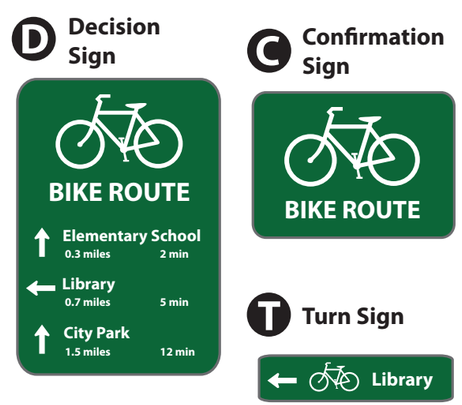
The treatments on the following two pages highlight some of the design features that may be found along Cleveland Priority Bikeways. The Cleveland Complete and Green Streets Design Guide will provide detailed information on the treatments shown here as well as additional Priority Bikeway treatments such as buffered bicycle lanes, separated multi-use paths, mid-block crossings and cycle tracks.

Neighborhood Greenways/Bicycle Boulevards



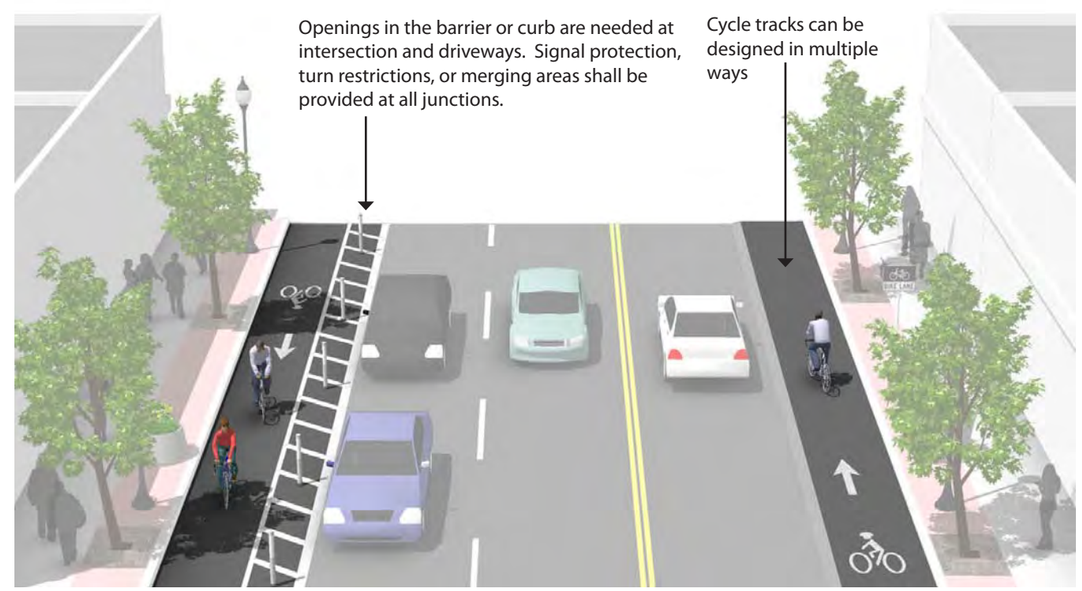
Colored Pavement for Bikeways and Conflict Areas

Bicycle Wayfinding Signage

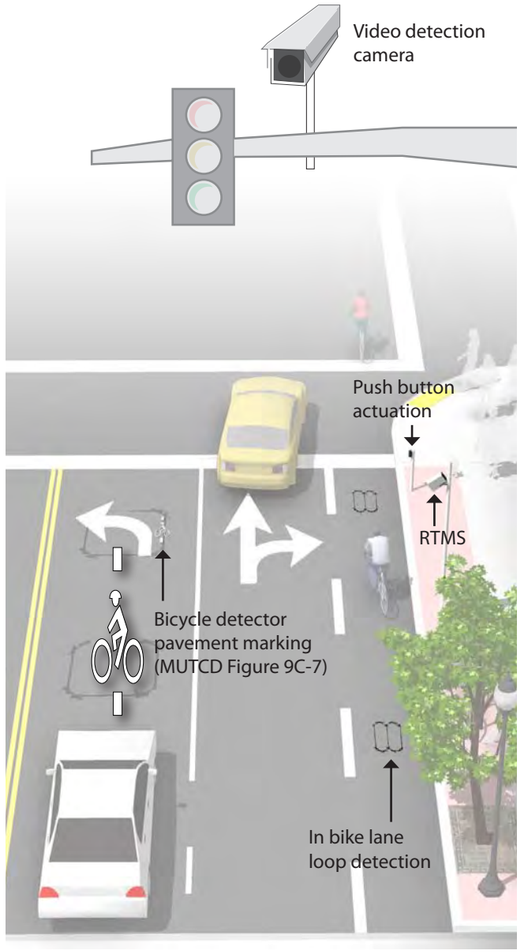


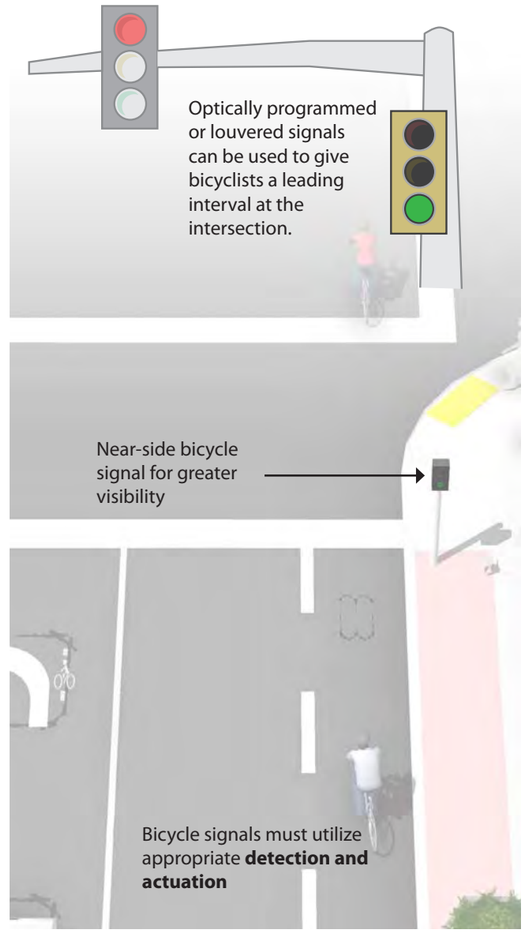
Protected or Separated Bikeways (also known as Cycletracks)

Note: This facility type is appropriate only when turning conflicts at intersections and driveways have been addressed with approved designs.

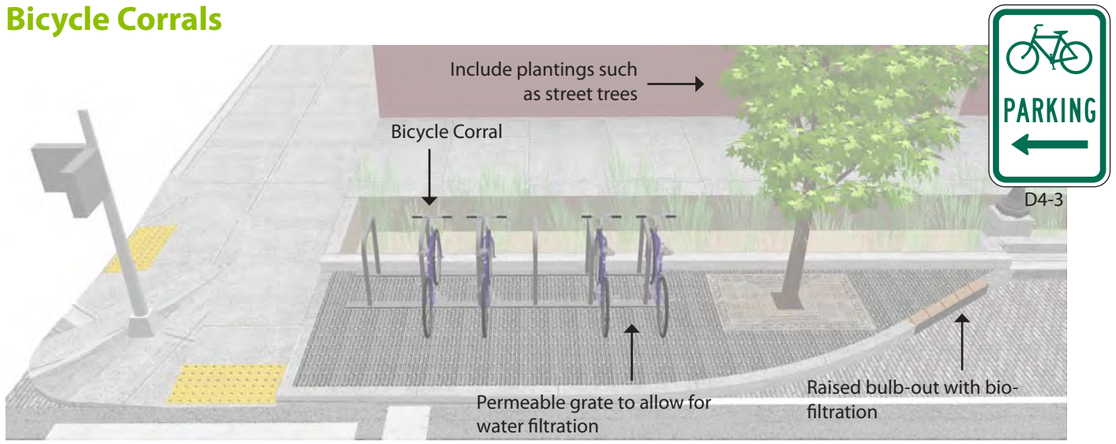


Bicycle Actuation, Detection and Signalization

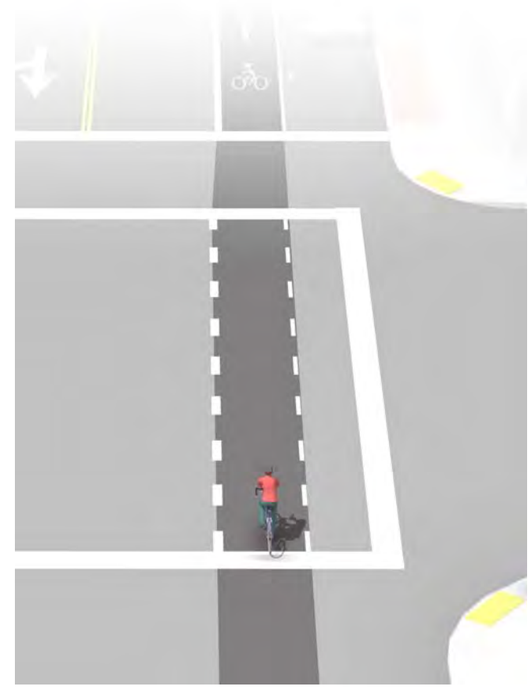


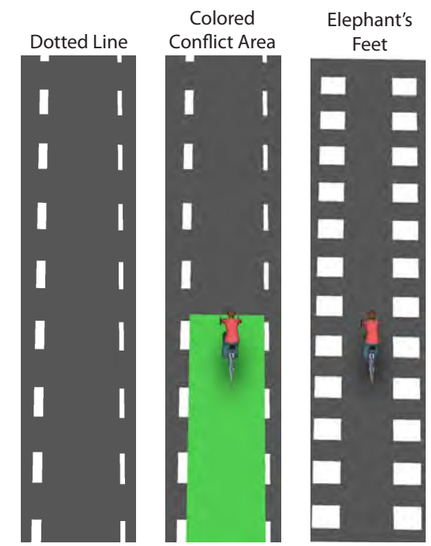


Bicycle Corrals

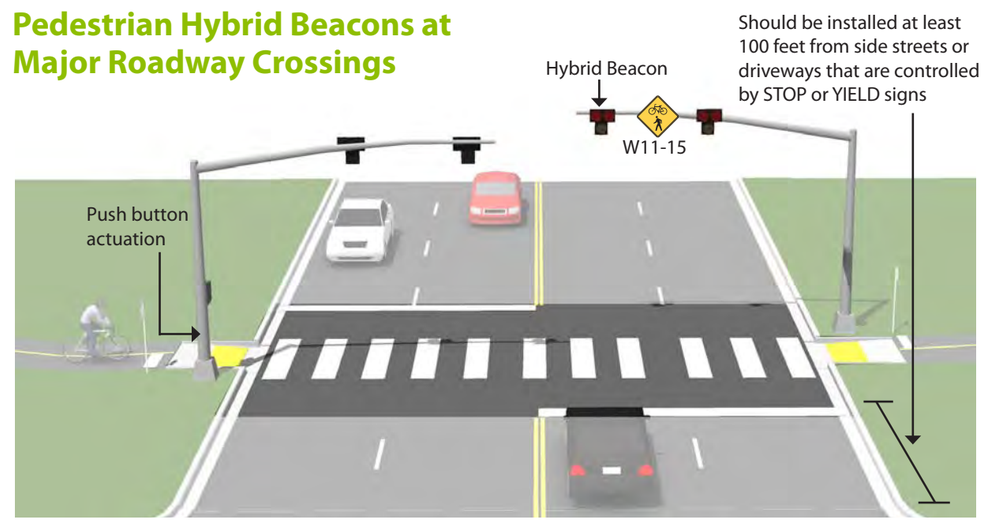


Bicycle Intersection Markings





Pedestrian Hybrid Beacons at Major Roadway Crossings



Cleveland Complete and Green Streets Typologies

Complete and Green Streets Typologies

- Limited Access,
- Atypical
- Very Large Streets, Commercial
- Very Large Streets, Commuter Street
- Very Large Streets, Industrial
- Large Streets, Commercial
- Large Streets, Industrial
- Large Streets, Neighborhood
- Medium Streets, Commercial
- Medium Streets, Industrial
- Medium Streets, Neighborhood
- Small Streets, Access+Alleys
- Small Streets, Commercial
- Small Streets, Neighborhood
- Access+Alleys
- Transit Spine Overlay
- Priority Bikeway Overlay

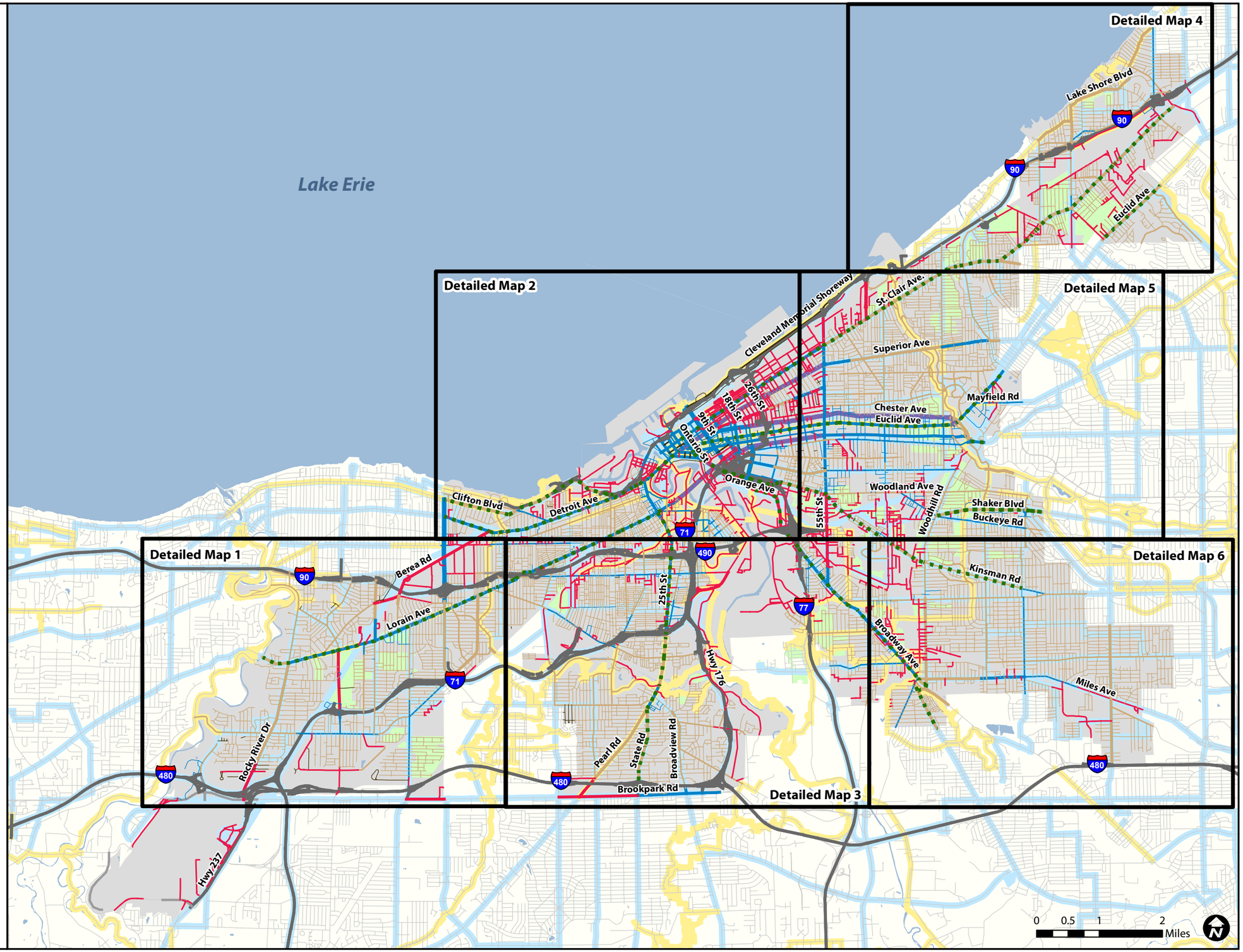
Streets Outside of City Limits

Transit Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits



Overview Map
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

CITY OF CLEVELAND
Mayor Frank G. Jackson

the YMCA

Cleveland Complete and Green Streets Typologies

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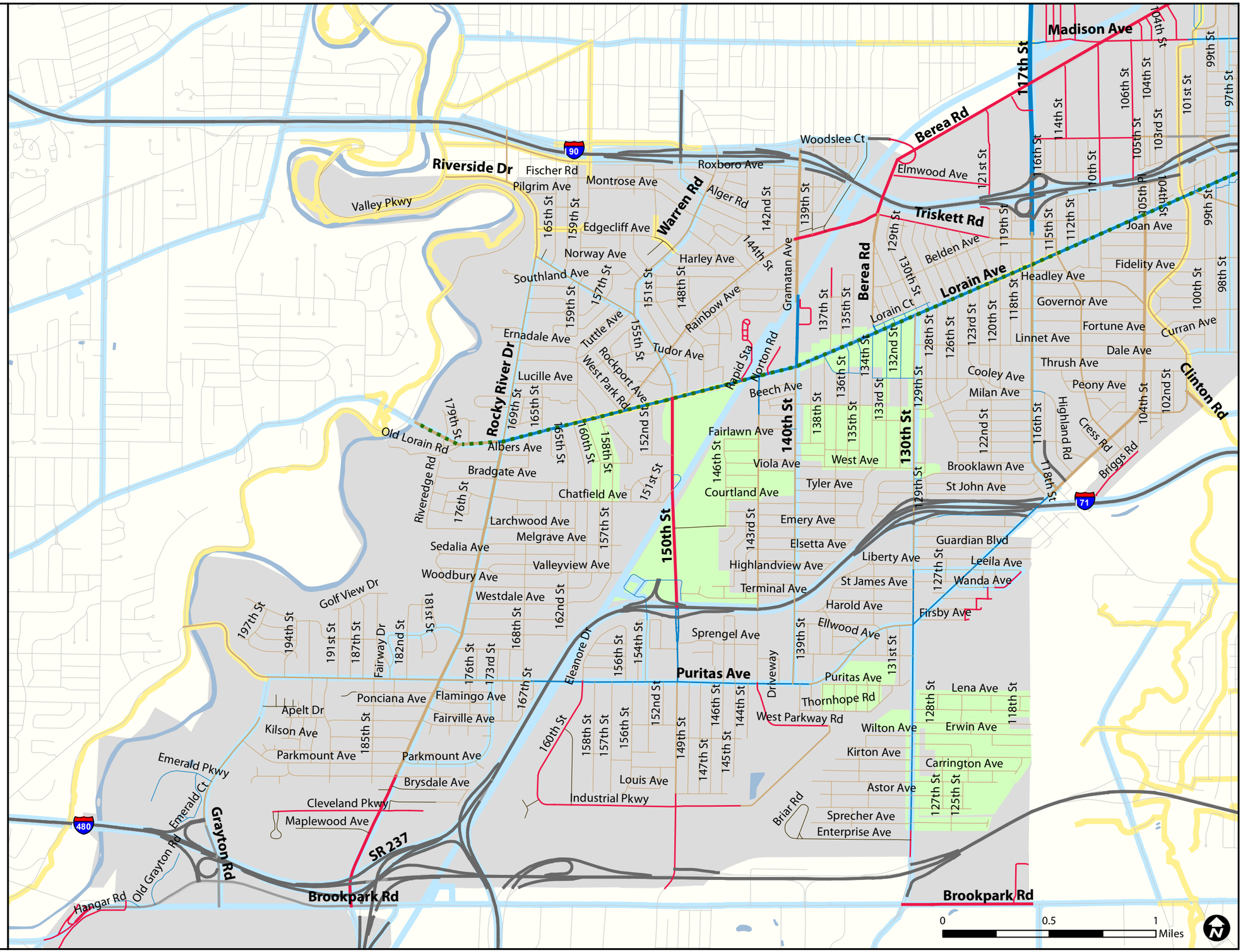
Streets Outside of City Limits

Transit Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits



Detailed Map 1
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

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- Small Streets, Neighborhood
- Access+Alleys
- Transit Spine Overlay
- Priority Bikeway Overlay

Streets Outside of City Limits

Transit Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits

Detailed Map 2
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

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Cleveland Complete and Green Streets Typologies

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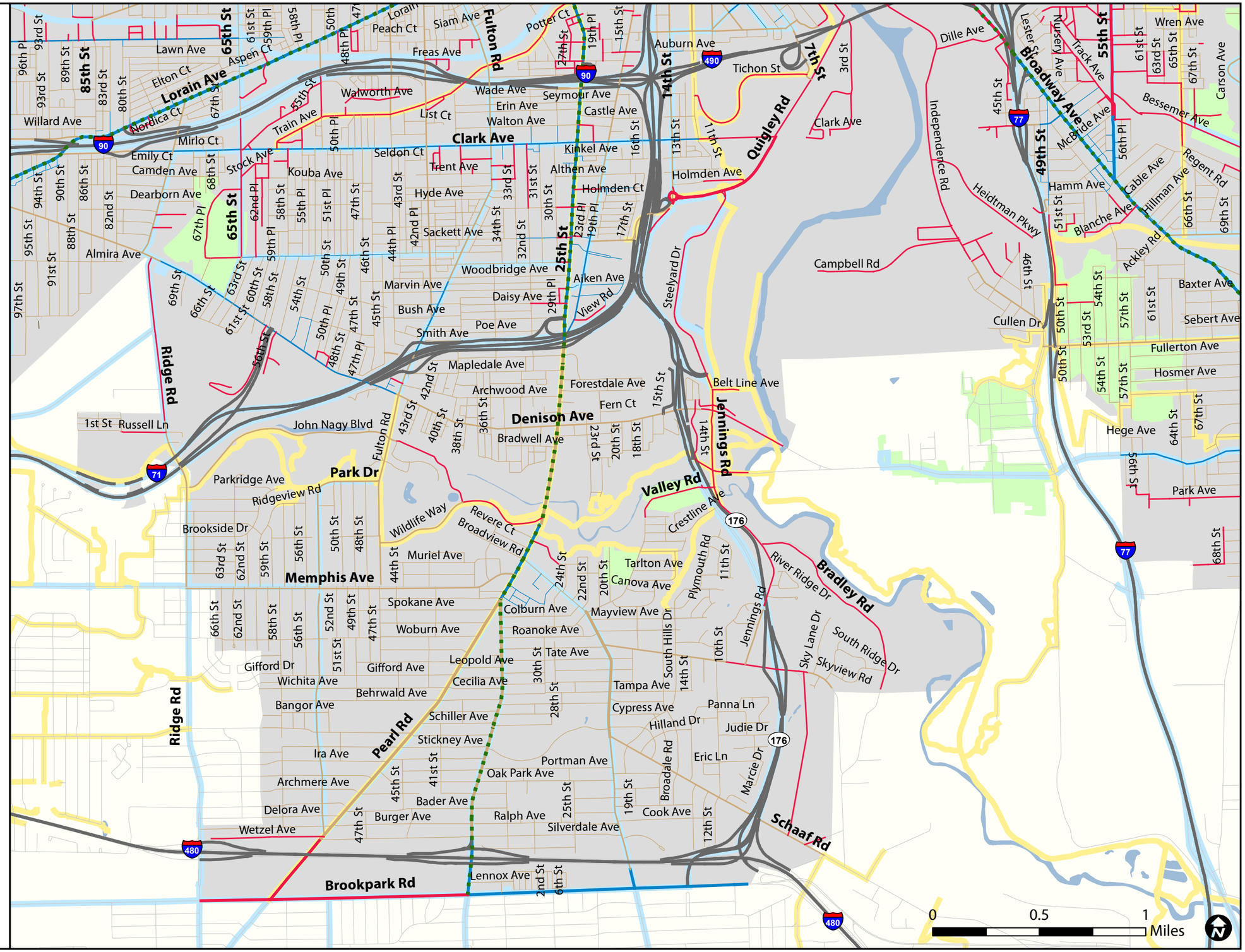
Streets Outside of City Limits

Transit Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits



Detailed Map 3
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

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Cleveland Complete and Green Streets Typologies

Complete and Green Streets Typologies

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- Priority Bikeway Overlay

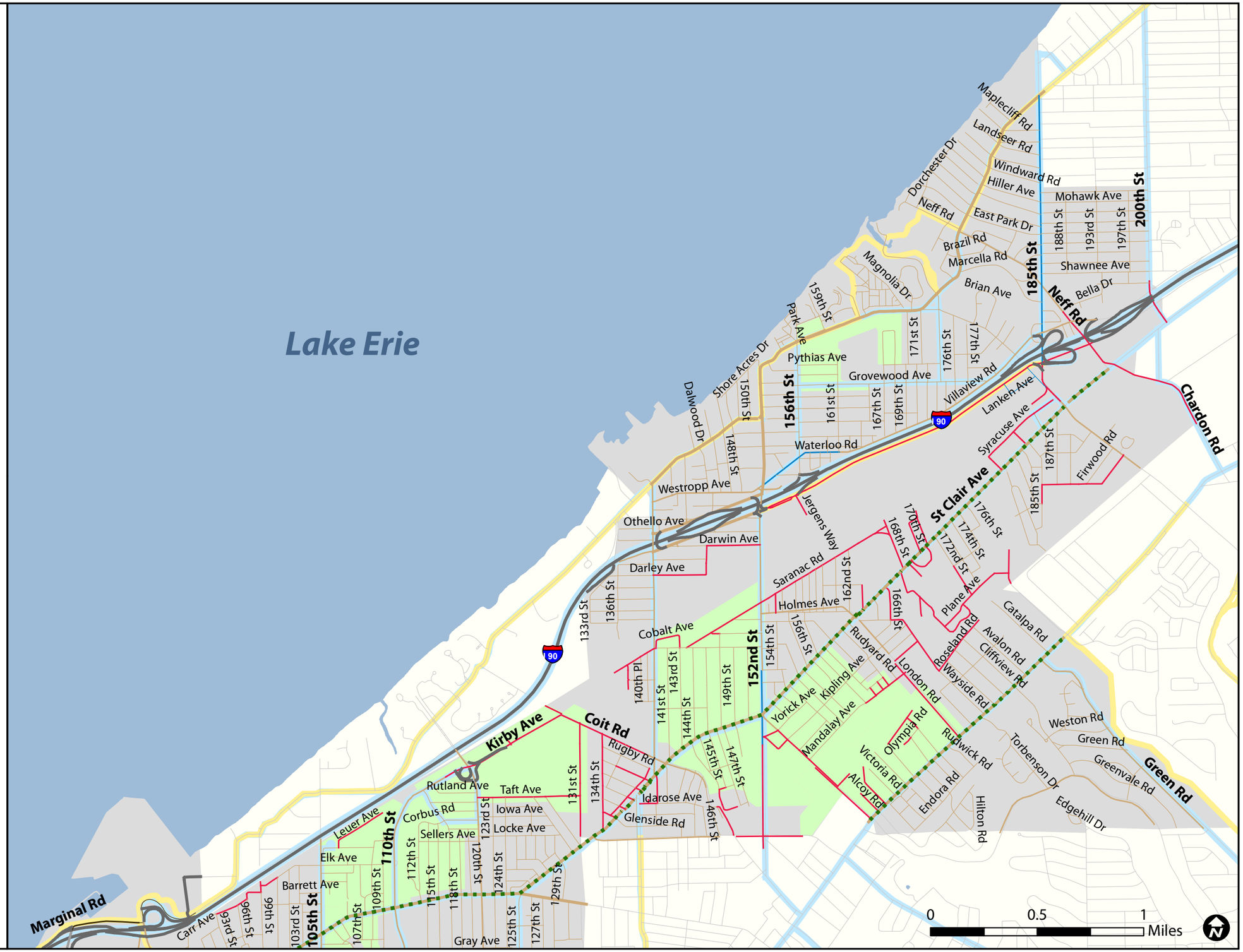
Streets Outside of City Limits

Transit Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits



Detailed Map 4
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

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Cleveland Complete and Green Streets Typologies

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- Transit Spine Overlay
- Priority Bikeway Overlay

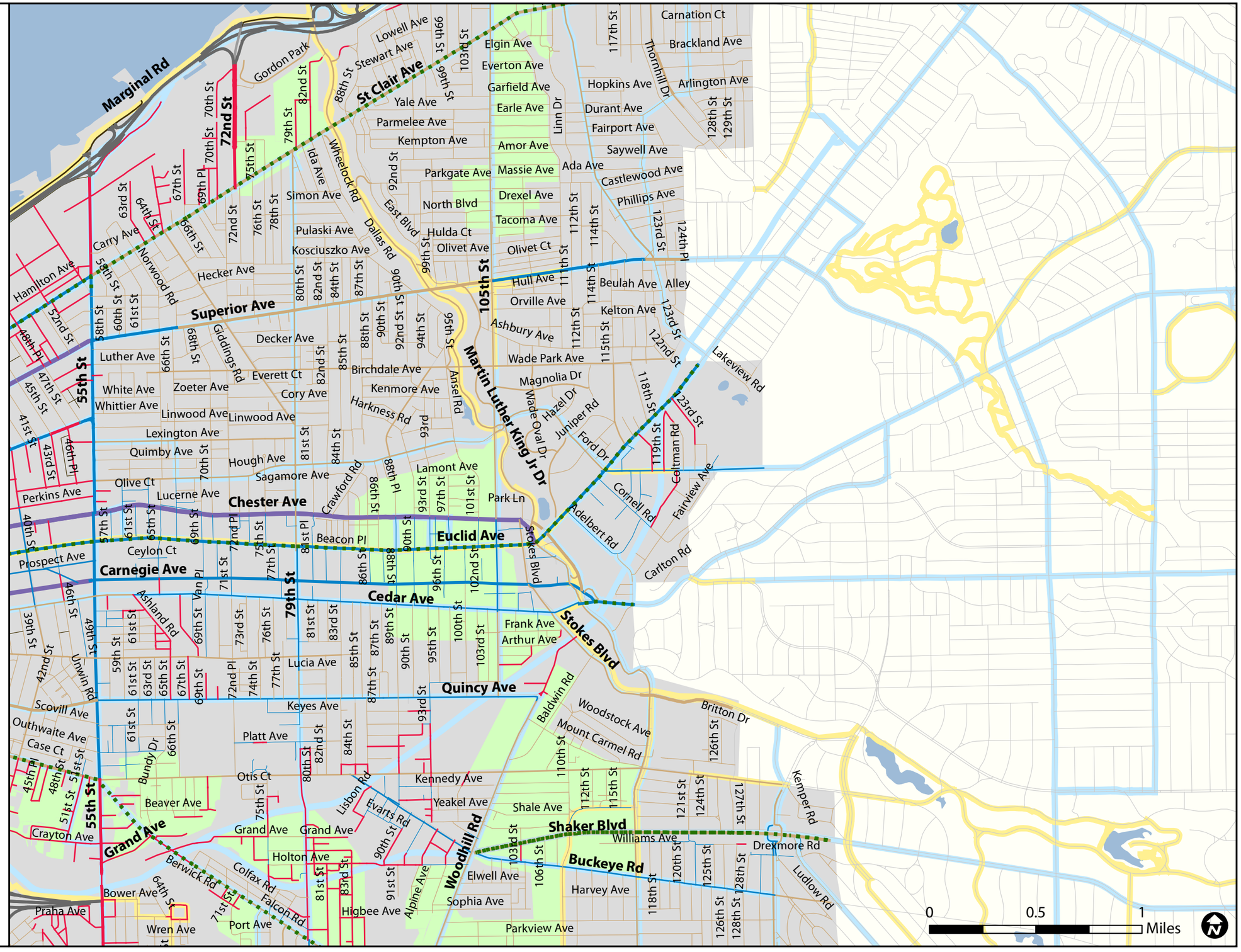
Streets Outside of City Limits

Transit Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits



Detailed Map 5
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

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Mayor Frank G. Jackson

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Cleveland Complete and Green Streets Typologies

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- Medium Streets, Neighborhood
- Small Streets, Access+Alleys
- Small Streets, Commercial
- Small Streets, Neighborhood
- Access+Alleys
- Transit Spine Overlay
- Priority Bikeway Overlay

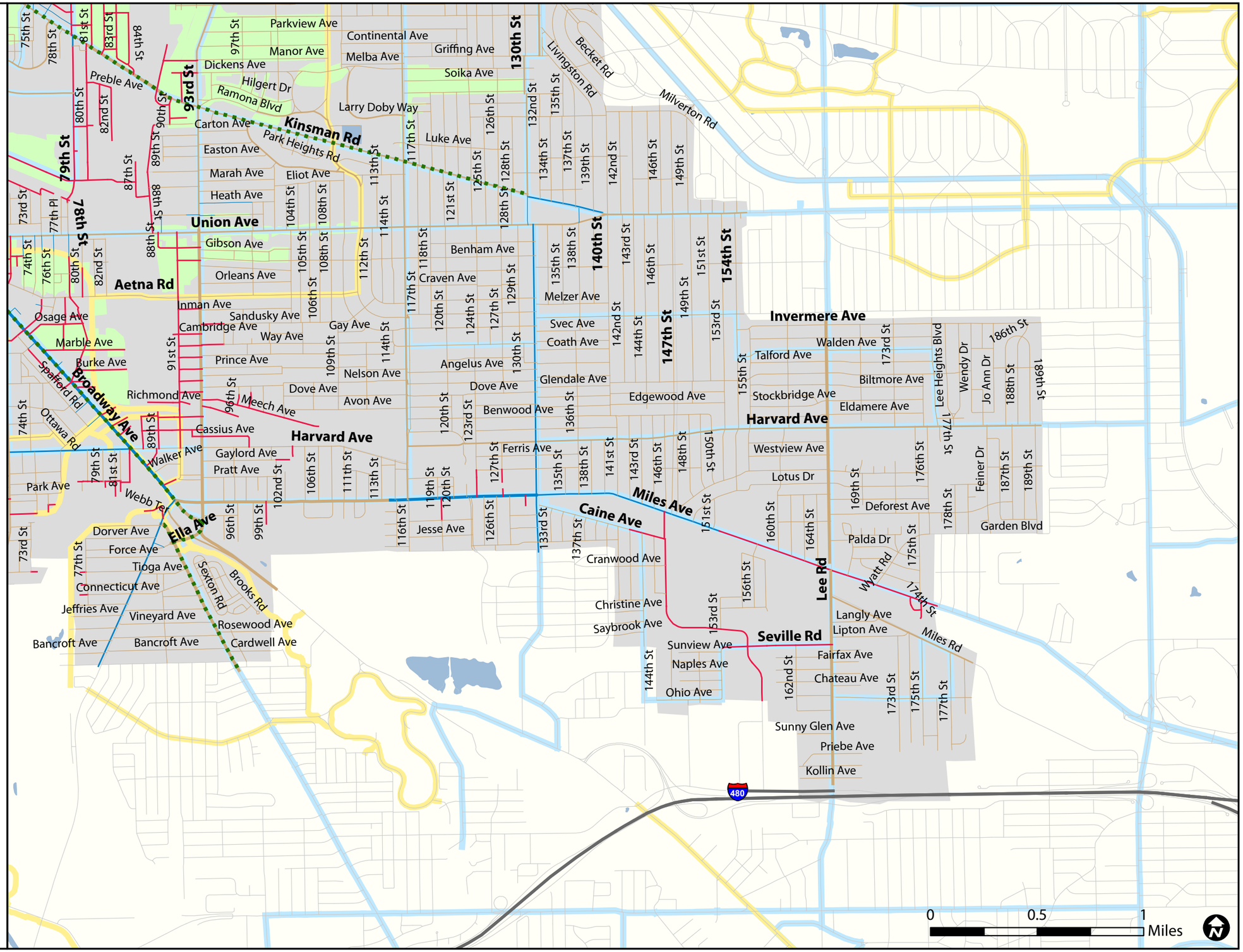
Streets Outside of City Limits

Bus Lines

Candidate Green Infrastructure Areas

Water Bodies

Cleveland City Limits



Detailed Map 6
City of Cleveland, OH

Sources: City of Cleveland, NOACA
Date: 8/16/2013
Authors: JC, SP
Alta Planning + Design

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Euclid Avenue

Appendix A
Results of January Typology Workshop

1 Introduction

The City of Cleveland recognizes that diverse public and stakeholder participation and input is an important part in the development of its Complete and Green Streets Design Guidelines. Therefore, it was identified early on that a thoughtful public involvement approach should be conducted to better guide the definition of Cleveland's street typologies and the subsequent development of street design guidelines. Although the street typologies and design guidelines will ultimately be refined by the Alta team working in conjunction with the project task force, public and stakeholder involvement would provide valuable insight as to the types of streets that exist in Cleveland and their typical attributes.

The input and outreach process for this project also serves the secondary purpose to better educate the public and stakeholders on the presence of and the importance of the project. The importance of and need for complete and green streets in Cleveland is great. Complete and green streets can help bolster the economy; increase public safety, health and livebility; and improve environmental health through stormwater remediation and the use of sustainable materials/construction.

2 Workshop Background

The primary purposes of this workshop were to:

- inform participants on the importance of complete streets in Cleveland,
- educate participants on the different strategies and techniques that can be used to "complete and green the streets,"
- build buy-in for the project from the various organizations represented,
- gather information and perspectives on the existing street types and conditions in Cleveland, and
- view what typical complete and green street techniques the participants preferred for Cleveland

Prior to the workshop, a list of invitees was developed that included at least one representative from Cleveland-related organizations viewed as having a direct and important stake in the project. These organizations included:

- The Cleveland Urban Design Collaborative
- LAND Studio
- The Northeast Ohio Regional Sewer District
- The Downtown Cleveland Alliance
- The GreenCityBlueLake Institute
- YMCA of Greater Cleveland
- The City of Cleveland Department of Aging
- The Northeast Ohio Areawide Coordinating Agency
- Cuyahoga County
- Ohio Department of Transportation
- The Greater Cleveland Regional Transit Authority
- Metroparks
- Cleveland City Council

A list of workshop attendees can be found in Attachment A. The workshop was held at the Sustainable Cleveland Center on January 23rd, 2013 from 12:00 to 4:00 PM. The workshop was broken up into three segments:

The first segment provided background information to participants on the need for complete and green streets, both in Cleveland and nationwide. This segment provided information supporting the need for complete streets and presented several comparisons of "incomplete," or heavily auto-oriented streets, and complete and green streets: those which consider the needs of all roadways users and consider environmental needs.

The second segment began by presenting information on the ways in which organizations and cities similar to Cleveland defined and classified their streets from a Complete Streets approach. This was done in order to inform participants on the various considerations that guide Complete Streets classification. Case studies included classifications from The National Association of City Transportation Officials (NACTO), Chicago IL, Charlotte NC, Brunswick ME,

Minneapolis MN, and New York City. Workshop participants were then asked to gather in pre-selected groups and given one hour to define current typologies for each type of street in Cleveland. Following the exercise, groups were asked to present their definitions and reasoning to the larger group. For each type of street in Cleveland, groups were asked to:

- create a name,
- include example streets in Cleveland,
- state the street's key purpose,
- identify transportation mode priority,
- define the typical speed,
- define acceptable auto congestion,
- define the importance of the street as a link and a place, and
- describe the street's context (surrounding land use).

The goal of this session was for the group to define existing street types in Cleveland, based on participant opinions of street conditions and context. Examples of both workshop worksheets are found in Attachment B and the compiled results of the two workshop segments can be found in Attachment C.

The third segment began by presenting the different techniques and strategies that can be used to make existing streets more complete and environmentally responsible. The presentation covered a thorough list of common traffic calming techniques for slowing or discouraging personal motor vehicle traffic. These techniques serve to make streets inviting and favorable for alternative forms of transportation such as walking bicycling and public transit, as well as more accommodating of uses other than transportation, such as play, street festivals and stormwater remediation. It was also explained that all traffic calming techniques are not appropriate on all types of roadways. For reference, a list of appropriate traffic calming techniques based on roadway type was presented and included in the worksheet. Participants were then asked to re-join their previous groups and decide upon the traffic calming and "greening" techniques they would like to see for each of their previously-

defined typologies. They were also asked to rank the techniques they selected from highest-desire to lowest. Examples of both workshop worksheets are found in Attachment B and the compiled results of the two workshop segments can be found in Attachment C.

3 Workshop Results

Following the workshop, the input from the groups was compiled, organized and analyzed in order to identify trends in the typology identification and determine overall preferences for traffic calming and greening techniques among workshop participants.

3.1 Typology

Results of the typology definition exercise were somewhat varied among the groups, but there is also some significant overlap in categorization. **Table 1** shows the typologies as created by the 5 workshop groups. In this table, the typologies are categorized by common attributes such as roadway size (determined from group-generated prototypical roadway examples), land use context and priority user in order to assist in identifying trends in the data. Detailed results from the Typology workshop can be found in Attachment C

Table 1. Summary of Workshop Typologies

Street Typology Name	Cleveland Example	Ped. Priority	Bike Priority	Transit Priority	Goods Prioirty	Auto priority	Typical Speed	Acceptable Congestion	Importance as a Link	Importance as a Place
Very Large Streets										
Spinal Route	Chester	Low	Low	Medium	Medium	High	35	Low	High	Low
Runway	Chester, Clifton, Carnegie, 150th	Low	Low	High	Medium	High	35-40	Low	High	Low
Parkways										
Large Streets										
Street District	W 25th Detroit	High	High	High	Low	High	25	High	Medium	High
Main Street	W 117, Prospect W. 25th, Cedar, E 79th	Low	Low	High	Medium	Medium	25-35	Medium	Medium	Medium
Commuter	Chester, Carnegie, Clifton	Medium	High	High	High	High	25-40	Medium	High	Medium
Commercial Ave.	Carnegie, Chester, Superior, Detroit	Low	Low	Med/High	High	High	35	Med-Low	High	Low
Transit Street	Euclid Ave, Clifton	High	High	High	Medium	Medium-Low	35	High-medium	High	Medium-Low
Medium Streets										
Neighborhood Connectors	W 130, W 150, Franklin, Riverside	High	High	High	Low	Medium	35	Medium	Medium	Medium
Neighborhood Connector/Center	Bridge, Madison, Buckeye	High	High	Medium	Medium	Medium	25	High	Medium	High
Neighborhood Connector	Broadway, Lorain, Pearl	Medium	High	High	High	high	25-35	Medium	High	Medium
Neighborhood Connector	Most numbered residential streets	High	High	Low	Low	Low	20	High	Medium	medium
Boulevard	(Shaker Blvd.)	Medium	Medium	High	Medium	High	45-50	Low	High	Medium
Neighborhood Connector	Franklin Blvd.	Medium	High	Medium	Low	High	35	medium	High	Medium
Small Residential Streets										
Neighborhood Streets	any residential street	High	High	Low	Low	Low	25	High	Low	High
Residential	Residential 2-lane residential	High	High	Low	Low	Medium	25 and less	High	Low	High
"Walk Your Car"	Market Street, N. End of E. 9th, Hessler	High	High	Medium	Medium	medium	15	Low	Low	High
Neighborhood Connector	Most numbered residential streets	High	High	Low	Low	Low	20	High	Medium	Medium

Street Typology Name	Cleveland Example	Ped. Priority	Bike Priority	Transit Priority	Goods Prioirty	Auto priority	Typical Speed	Acceptable Congestion	Importance as a Link	Importance as a Place
Neighborhood Residential Street	West Clinton	High	High	Low	Low	Medium	25	Medium	Low	Medium
Small Commercial Streets										
Street District	W 25th Detroit	High	High	High	Low	High	25	High	Medium	High
Sin Streets	E 4th, Coventry, Markey, W 25 @ Market	High	High	Low	Low	Low	0-20	High	Low	High
Main Street	W. 25th Street, Mayfield in Little Italy, Detroit by Garden Square	High	High	High	Medium	Medium	25	High	Medium	High
Main Street	Mayfield (little italy), w.65/Detroit, w.25/bridge	High	High	High	Medium	Medium	25	High	Medium	High
Activity Area Street	Market Ave.	High	High	High	Low	Low	15	High	Low	High
Pedestrian Only/Oriented Street										
Destination Street	Market, E 4th, Alleys	High	High	High	Low	Low	0	High	Low	High
Sin Streets	E 4th, Coventry, Markey, W 25 @ Market	High	High	Low	Low	Low	0-20	High	Low	High
"Festival Street"	E. 4th Street, Times Square	High	Medium	Low	Medium	Low	0	Low	Low	High
Polka Street - Pedestrian Way	East 4th/Sometimes Market Ave	High	Low	Low	Low	None	0	None	n/a	High
Pedestrian Street	E. 4th Street, Uptown	High	Medium	n/a	n/a	n/a	10	n/a	Low	High
Other										
Intersections	n/a	Medium	Medium	High	High	High	n/a	Low	High	Medium (Vary)
Alleys	Johnston Court, Franfort, Bolivar	Medium	Medium	Low	High	Low	0-10	High	Low	Low
Industrial Roadway	Bessemel	Low	Low	Low	High	High	35	medium	Medium	High

The main ways that groups categorized the streets were by transportation function, land use connectivity, surrounding land use and surrounding activity. Overall size of the street was not a major consideration among the groups. The graphic below displays the primary words that were used in the definition of typology names. The larger a word appears in the graphic, the more instances it occurs in the definitions. Common, non-descriptive nomenclature such as Street and Avenue was removed to emphasize the adjectives:

Other notable trends in the data are as follows:

- More typologies were defined for smaller, less auto-oriented streets than large auto-oriented streets.
- Motor vehicles received the highest priority on the largest defined roadways. In general, this priority declined as the size of the roadway decreased and its functions diversified. The opposite is true for bicyclists and pedestrians, except that these users were given medium to high priority in all but the largest roadway categories.
- The highest typical roadway speed for the typologies was 50 MPH and the lowest was 0 MPH. The vast majority of roadways were listed as 35 MPH or less.
- In response to the question: *What is the importance of a roadway to serve as a place?,* the vast majority of roadways were listed as having a medium or high importance.

3.2 Traffic Calming and Street "Greening" Preferences

Groups selected and ranked traffic calming and street "greening" preferences based on information presented in the PowerPoint presentation. These results are summarized in the following figures. These summaries were generated by averaging the selected, ranked treatments of all typologies in each typology category. The typology categories are identified in **Table 1** above**.** Treatments preceded by the word "Other" were those that were written in by individual groups. Detailed results from this exercise can be seen in Attachment C.

General observations about the data include:

- Street trees and High Visibility Crosswalks were popular traffic calming treatments for all typology categories.
- Street trees were the most popular street "greening" technique for all typology categories
- Many groups voluntarily added bicycle lanes or shared lane markings to the list even though the intent was that the Road Diet/Road Resizing treatment included the potential inclusion of bicycle lanes.

Figure 2. Traffic Calming and Greening Treatment Rankings for Very Large Streets

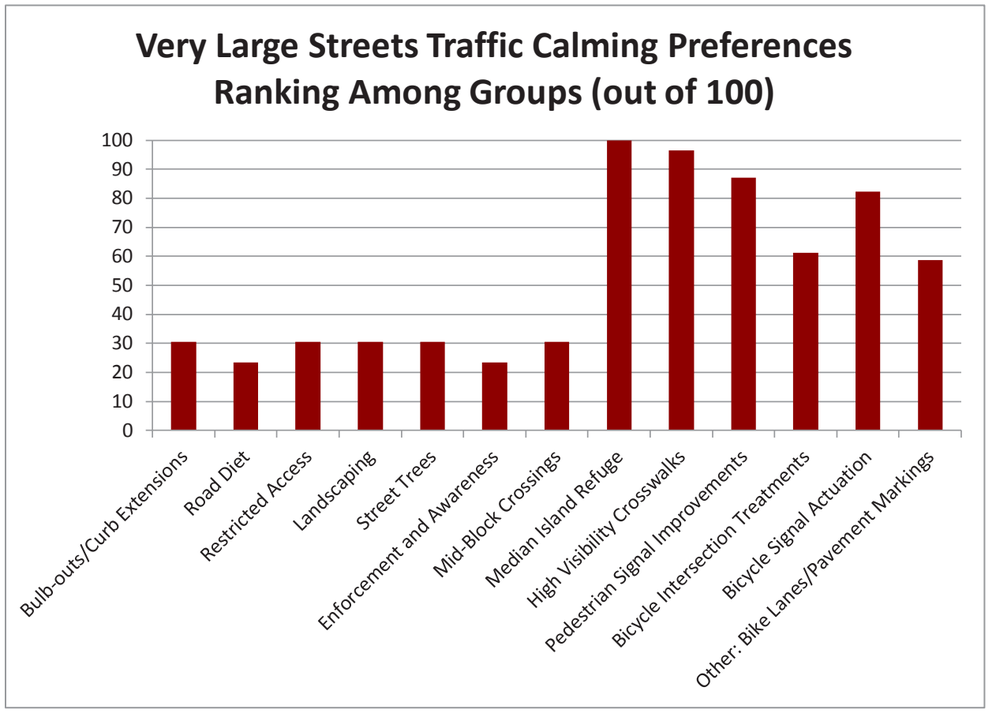
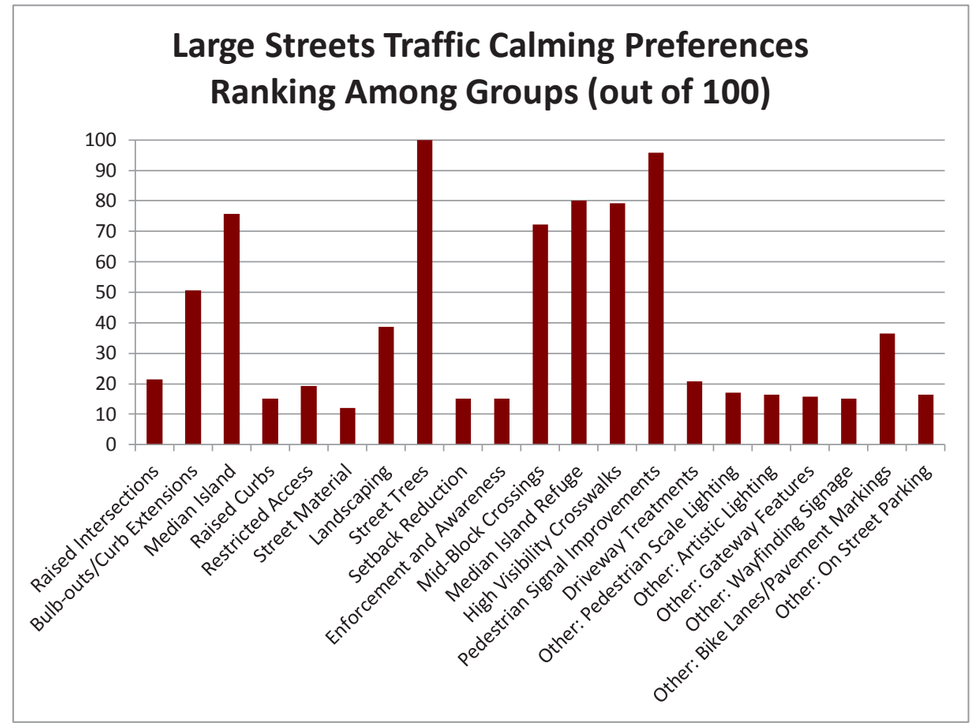
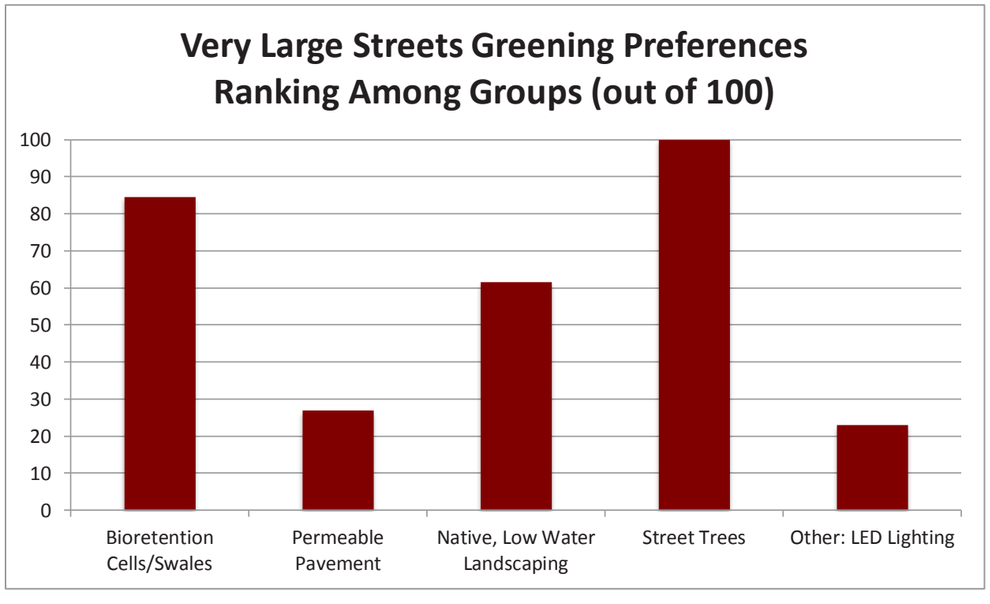


Figure 1. Traffic Calming and Greening Treatment Rankings for Large Streets





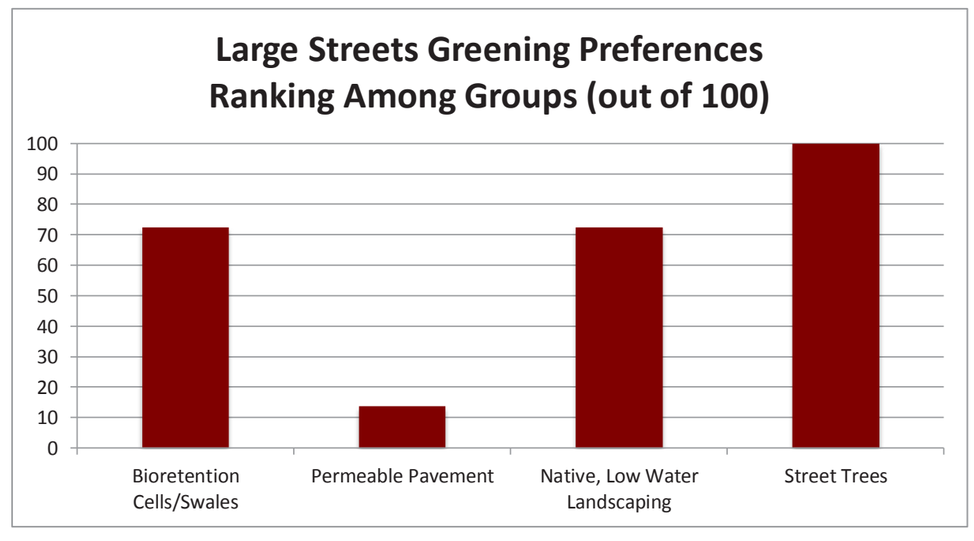


Figure 3. Traffic Calming and Greening Treatment Rankings for Medium Streets

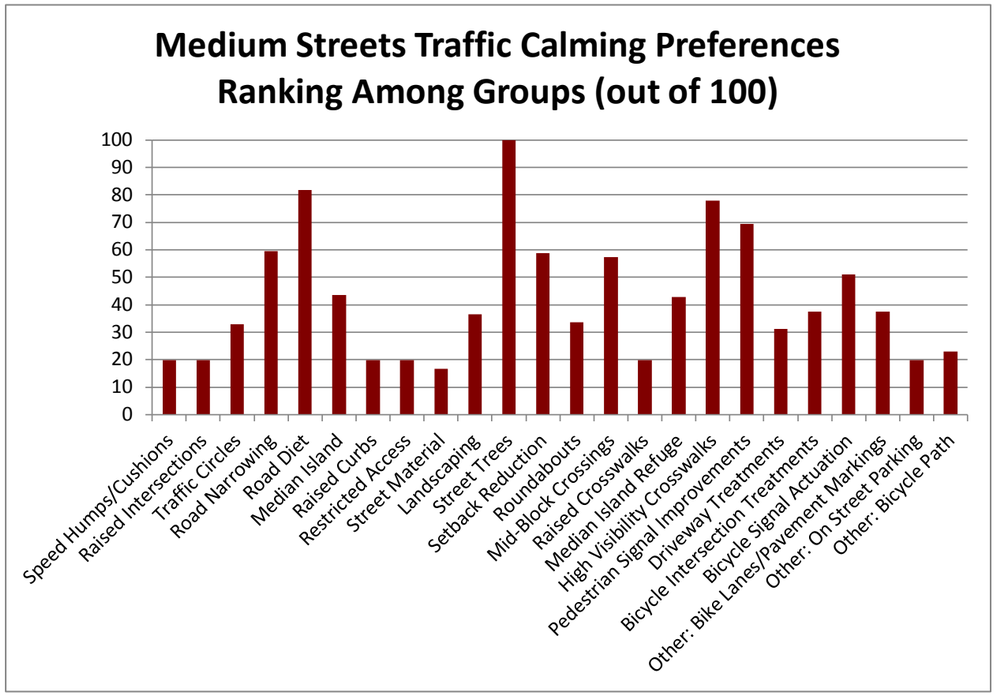
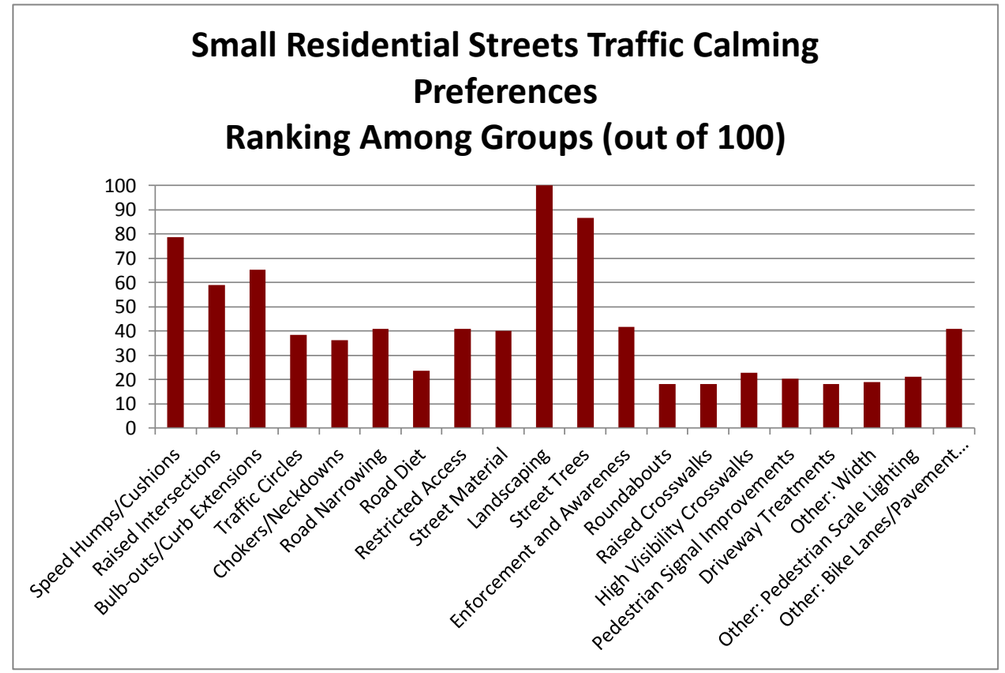
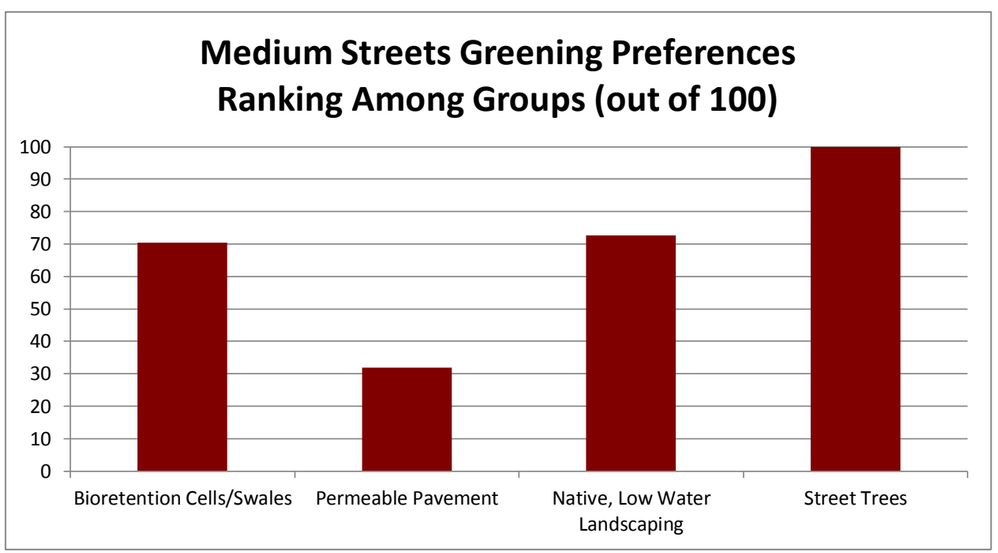


Figure 4. Traffic Calming and Greening Treatment Rankings for Small Residential Streets





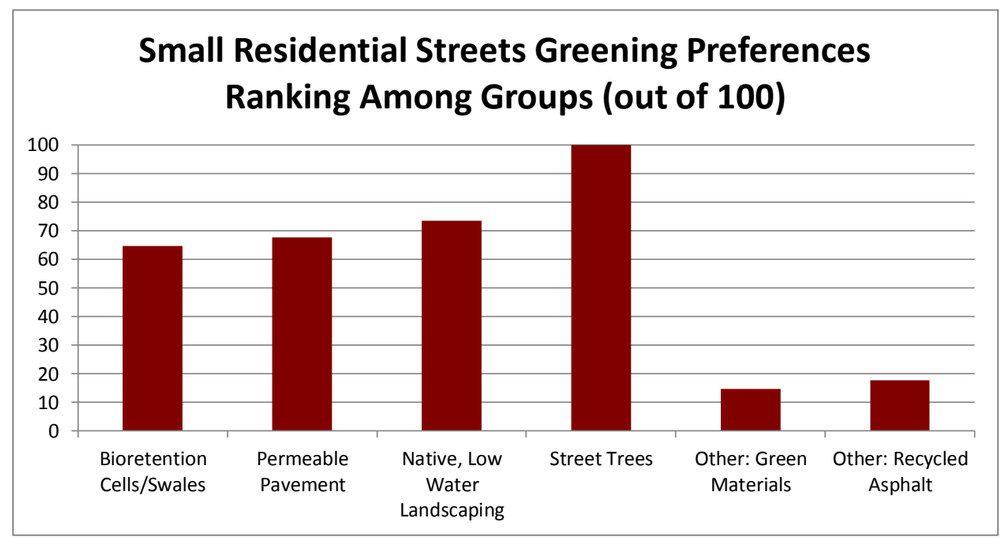


Figure 5. Traffic Calming and Greening Treatment Rankings for Small Commercial Streets

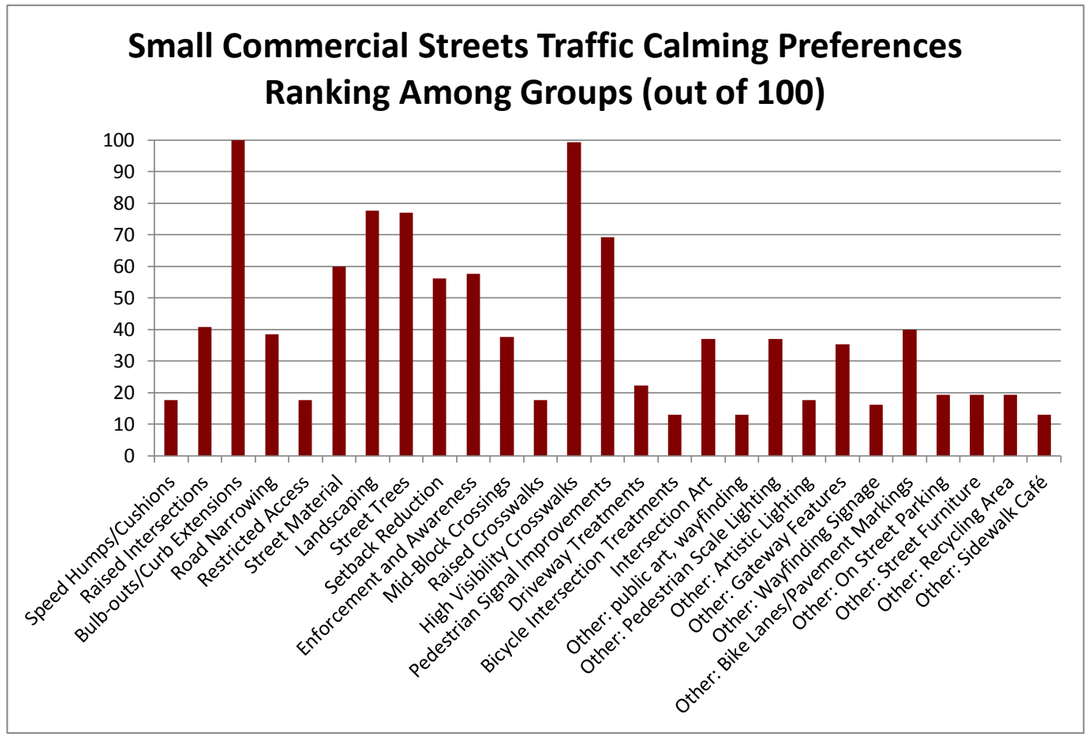
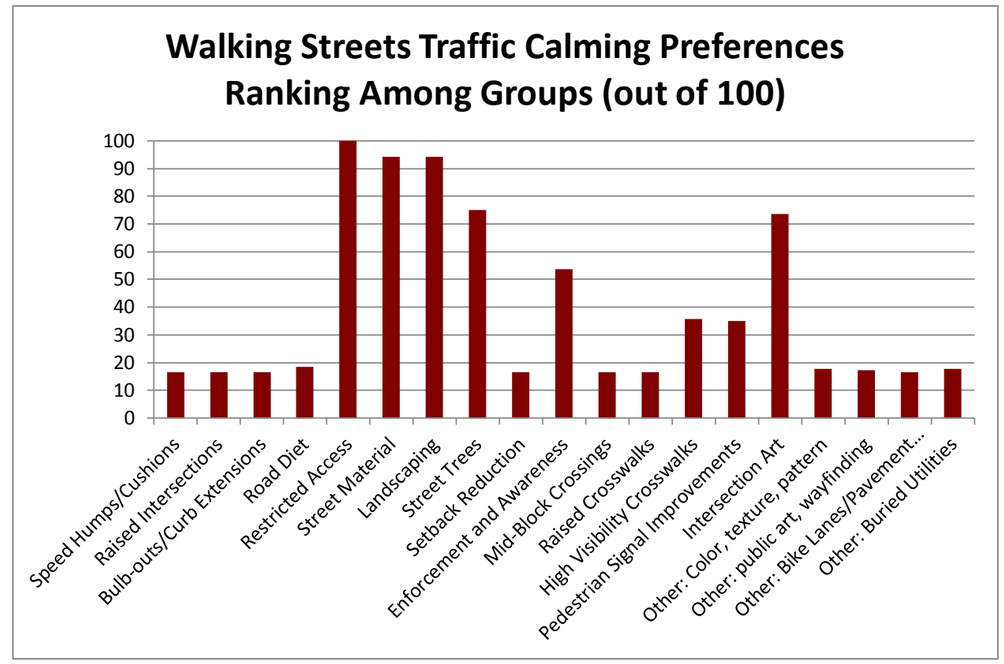
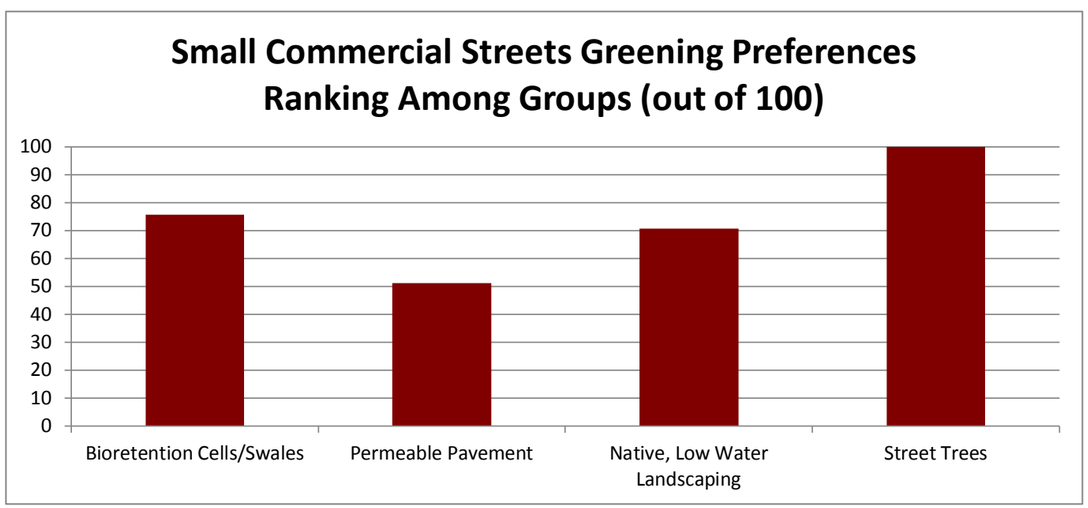
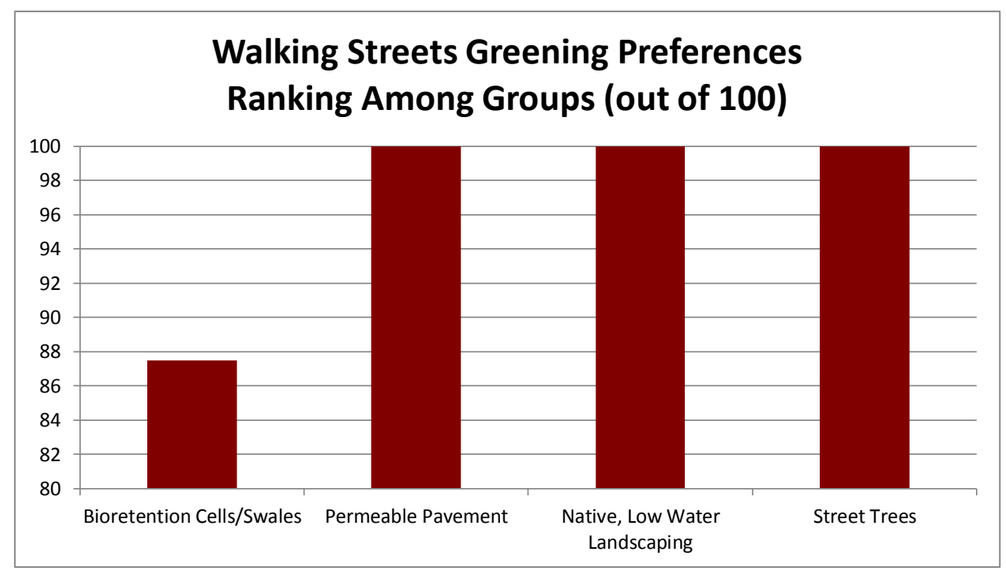


Figure 6. Traffic Calming and Greening Treatment Rankings for Walking Streets







4 Conclusion

The main ways that streets were categorized were by transportation function, land use connectivity, surrounding land use, and surrounding activity. Overall size of the street was not a major consideration among the groups. In general, more emphasis was placed on generating typologies for smaller streets with more localized functions such as those that serve neighborhoods.

The most popular traffic calming techniques across all categories were the addition of street trees and High Visibility Crosswalks. The addition of street trees was listed as the most popular street "greening" technique as well. The inclusion of bicycle lanes or roadway markings as a traffic calming technique was a popular treatment that was added by the groups to the consultant-generated list of treatments.

In general, participants expressed that the workshop was informative and helpful. They were attentive through the presentations, seen actively taking notes, and most were actively involved in the group breakout sessions. Overall it seemed to be well received based on the informal comments following the workshop. The comment was made by some that they would have liked to see representation from the City Engineering Department at the workshop.

The results include worthy ideas and show some notable trends that will be taken into consideration in the definition of Cleveland's street typologies and design guidelines. Defining the street typologies and the design guidelines will be led by the Task Force and the Alta team.

5 Attachment A: Workshop Attendance

- Craig Williams
- Jack Cebe
- Anna Swanberg
- Barb Clint
- Chris Bongorno
- Emily Guiliani
- Gayle Lewin
- Heather Boden
- Jacob Van Sickle
- Jenita McGowan
- Marc Von Allmen
- Maribeth Feke
- Marty Cader
- Matt Gray
- Matt Hils
- Matt Zone
- Nancy Lyon Stadler
- Perrin Verzi
- Ray Odom
- Richard Sicha
- Ryan Mackin
- Valerie Webb
- Victoria McCauley
- Wendy Albin Sattin
- Randy Lane
- Marc Lefkowitz
- Ethan Cameron

6 Attachment B: Worksheet Examples

1/23/2013 Cleveland Complete and Green Streets Workshop

Street Typology Name
(include street example in parenthesis)

Traffic Calming/Street Resizing/Intersection Improvement Technique (prioritize with 1 being the highest)

_ Speed Humps/Cushions	_ Street Material	_ Driveway Treatments
_ Raised Intersections	_ Landscaping	_ Bicycle Intersection Treatments
_ Chicanes	_ Street Trees	_ Bicycle Signal Actuation
_ Bulb-outs/Curb Extensions	_ Setback Reduction	_ Intersection Art
_ Traffic Circles	_ Enforcement and Awareness	_ _____
_ Chokers/Neckdowns	_ Roundabouts	_ _____
_ Road Narrowing	_ Mid-Block Crossings	_ _____
_ Road Diet	_ Raised Crosswalks	_ _____
_ Median Island	_ Median Island Refuge	_ _____
_ Raised Curbs	_ High Visibility Crosswalks	
_ Restricted Access	_ Pedestrian Signal Improvements	

Street Greening Technique (prioritize with 1 being the highest)

_ Bioretention Cells/Swales	_ Street Trees	_ _____
_ Permeable Pavement	_ _____	_ _____
_ Native, Low Water Landscaping	_ _____	_ _____

Traffic Calming Type Applicability (source MassDOT)

	Arterials	Major Collectors	Minor Collectors	Local Roads
Street Narrowing				
Narrow Lanes		Δ	■	■
Raised Curbs	■	■	■	■
Street Furniture	■	■	■	■
Street Trees	■	■	■	■
Street Lighting	■	■	■	■
Spot Narrowing	Δ	■	■	■
Medians and Crossing Islands	■	■	■	■
Curb Extensions	■	■	■	■
Road Diets	Δ	Δ	■	■
Building Siting	■	■	■	■
Horizontal Deflection				
Chicanes			■	■
Crossing Islands/Short Medians	■	■	■	■
Mid-Block Traffic Circles			Δ	■
Roundabouts	■	■	■	■
Lane Offsets		Δ	Δ	■
Profile Alterations				
Speed Humps		Δ	Δ	■
Raised Crosswalks		Δ	■	■
Raised Intersections		Δ	■	■
Textured Pavement	■	■	■	■
Traffic Management	Δ	Δ	Δ	Δ

■ Often used for new design or retrofit programs in traffic calming settings
Δ May be suitable

1/23/2013 Cleveland Complete and Green Streets Workshop

Street Typology Name
(include street example in parenthesis)

Key Purpose	Mode Priority		Typical Speed	Acceptable Auto Congestion	Importance of Street to Function as a		Context	Other Considerations
					Link	Place		
	Ped Bike Transit Goods Auto	H M L H M L H M L H M L H M L		H M L	H M L	H M L		

Typology Name Examples:

NACTO Typologies:
Very Large Streets
Large Streets
Medium Streets
Small Street
Very Small Streets
Alleys and Passageways
Pedestrians Streets
Shared Streets/Home Zones
Transit Streets
Intersections

Chicago Typologies:
Thoroughfare
City Connector
Neighborhood Connector
Lane
Alley
Pedestrian Way

Minneapolis Typologies:
Commuter Street
Commerce Street
Activity Area Street
Community Connector
Neighborhood Connector
Industrial Connector

Charlotte Typologies:
Main Streets
Avenues
Boulevards
Parkways
Local Streets

Brunswick Typologies:
Highway
Commercial Arterial
Drive
Destination Street
Commercial Avenue
Residential Avenue
Slow-Flow Street
Shared Use Path

7 Attachment C: Complete Workshop Results

Table 1: Typology Results by Group

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
1	Spinal Route	Chester	Through Movement w/ some commercial access	Low	Low	Medium	Medium	High	35	Low	High	Low	Light Industrial, Commercial, Institutional	
1	Neighborhood Connectors	W 130, W 150, Franklin, Riverside	Small scale spinal conneting neighborhoods	High	High	High	Low	Medium	35	Medium	Medium	Medium	Varies Based on Surrounding Land Uses	Biking Connectors, Access to Business
1	Street District	W 25th Detroit	Nodes of interest, Entertainment, Cultural Institutions	High	High	High	Low	High	25	High	Medium	high	Nodes of interest, Entertainment, Cultural Institutions	historic, cultural, aesthetics
1	Neighborhood Streets	any residential street	provide access for residents living on the street: recreational, local business, local connections, daily activity	High	High	Low	Low	Low	25	High	Low	High	Residential, light commercial, shared space	KIDS, fire truck, safety services
1	Destination	Market, E	Serves as a place,	High	High	High	Low	Low	0	High	Low	High	Serves as a place,	bike/ped linkages,

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
	Street	4th, Alleys	partying, churches, schools										partying, churches, schools	historic, cultural aesthetics
2	Runway	Chester, Clifton, Carnegie, 150th	Move Cars	Low	Low	High	Medium	High	35-40	Low	High	Low	Connection to highways and Employment Areas - Vary	Continuous Sidewalks, Ramps
2	Intersections	n/a	Connect Streets, Crossings	Medium	Medium	High	High	High		Low	High	Medium (Vary)	Vary	Turning Lane, Crosswalk, Crossing Time
2	Alleys	Johnston Court, Franfort, Bolivar	Deliverables, Ped Shortcuts, Trash Pickup	Medium	Medium	Low	High	Low	0-10	High	Low	Low	Highly Urban, Scary	Function, Mix w/trucks, delivery/travel
2	Sin Streets	E 4th, Coventry, Markey, W 25 @ Market	Entertainment	High	High	Low	Low	Low	0-20	High	Low	High	Fun, Stay Long, Safe	Parking, Crosswalks, Fun, Atmosphere
2	Neighborhood Connector/Center	Bridge, Madison, Buckeye	Local Traffic, Movement, Social Connection	High	High	Medium	Medium	Medium	25	High	Medium	High	Local Business, Gathering	Social Interation

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
2	Main Street	W 117, Prospect W. 25th, Cedar, E 79th	Commerce Through-put	Low	Low	High	Medium	Medium	25-35	Medium	Medium	Medium	Mixed-Use	Higher Density, Connection to Runways
2	Residential	Residential 2-lane residential	Home Destination	High	High	Low	Low	Medium	25 and less	High	Low	High	Housing Low-Med Density	Social, parks, Biking, Pedestrian
3	Commuter	Chester, Carnegie, Clifton	Commuting	Medium	High	High	high	high	25-40	Medium	High	Medium	Mixed but Move industrial	no longer small neighborhood scale, no stop signs, needs designate bike facility
3	Neighborhood Connector	Broadway, Lorain, Pearl	Moving to and Thru, Errands or commute	Medium	High	High	High	high	25-35	Medium	High	Medium	Mixed use, light industrial, medium density	No Semi's, landscaping and pedestrian oriented at key nodes

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
3	Main Street	W. 25th Street, Mayfield in Little Italy, Detroit by Garden Square	Traditional, Commercial Districts, Commuter Route	High	High	High	medium	Medium	25	High	Medium	High	Mixed-use, neighborhood services, schools, churches, institutions	Design amenities, Bike lanes, Ped crosszones, on-street parking
3	"Walk Your Car"	Market Street, N. End of E. 9th, Hessler	Could be residential Destination	High	High	Medium	Medium	medium	15	Low	Low	High	Residential, Entertainment District, Commercial retail	Would lend itself to bike bouldevard in residential
3	"Festival Street"	E. 4th Street, Times Square	Community garhering, small business, destination "place", vibrant flexible	High	Medium	Low	Medium	Low	0	Low	Low	High	Entertainment, Commercial/ residential small bus.	lighting, security, landscape, move business encroachment on ROW
4	Commercial Ave.	Carnegie, Chester, Superior, Detroit	moving vehicles, goods, connecting areas	Low	Low	Med/High	High	High	35	Med-Low	High	Low	Consider neighborhoods, it passes through especially in intersections.	Express busses, street trees, highway/freeway pedestrian crossings

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
4	Transit Street	Euclid Ave, Clifton	Transit Connectivity, Pedestrian and Cycle Accessibility, mode options + access to transit	High	High	High	medium	Medium-Low	35	High-medium	High	Medium-Low	TOD as place making	Transit Hubs and how they connect, wayfinding, transit waiting environment, lighting
4	Main Street	Mayfield (little italy), w.65/Detroit, w.25/bridge	shopping/retail/dining predestrian oriented, destination	High	High	High	Medium	Medium	25	High	Medium	High	Mixed-use district, dense urban scale	separated bicycle facilities, bike parking, transit and waiting environments, sidewalks and café seating, signage and lighting

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
4	Neighborhood Ave	Franklin Ave, Wade park Ave.	More of a link, but to be safe and calm	High	High	Medium	Low	Medium	25-3035	Medium	High	Low	Primarily Residential, but more through traffic	Consult Bikeway master plan for Bike Consideration. Street trees, tree lawns, bulb-outs
4	Neighborhood Connector	Most numbered residential streets	Very Local circulator, safe spaces for family, social interactions	High	High	Low	Low	Low	20	High	Medium	medium	Mostly residential, some small retail on corners	on street parking, traffic calming, street trees
4	Polka Street - Pedestrian Way	East 4th/Sometimes Market Ave	Place making, some commerce	High	Low	Low	Low	None	0	None	n/a	High	A destination, active, ground floor retail, plaza, recreation	Accommodate cyclists if street widths allows safety.
4	Parkways													
5	Boulevard	(Shaker Blvd.)		Medium	Medium	high	Medium	High	45-50	Low	High	Medium	Median-Landscaped	
5	Industrial Roadway	Bessemel	Heavy Industrial Use Trucks	Low	Low	Low	High	High	35	medium	Medium	High	Industry	Roadway Built For Trucks
5	Commuter Street	Chester, Clifton, Carnegie	Moving all Motorized Vehicles	Low	Low	High	High	High	35	Low	High	Low	Multiple Lanes, Wide Cartway, Roadway Lighting	Good Traffic Flow

Group	Street Typology Name	Cleveland Example	Key purpose	Ped Priority	Bike Priority	Transit Priority	Goods Priority	Auto priority	Typical Speed	Acceptable Congestion	Importance as a link	Importance as a place	Context	Other
5	Fun Street/Commercial Street	Lorain, Detroit Ave	Connections and Destination	medium	Medium	High	Medium	High	35	Medium	High	Medium	Mixed-use, commercial nodes, transit routes	bike lanes/sharrows, land-use
5	Neighborhood Connector	Franklin Blvd.	Neighborhood Connections	medium	High	Medium	Low	High	35	medium	High	Medium	On-street parking, responsible striping or roadway	sharrows/bike lanes
5	Neighborhood Residential Street	West Clinton	Get Home	High	High	Low	Low	Medium	25	Medium	Low	Medium	No Stiping, on-street parking, tree lawns, sidewalks	none
5	Activity Area Street	Market Ave.	Pedestrian Movement priority and destination	High	High	High	Low	Low	15	High	Low	High	Mixed-use retail, entertainment/activity	zoning, land-use, pro.zoning
5	Pedestrian Street	E. 4th Street, Uptown	Destination Place	High	Medium	n/a	n/a	n/a	10	n/a	Low	High	Retail, residential, mixed-use	zoning and land-use. Pedestrian Retail Overlay

Table 2: Traffic Calming and "Greening" Results by Group

	Group 1					Group 2						
Traffic Calming Technique	**Spinal Route**	**Neighborhood Connectors**	**Street District**	**Neighborhood Streets**	**Destination Street**	**Intersections**	**Alleys**	**Sin Streets**	**Residential**	**Neighborhood Connector/Center**	**Main Street**	**Runway**
Speed Humps/Cushions	0	0	0	6	0	0	0	8	8	0	0	0
Raised Intersections	0	0	1	0	0	0	0	8	8	0	0	0
Chicanes	0	0	0	0	0	0	0	0	8	0	0	0
Bulb-outs/Curb Extensions	0	0	4	5	0	0	0	8	0	9	0	0
Traffic Circles	0	7	0	0	0	0	0	0	8	0	0	0
Chokers/Neckdowns	0	0	0	0	0	0	0	0	8	0	0	0
Road Narrowing	0	1	0	0	0	0	0	0	8	9	0	0
Road Diet	0	2	0	0	0	0	0	0	0	9	1	0
Median Island	1	3	0	0	0	0	0	0	0	0	2	2
Raised Curbs	0	0	0	0	0	0	0	0	0	0	0	0
Restricted Access	0	0	0	2	1	0	4	8	8	0	0	0
Street Material	0	0	0	0	4	0	0	8	0	9	0	0
Landscaping	0	0	0	4	3	5	0	8	8	9	0	0
Street Trees	0	0	0	3	0	5	0	8	8	9	2	0
Setback Reduction	0	0	0	0	0	0	0	8	0	9	0	0
Enforcement and Awareness	0	0	0	1	0	0	0	8	0	0	0	0
Roundabouts	0	6	0	0	0	0	0	0	8	0	0	0
Mid-Block Crossings	0	0	5	0	0	0	0	8	0	9	5	0
Raised Crosswalks	0	0	0	0	0	0	0	8	8	0	0	0
Median Island Refuge	2	0	0	0	0	0	0	0	0	0	3	1
High Visibility Crosswalks	3	0	3	0	0	0	0	8	0	9	0	3
Pedestrian Signal Improvements	4	0	6	0	5	5	0	8	0	9	4	4
Driveway Treatments	0	0	2	0	0	0	0	0	8	9	0	0
Bicycle Intersection Treatments	5	4	0	0	0	5	0	0	0	9	0	5

	Group 1					Group 2						
Traffic Calming Technique	**Spinal Route**	**Neighborhood Connectors**	**Street District**	**Neighborhood Streets**	**Destination Street**	**Intersections**	**Alleys**	**Sin Streets**	**Residential**	**Neighborhood Connector/Center**	**Main Street**	**Runway**
Bicycle Signal Actuation	6	5	0	0	0	5	0	0	0	9	0	6
Intersection Art	0	0	0	0	2	5	0	8	0	0	0	0
Other: Width	0	0	0	7	0	0	0	0	0	0	0	0
Other: Color, texture, pattern	0	0	0	0	6	0	0	0	0	0	0	0
Other: public art, wayfinding	0	0	0	0	7	0	0	0	0	0	0	0
Other: Pedestrian Scale Lighting	0	0	7	0	0	5	4	0	0	0	0	0
Other: Artistic Lighting	0	0	8	0	0	0	0	0	0	0	0	0
Other: Gateway Features	0	0	9	0	0	0	0	0	0	0	0	0
Other: Wayfinding Signage	0	0	10	0	0	0	0	0	0	0	0	0
Other: Bike Lanes/Pavement Markings	7	0	0	0	0	0	0	8	8	9	6	0
Other: Crosswalks	0	0	0	0	0	5	0	0	0	0	0	0
Other: Buried Utilities	0	0	0	0	0	5	0	0	0	0	0	0
Other: Awareness Signage	0	0	0	0	0	0	4	0	0	0	0	0
Other: On Street Parking	0	0	0	0	0	0	0	0	0	0	0	0
Other: Street Furniture	0	0	0	0	0	0	0	0	0	0	0	0
Other: Recycling Area	0	0	0	0	0	0	0	0	0	0	0	0
Other: Sidewalk Café	0	0	0	0	0	0	0	0	0	0	0	0
Other: Bicycle Path	0	0	0	0	0	0	0	0	0	0	0	0
Greening												
Bioretention Cells/Swales	2	1	3	4	0	0	3	0	1	0	1	1
Permeable Pavement	0	0	2	3	0	4	2	1	2	1	1	0
Native, Low Water Landscaping	3	0	1	0	0	5	0	0	3	2	2	2
Street Trees	4	0	4	5	0	0	1	0	4	3	3	3
Other: Green Materials	0	0	0	1	0	0	0	0	0	0	0	0

	Group 1					Group 2						
Traffic Calming Technique	**Spinal Route**	**Neighborhood Connectors**	**Street District**	**Neighborhood Streets**	**Destination Street**	**Intersections**	**Alleys**	**Sin Streets**	**Residential**	**Neighborhood Connector/Center**	**Main Street**	**Runway**
Other: Recycled Asphalt	0	0	0	2	0	0	0	0	0	0	0	0
Other: Green Wall	0	0	0	0	0	3	0	0	0	0	0	0
Other: Grey Water Reuse	0	0	0	0	0	2	0	0	0	0	0	0
Other: Fountains	0	0	0	0	0	1	0	0	0	0	0	0
Other: LED Lighting	1	0	0	0	0	0	0	0	0	0	0	0

	Group 3					Group 4						
Traffic Calming Technique	**Commuter**	**Neighborhood Connector**	**Main Street/Transit Street**	**Walk Your Car**	**Festival Streets**	**Neighborhood Connector**	**Neighborhood Ave**	**Polka Street**	**Parkways**	**Main Street**	**Commercial Ave.**	**Transit Street**
Speed Humps/Cushions	0	0	0	0	0	5	0	0	0	0	0	0
Raised Intersections	0	0	0	5	0	5	5	0	0	0	0	0
Chicanes	0	0	0	7	0	5	0	0	0	0	0	0
Bulb-outs/Curb Extensions	0	0	1	0	0	2	12	0	5	6	8	10
Traffic Circles	0	0	0	0	0	5	12	0	0	0	0	0
Chokers/Neckdowns	0	0	0	0	0	8	0	0	0	0	0	0
Road Narrowing	0	0	0	2	0	0	5	0	0	6	0	0
Road Diet	0	1	0	1	0	0	0	0	11	0	8	0
Median Island	0	0	0	0	0	0	0	0	11	0	4	10
Raised Curbs	0	0	0	0	0	0	5	0	0	0	0	10
Restricted Access	0	0	0	0	1	0	0	4	5	0	0	4
Street Material	0	0	0	3	4	8	0	4	0	6	0	14
Landscaping	0	0	7	6	3	5	5	4	5	6	4	4
Street Trees	4	5	4	0	5	2	5	4	5	6	4	4
Setback Reduction	0	2	0	0	0	0	0	0	0	6	0	10
Enforcement and Awareness	0	0	7	8	2	0	0	8	11	0	0	10
Roundabouts	0	0	0	0	0	0	12	0	0	0	0	0
Mid-Block Crossings	0	4	0	0	0	0	0	0	5	0	0	10
Raised Crosswalks	0	0	0	0	0	0	5	0	0	0	0	0
Median Island Refuge	1	3	0	0	0	0	0	0	5	0	4	4
High Visibility Crosswalks	2	6	3	0	0	0	5	4	5	6	4	4
Pedestrian Signal Improvements	3	7	0	0	0	0	12	0	11	14	4	4
Driveway Treatments	0	0	0	0	0	0	12	0	0	0	0	0
Bicycle Intersection Treatments	0	0	0	0	0	0	0	0	0	14	0	0

	Group 3					Group 4						
Traffic Calming Technique	**Commuter**	**Neighborhood Connector**	**Main Street/Transit Street**	**Walk Your Car**	**Festival Streets**	**Neighborhood Connector**	**Neighborhood Ave**	**Polka Street**	**Parkways**	**Main Street**	**Commercial Ave.**	**Transit Street**
Bicycle Signal Actuation	0	0	0	0	0	0	12	0	11	0	0	0
Intersection Art	0	0	0	0	7	0	0	4	0	6	0	0
Other: Width	0	0	0	0	0	0	0	0	0	0	0	0
Other: Color, texture, pattern	0	0	0	0	0	0	0	0	0	0	0	0
Other: public art, wayfinding	0	0	0	0	0	0	0	0	0	14	0	0
Other: Pedestrian Scale Lighting	0	0	7	4	0	0	0	0	0	0	0	0
Other: Artistic Lighting	0	0	0	0	0	0	0	0	0	0	0	0
Other: Gateway Features	0	0	7	0	0	0	0	0	0	0	0	0
Other: Wayfinding Signage	0	0	0	0	0	0	0	0	0	0	0	0
Other: Bike Lanes/Pavement Markings	5	4	2	0	0	2	0	0	5	0	0	0
Other: Crosswalks	0	0	0	0	0	0	0	0	0	0	0	0
Other: Buried Utilities	0	0	0	0	6	0	0	0	0	0	0	0
Other: Awareness Signage	0	0	0	0	0	0	0	0	0	0	0	0
Other: On Street Parking	0	0	0	0	0	0	5	0	0	6	8	0
Other: Street Furniture	0	0	0	0	0	0	0	0	0	6	0	0
Other: Recycling Area	0	0	0	0	0	0	0	0	0	6	0	0
Other: Sidewalk Café	0	0	0	0	0	0	0	0	0	14	0	0
Other: Bicycle Path	0	0	0	0	0	0	0	0	0	0	0	0
Greening												
Bioretention Cells/Swales	0	0	0	0	0	0	0	0	0	0	0	0
Permeable Pavement	1	0	0	2	2	2	1	1	0	1	1	1
Native, Low Water Landscaping	0	0	0	0	0	4	2	1	1	1	0	0
Street Trees	0	1	1	0	3	3	2	2	1	2	1	1
Other: Green Materials	2	2	2	1	1	1	0	2	1	2	1	1

	Group 3					Group 4						
Traffic Calming Technique	**Commuter**	**Neighborhood Connector**	**Main Street/Transit Street**	**Walk Your Car**	**Festival Streets**	**Neighborhood Connector**	**Neighborhood Ave**	**Polka Street**	**Parkways**	**Main Street**	**Commercial Ave.**	**Transit Street**
Other: Recycled Asphalt	0	0	0	0	0	0	0	0	0	0	0	0
Other: Green Wall	0	0	0	0	0	0	0	0	1	0	0	0
Other: Grey Water Reuse	0	0	0	0	0	0	0	0	0	0	0	0
Other: Fountains	0	0	0	0	0	0	0	0	0	0	0	0
Other: LED Lighting	0	0	0	0	0	0	0	0	0	0	0	0

	Group 5							
Traffic Calming Technique	**Pedestrian Street**	**Activity Area Street**	**Neighborhood Residential Street**	**Neighborhood Connector**	**Fun/Commercial St**	**Commuter Street**	**Boulevard**	**Industrial Roadway**
Speed Humps/Cushions	0	0	5	5	0	0	0	0
Raised Intersections	0	0	0	0	0	0	0	0
Chicanes	0	0	0	0	0	0	0	0
Bulb-outs/Curb Extensions	0	6	3	5	0	0	0	0
Traffic Circles	0	0	0	0	0	0	0	0
Chokers/Neckdowns	0	0	0	0	0	0	0	0
Road Narrowing	0	6	0	0	5	0	0	0
Road Diet	5	0	0	5	0	0	0	0
Median Island	0	0	0	0	0	2	2	0
Raised Curbs	0	0	0	0	0	0	0	0
Restricted Access	1	0	0	5	0	0	0	0
Street Material	3	1	0	0	0	0	0	0
Landscaping	5	2	5	0	4	0	0	0
Street Trees	2	6	1	1	7	1	4	0
Setback Reduction	0	6	0	5	0	0	0	0
Enforcement and Awareness	0	3	0	0	0	0	0	0
Roundabouts	0	0	0	0	0	0	0	0
Mid-Block Crossings	0	0	0	0	0	3	5	0
Raised Crosswalks	0	0	0	0	0	0	0	0
Median Island Refuge	0	0	0	0	0	0	3	0
High Visibility Crosswalks	0	6	2	2	2	0	0	0
Pedestrian Signal Improvements	0	6	5	5	3	0	0	0
Driveway Treatments	0	0	0	0	0	0	0	0
Bicycle Intersection Treatments	0	0	0	0	0	0	0	0

	Group 5							
Traffic Calming Technique	**Pedestrian Street**	**Activity Area Street**	**Neighborhood Residential Street**	**Neighborhood Connector**	**Fun/Commercial St**	**Commuter Street**	**Boulevard**	**Industrial Roadway**
Bicycle Signal Actuation	0	0	0	0	0	0	0	0
Intersection Art	0	0	0	0	7	0	0	0
Other: Width	0	0	0	0	0	0	0	0
Other: Color, texture, pattern	0	0	0	0	0	0	0	0
Other: public art, wayfinding	0	0	0	0	0	0	0	0
Other: Pedestrian Scale Lighting	0	0	0	0	0	0	0	0
Other: Artistic Lighting	0	0	0	0	0	0	0	0
Other: Gateway Features	0	0	0	0	0	0	0	0
Other: Wayfinding Signage	0	0	0	0	0	0	0	0
Other: Bike Lanes/Pavement Markings	0	0	0	0	1	0	0	0
Other: Crosswalks	0	0	0	0	0	0	0	0
Other: Buried Utilities	0	0	0	0	0	0	0	0
Other: Awareness Signage	0	0	0	0	0	0	0	0
Other: On Street Parking	0	0	0	0	0	0	0	0
Other: Street Furniture	0	0	0	0	0	0	0	0
Other: Recycling Area	0	0	0	0	0	0	0	0
Other: Sidewalk Café	0	0	0	0	0	0	0	0
Other: Bicycle Path	0	0	0	0	0	0	1	0
Greening								
Bioretention Cells/Swales	0	0	0	0	0	0	0	0
Permeable Pavement	1	0	0	0	0	0	1	2
Native, Low Water Landscaping	0	2	1	0	0	0	0	0
Street Trees	2	0	1	0	1	1	0	0
Other: Green Materials	2	1	1	1	2	2	2	1

	Group 5							
Traffic Calming Technique	**Pedestrian Street**	**Activity Area Street**	**Neighborhood Residential Street**	**Neighborhood Connector**	**Fun/Commercial St**	**Commuter Street**	**Boulevard**	**Industrial Roadway**
Other: Recycled Asphalt	0	0	0	0	0	0	0	0
Other: Green Wall	0	0	0	0	0	0	0	0
Other: Grey Water Reuse	0	0	0	0	0	0	0	0
Other: Fountains	0	0	0	0	0	0	0	0
Other: LED Lighting	0	0	0	0	0	0	0	0

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Appendix B

Roadways Used to Generate Cleveland Typologies

This table shows Complete and Green Streets roadway typologies for the City of Cleveland. Typologies were generated based on peer examples of Complete Streets typologies, the consideration of multiple roadway characteristics and input received during the Cleveland Complete and Green Streets roadway typology workshop. The streets listed in the table were identified by workshop participants as archetypal Cleveland roadways.

Roadways are organized into two major categories:

1. Streets are primarily classified according to pavement width. The reason this categorization method was chosen is because the curb-to-curb width of the street will often be the major restricting characteristic in determining what Complete Streets retrofits can be made to a corridor. On occasion, it may be determined that curb width reduction or expansion may be the best solution for achieving the complete street goals of a roadway. However, a complete re-engineering of the roadway can be costly and time consuming. It is likely that the majority of Complete Street retrofits will take place within the corridor's existing pavement width and right-of-way. The pavement width categories were determined by grouping roadways by common number of motor vehicle lanes. Very Large Streets typically have six or more lanes, Large Streets typically have four to five lanes, Medium Streets have two to three lanes and Small Streets have two or less.
2. Within the primary roadway categories, streets were classified based on primary roadway function. These categories were derived from feedback received during the Cleveland Complete and Green Streets roadway typology workshop. Roadway function may be transportation mode, connectivity or land-use based (or a combination of multiple characteristics).

Roadway Name	Typical Pavement Width (ft)	ROW (ft)	Connectivity Function	Land Use (Primary/ Secondary)	Motor Vehicle Lanes	Parking	Speed Limit	ADT	Truck ADT	Transit	Notes
Very Large Streets > 70 ft. Pavement Width											
Commuter Street											
Clifton Blvd.	74	125	High/Regional	Residential	7	No	35	15330	190	Bus	
Carnegie Ave. (west of E 55th)	72	100	Medium/Crosstown Connection	Commercial	7	No	35	unk.	unk.	None	
Chester Ave. (E 55th to E 105th)	70	120	High/Crosstown Connection	Commercial /Residential	6 (separated)	No	35	25540	1410	Bus (near downtown)	
Commercial Street											
Superior Ave. (west of E 55th)	76	128	High/Crosstown Collection	Commercial /Residential	6	No	35	10756	665	BRT	
E 9th St[1]	71-56	100	Medium	Commercial	6-2	Yes	35	unk.	unk.	Bus	Near-term Capital Improvement Project: E 9 Resurfacing

[1] 9th St. through downtown Cleveland is a unique roadway example in that it is a very wide, high capacity roadway that also serves as an important pedestrian corridor. It drops down to 2 lanes at the lakefront where it becomes a pedestrian-oriented parking zone.

Roadway Name	Typical Pavement Width (ft)	ROW (ft)	Connectivity Function	Land Use (Primary/ Secondary)	Motor Vehicle Lanes	Parking	Speed Limit	ADT	Truck ADT	Transit	Notes
Large Streets 69-48 ft. Pavement Width											
Commercial Street											
Carnegie Ave. (east of E 55th)	56	100	Medium/Crosstown Connection	Commercial	5	No	35	unk.	unk.	None	
Prospect Ave.	54	80	Medium/Feeder	Commercial	4	Yes	35	unk	unk	Bus	
Detroit Ave.	48	66	High/Crosstown Collection	Commercial /Residential	4-2	Yes	35	9897	342	Bus	
Broadway Ave.	48	60-70	High/Regional	Commercial /Residential	4	No	35	unk.	unk.	Bus	
Lorain Ave.	48	66	High/Regional	Commercial/Residential	4	Yes	35	unk.	unk.	Bus	
W 25th St. (Lorain Ave. to Detroit Ave.)	65	100	High/Feeder	Commercial /Residential	6	Yes	25	unk.	unk.	Bus	Parking in outside lane
Neighborhood Street											
W 117th St (south of Hwy 90)	59	80	High/Crosstown Collection	Residential/Commercial	5	No	35	unk.	unk.	Bus	
Pearl Rd. (Between I 71 and I 480)	56-44	100-66	High/Regional	Residential/Commercial	5-2	No	25	10122	394	Bus	
Cedar Ave.[2]	44	66	High/Crosstown Collection	Commercial /Residential	4	No	35	6942	unk.	Bus	
Industrial Street											
W 150th St. (North of Puritas)	60	75	Medium/Feeder	Commercial	5	No	35	unk	unk	None	

[2] While less than 48 feet, Cedar Ave. more closely fits the Medium Streets designation due to having 4 lanes and a high level of connectivity.

Roadway Name	Typical Pavement Width (ft)	ROW (ft)	Connectivity Function	Land Use (Primary/ Secondary)	Motor Vehicle Lanes	Parking	Speed Limit	ADT	Truck ADT	Transit	Notes
St. Clair Ave. (Between 13th St. and Hwy 90)	60	100	High/Regional	Industrial/Commercial	4	Yes	35	unk.	unk.	Bus	
Payne Ave (Between 13th St. and Hwy 90)	58	85	Medium	Industrial/Commercial	4	Yes	35	unk.	unk.	Bus	
Ridge Rd. (north of Hwy 71)	52	85	High/Regional	Industrial/Commercial	4	No	35	unk.	unk.	Bus	
18th St. (north of Payne Ave.)	48	70	Medium	Industrial/Commercial	2	Yes	35	unk.	unk.	None	
Broadway Ave. (Between Hwy 77 and Hwy 90)	48	90	High/Regional	Industrial	4	No	35	6510	400	Bus	
Medium Streets 48-30 ft. Pavement Width											
Neighborhood Street											
Madison Ave.	40	66	Medium/Feeder	Residential/Commercial	2	Yes	35	8177	unk.	Bus (Western)	
Schaaf Rd. (Van Epps Rd. to Broadview Rd.)	40	75	Medium	Residential	2	Yes	35	unk.	unk.	None	
W 130th St. (north of Leeila Ave.)	40	60	Medium/Feeder	Residential	2	No	35	unk.	unk.	Bus (southern segments)	
West Blvd	40	130	Medium	Residential	2	Yes	35	unk.	unk.	Bus	(Interesting example small roadway, huge ROW)
Riverside Dr.	38	55-66	High/Feeder	Residential.	2	No	35	6750	120	Bus (some segments)	

Roadway Name	Typical Pavement Width (ft)	ROW (ft)	Connectivity Function	Land Use (Primary/ Secondary)	Motor Vehicle Lanes	Parking	Speed Limit	ADT	Truck ADT	Transit	Notes
Bridge Ave.	35	66	Medium/Feeder	Residential	2	Yes	25	unk.	unk.	None	
Franklin Blvd.	31	66	Medium/Feeder	Residential	2	Yes	35	unk.	unk.	None	
E 79th St.	30	50-60	High/Crosstown Collection	Residential	2 (4 in segments)	Yes	35	unk.	unk.	Bus	
Commercial Street/Pedestrian Shopping Street											
Wade Park Ave	40	68	Medium	Residential	2	Yes	25	unk.	unk.	Bus	Near-term Civic Improvement Project
E 185th (North Extents to S Watreloo Rd)	40	58	Medium/Feeder	Commercial	2	Yes	25	unk.	unk.	Bus	
Mayfield Rd. (in Little Italy)	32	60	High/Regional	Commercial	2	Yes	35	15730	400	Bus	
Industrial Street											
Bessemer Ave.	40	72	Medium	Industrial/Access	2	No	25	unk.	unk.	Bus	
Lakeside Ave (east of 13th St.)	40	66	Low	Industrial/Commercial	2	Yes	35	unk.	unk.	None	
Independence Rd.	40	61	Medium	Industrial/Residential	2	No	25	unk.	unk.	None	
Ivanhoe (Euclid to E 152)	40	58	Medium	Commercial/Industrial	4	No	35	unk.	unk.	None	Near-term Civic Improvement Project: New Curbs, sidewalks and street surface
Scranton Rd. (north of Train Ave.)	36	61	Medium	Industrial/Residential	2	Yes	25	unk.	unk.	None	
Train Ave.	30	61	Medium	Industrial/Residential	2	No	35	unk.	unk.	None	

Roadway Name	Typical Pavement Width (ft)	ROW (ft)	Connectivity Function	Land Use (Primary/ Secondary)	Motor Vehicle Lanes	Parking	Speed Limit	ADT	Truck ADT	Transit	Notes
Small Streets < 30 ft. Pavement Width											
Neighborhood Street											
E 75th	28	60	Low	Residential	1	Yes	25	unk.	unk.	None	
E 64th St.	28	44	Low	Residential	1	Yes	25	unk.	unk.	None	1 lane 2 way traffic
Lawnview Ave.	26	50	Low	Residential	1	Yes	25	unk.	unk.	None	1 lane 2 way traffic
E 65th St.	26	48	Medium	Residential	1	Yes	25	unk.	unk.	None (Bus in some segments)	1 lane 2 way traffic
E 74th St	26	40	Medium	Residential	1	Yes	25	unk.	unk.	None	
W 61st St.	22	55	Low	Residential	1	Yes	25	unk.	unk.	None	
Numbered Residential Streets	22-20	50-30	Low	Residential	2	Typically	25	unk.	unk.	None	one way
Hessler Rd.	20	36	Low	Residential	1	Yes	25	unk.	unk.	None	
Ellen Ave	20	30	Low	Residential	1	Yes	25	unk.	unk.	None	
Commercial Street/Pedestrian Shopping Street											
Market Ave.	28	66	Low	Commercial	1	Yes	n/a	unk.	unk.	None	One lane, one way, cobblestone
E 4th St.	20	40	Low	Commercial	1/none	Loading	none	unk.	unk.	None	
Variable Width Typologies/Overlays											
Alleyways/Access Streets											
Bolivar Rd.	35	66	Low	Access	2	Yes	25	unk.	unk.	None	Access/Alley
Frankfort Ave.	20	40	Low	Commercial /Access	1	Loading	25	unk.	unk.	None	Alley/Access

Roadway Name	Typical Pavement Width (ft)	ROW (ft)	Connectivity Function	Land Use (Primary/ Secondary)	Motor Vehicle Lanes	Parking	Speed Limit	ADT	Truck ADT	Transit	Notes
Johnson Ct.	20	33	Low	Access	1	Yes	25	unk.	unk.	None	Alley/Access
Transit Spine Overlay - These are roadways that have been identified as future express bus or Bus Rapid Transit corridors by the Cleveland Regional Transit Authority. However, Transit Spine Overlay treatments may be warranted on Medium to Very Large streets that serve a significant transit function and have excess vehicular capacity. Warrants for the Transit Spine Overlay typology will be discussed in the Cleveland Complete and Green Streets Design Guide. Roadway priorities should be given to transit users, pedestrians and bicyclists.											
Broadway Ave. (Between Hwy 77 and Hwy 90)	48	90	High/Regional	Industrial	4	No	35	6510	400	Bus	
Detroit Ave.	48	66	High/Crosstown Collection	Commercial /Residential	4-2	Yes	35	9897	342	Bus	
Priority Bikeway Overlay - While all typologies include accommodations for bicyclists, the Priority Bikeway Overlay uses additional treatments that give roadway priority to bicycle users. These treatments are intended to improve safety, comfort and convenience for bicyclists and encourage them to utilize these routes as much as possible for trips. The Priority Bikeway Overlay is applied to corridors that are identified in the Cleveland Bikeway Master Plan. Additionally, the Priority Bikeway Overlay will be applied to roadways that meet the warrants described in the future Cleveland Complete and Green Streets Design Guide.											
Pearl Rd. (Between I 71 and I 480)	56-44	100-66	High/Regional	Residential/Commercial	5-2	No	25	10122	394	Bus	
Clifton Blvd.	74	125	High/Regional	Residential	7	No	35	15330	190	Bus	

Appendix L:

Climate Resilient Street Sections

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TIP: When going outdoors, don't forget to apply sunblock to reduce your risk of sun-related illnesses!

TIP: If cycling on a day of high heat, be sure to wear light-colored clothing and keep a bottle of water on you at all times! Additionally, if possible, ride along shaded streets and pathways!

TIP: When possible, walk on the shady side of the street to reduce exposure to direct sun!

TIP: Always stay well-hydrated on days of high heat to prevent dehydration and heat exhaustion!

STOREFRONT AWNINGS

Awnings provide shade for sidewalks and storefronts, saving energy on interior cooling and creating a refuge from the heat of the sun and heavy precipitation. Awnings can also add a welcoming, human-scale element to larger commercial buildings.

PERMEABLE SIDEWALKS

Paving sidewalks with coarse brick, small concrete block, or pourous concrete can reduce the heat that is soaked in by conventional concrete sidewalks, while allowing rainwater and other runoff to seep into the ground below rather than overburdening storm sewers.

ENHANCED BUS SHELTERS

To make transit waiting a more hospitable experience on days of high heat, glass can be tinted to reduce heat absorption Openings in the shelter enclosure should be oriented toward the north or on the face adjacent to a taller building to allow breeze and access while not letting direct sunlight pass through.

TRANSIT WAITING TECH

Digital screens that show upcoming bus arrival times are useful to allow riders to make informed decision as to whether waiting out in the elements or somewhere indoors is worth doing. Additionally, these boards can display the current outdoor temperature along with weather bulletins and alerts to keep riders alert and safe.

PERMEABLE STREETS

To reduce stormwater runoff, urban heat island effect, and groundwater pollution, permeable pavers such as brick, block, or pourous concrete can be used to pave streets. Materials should be chosen based on a road's traffic volume and the material's weight and wear capacity commensurate to that volume.

SWALE MEDIANS

On particularly wide thoroughfares, space can be used in the road's center for a swale median. These can soak up a lot of the road's water runoff, provide a place for air-cleansing plants to grow, and even a place where shade trees can be planted to further reduce the heat given off by streets. They also provide refuge for crossing pedestrians.

COOL PAVEMENTS

Where permeable pavers are less practical, a different spin on conventional road materials can be utilized. Using a white or similarly light-colored concrete or asphalt mixture instead of the conventional grey, for example, reflects much more heat from ground-level. Additionally, existing pavement can simply be painted a lighter color to similar [but less permanent] effect.

SHADE TREES

A continuous line of shade trees planted along sidewalks and roads can significantly reduce ground-level heat and create a much more pleasant pedestrian experience, while encouraging people to walk longer distances on higher heat days.

WATER STATIONS

Along major pedestrian routes, public water stations can be implemented to allow pedsetrians and cyclists to stay well-hydrated on hotter days. These stations can also have permanent signs and take-home brochures that provide information on actions one should take during times of extreme heat, both while outdoors and when at home.

SIDEWALK PAVING
Paving sidewalks with coarser materials, like coarse brick or concrete block, can reduce slippage when sidewalks are wet or icy. Additionally, providing sidewalks with proper foundations to keep them level (with a slight tilt toward the road) can prevent water pooling which can turn to dangerous ice patches.

ENHANCED BUS SHELTERS
To make transit waiting a more hospitable experience on days of high heat, glass can be tinted to reduce heat absorption Openings in the shelter enclosure should be oriented toward the north or on the face adjacent to a taller building to allow breeze and access while not letting direct sunlight pass through.

TRANSIT WAITING TECH
Digital screens that show upcoming bus arrival times are useful to allow riders to make informed decision as to whether waiting out in the elements or somewhere indoors is worth doing. Additionally, these boards can display the current outdoor temperature along with weather bulletins and alerts to keep riders alert and safe.

SWALE MEDIANS
On particularly wide thoroughfares, space can be used in the road's center for a swale median. Snow melt and other precipitation can then collect here rather than in the roads, thus when freezing cold comes, the ice remains principally in the swale and not on the road itself. Plowed snow can also be piled here rather than on the sidewalks.

STREET TREES
A continuous line of trees planted along sidewalks and roads can diffuse frigid winds blowing across the landscape in times of extreme cold. This can protect pedestrians and buildings from the agressive cold.

SIDEWALK CLEARANCE
Business and property owners should be held accountable for clearing snow and ice from the public sidewalks adjacent to their property. On major roads running through areas of high pedestrian activity, local agencies may be created or utilized to plow or shovel sidewalks along a particular stretch of road on a regular basis.

PORCHES
Most historic homes have front porches that provide shade and refuge from the heat of the sun and allow residents to take advantage of outdoor breezes when indoor temperatures become too hot. For homes without porches, owners should consider adding some type of awning or covering over their doors and windows during the summer to lower indoor temperatures.

HOME SHADE TREES
Whether a home has porches or not, large trees around a building can significantly reduce indoor temperature by shading roofs, walls, and windows. This low-maintenance strategy also cleans the air surrounding a home and soaks up water during heavy rain that may otherwise flood a home's basement.

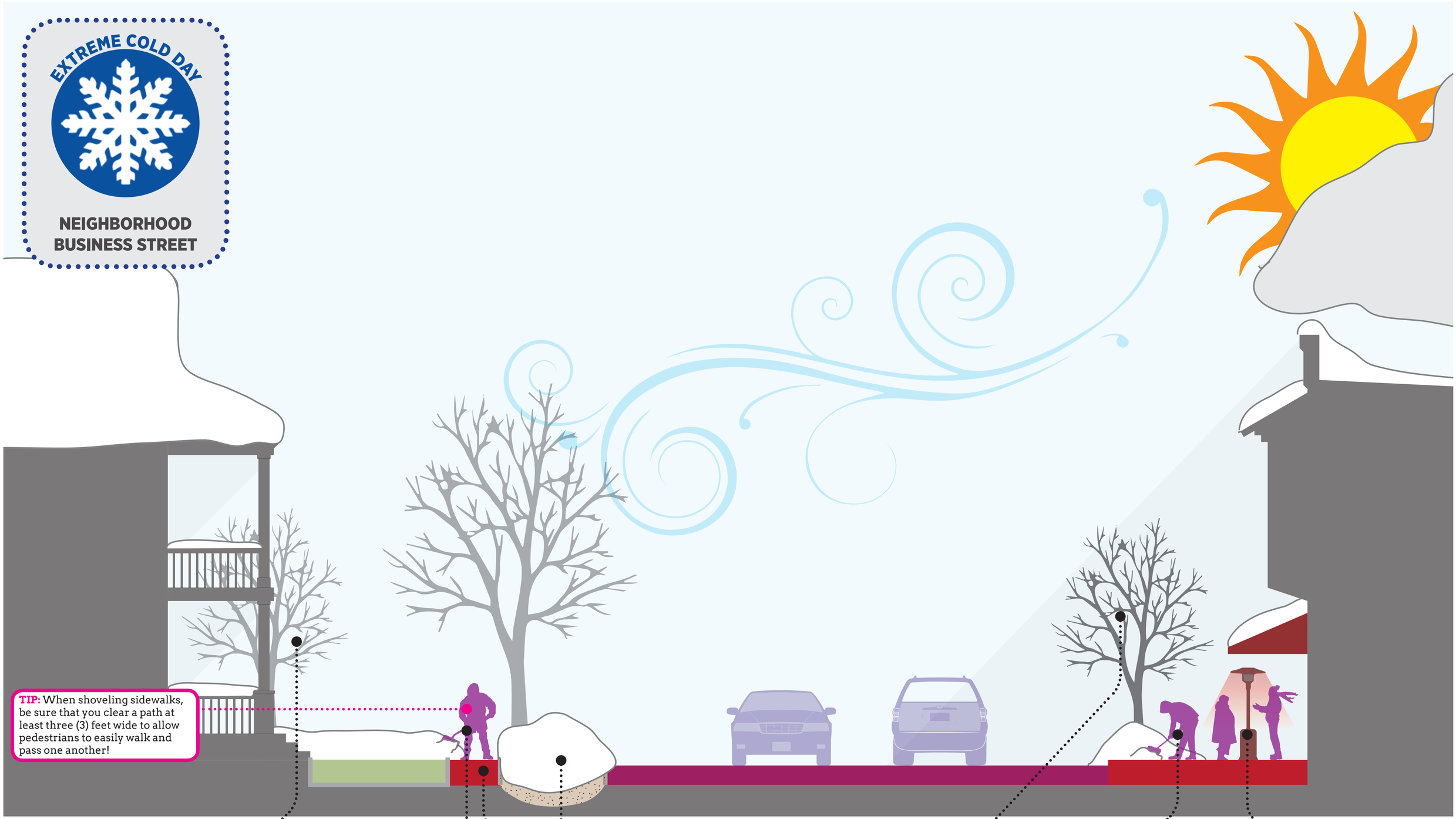
SWALE TREE LAWNS
The tree lawns abutting many residential streets is space that can be used for a swale or rain garden. These can soak up a lot of the road's water runoff, provide a place for air-cleansing plants to grow, and even a place where shade trees can be planted to further reduce the heat given off by streets.

PERMEABLE STREETS
To reduce stormwater runoff, urban heat island effect, and groundwater pollution, permeable pavers such as brick, block, or pourous concrete can be used to pave streets. Materials should be chosen based on a road's traffic volume and the material's weight and wear capacity commensurate to that volume.

COOL PAVEMENTS
Where permeable pavers are less practical, a different spin on conventional road materials can be utilized. Using a white or similarly light-colored concrete or asphalt mixture instead of the conventional grey, for example, reflects much more heat from ground-level. Additionally, existing pavement can simply be painted a lighter color to similar [but less permanent] effect.

SHADE TREES
A continuous line of shade trees planted along sidewalks and roads can significantly reduce ground-level heat and create a much more pleasant pedestrian experience, while encouraging people to walk longer distances on higher heat days.

WATER STATIONS
Along major pedestrian routes, public water stations can be implemented to allow pedsetrians and cyclists to stay well-hydrated on hotter days. These stations can also have permanent signs and take-home brochures that provide information on actions one should take during times of extreme heat, both while outdoors and when at home.



HOME SHADE TREES
Larger trees and plantings placed close to homes can be of great benefit in the winter when harsh frigid winds blow through town. These plants can help to break up this biting wind and prevent much of it from pushing its way through poorly insulated walls and unsealed windows, thus keeping indoor temperatures more stable and slightly reducing heating costs.

SIDEWALK CLEARANCE
Private homeowners are responsible for clearing snow and ice from the sidewalks abutting their property, though for some this may be a difficult task due factors such as to age, ailment, or work schedule. To acommodate this and provide safe and clear sidewalks for neighborhood residents, block clubs and community organizations can assemble snow shoveling teams that mobilize before, during, and after snowfall to clear priority walking routes throughout their neighborhoods. These groups can also encourage local able-bodied youth to clear the sidewalks of their neighbors or nearby homes of less capable residents.

SIDEWALK PAVING
Paving sidewalks with coarser materials, like coarse brick or concrete block, can reduce slippage when sidewalks are wet or icy. Additionally, providing sidewalks with proper foundations to keep them level (with a slight tilt toward the road) can prevent water pooling which can turn to dangerous ice patches.

SWALE TREE LAWNS
The tree lawns abutting many residential streets is space that can be used for a swale or rain garden. In the winter, snow melt and other precipitation can then collect here rather than in the roads, thus when freezing cold comes, the ice remains principally in the swale and not on the road itself. Plowed snow from the road also gets piled here rather than on the sidewalks, making cold-weather walking less dangerous.

STREET TREES
A continuous line of trees planted along sidewalks and roads can diffuse frigid winds blowing across the landscape in times of extreme cold. This can protect pedestrians and buildings from the agressive cold.

SIDEWALK CLEARANCE
Business and property owners should be held accountable for clearing snow and ice from the public sidewalks adjacent to their property. On major roads running through areas of high pedestrian activity, local agencies may be created or utilized to plow or shovel sidewalks along a particular stretch of road on a regular basis.

WARMING STATIONS
When extreme cold occurs and pedestrians must either walk for long distances or wait longer for delayed buses, businesses and institutions can provide warming stations along the sidewalk to help people fight the bitter cold. These can be temporary or permanent, depending on funding and location.

PORCHES
Most historic homes have front porches that provide shade and refuge from the heat of the sun and allow residents to take advantage of outdoor breezes when indoor temperatures become too hot. For homes without porches, owners should consider adding some type of awning or covering over their doors and windows during the summer to lower indoor temperatures.

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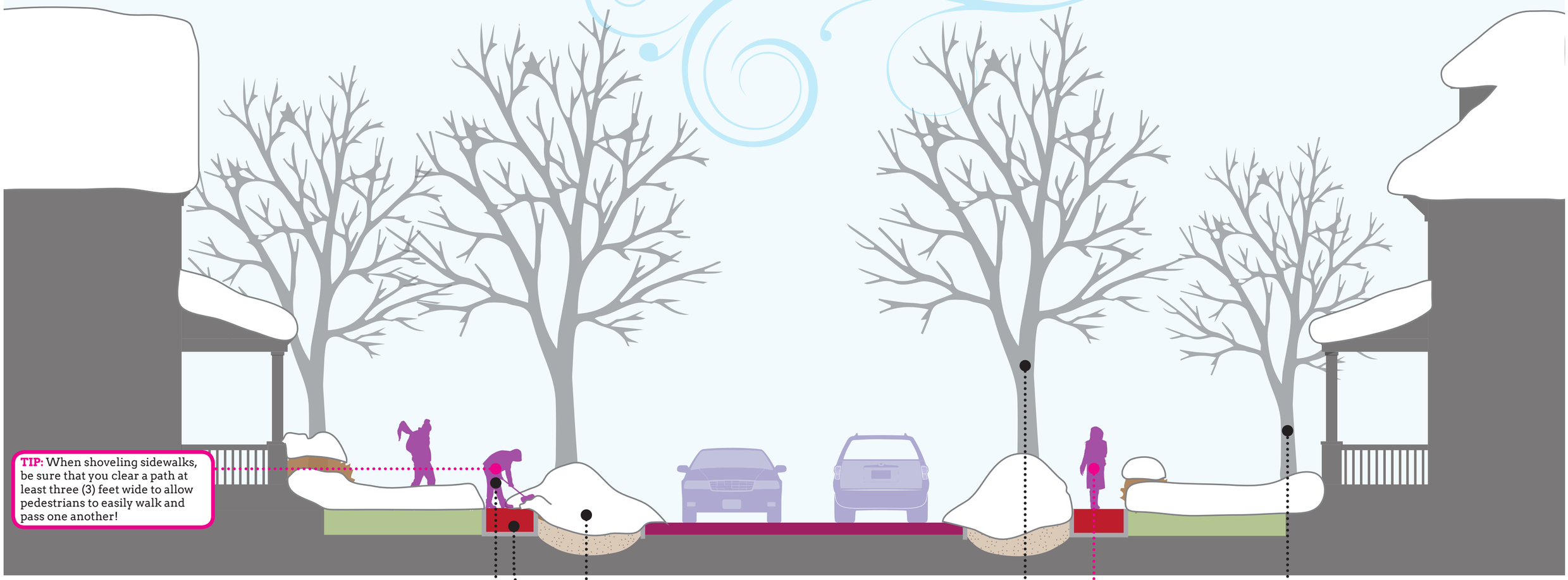
EXTREME COLD DAY

LOCAL RESIDENTIAL STREET



TIP: When shoveling sidewalks, be sure that you clear a path at least three (3) feet wide to allow pedestrians to easily walk and pass one another!

TIP: If you have to travel outside on days of extreme cold, be sure to cover all exposed skin. Wear many layers on your body, a scarf, gloves, a hat and a face mask to prevent frost bite and other exposure-related health issues!

SIDEWALK CLEARANCE

Private homeowners are responsible for clearing snow and ice from the sidewalks abutting their property, though for some this may be a difficult task due factors such as to age, ailment, or work schedule. To acommodate this and provide safe and clear sidewalks for neighborhood residents, block clubs and community organizations can assemble snow shoveling teams that mobilize before, during, and after snowfall to clear priority walking routes throughout their neighborhoods. These groups can also encourage local able-bodied youth to clear the sidewalks of their neighbors or nearby homes of less capable residents.

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Appendix M:

Planting With Purpose: An Excerpt from the Draft Cleveland Tree Plan

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Planting with Purpose

"Right Tree in the Right Place" is an urban forestry concept that should guide decisions for every planting project. However, planting with purpose must also factor in to the planning process. What do we want our trees to do? What benefits do we need to realize from this planting project? Why are we planting trees?

Urban trees play an important role in our daily lives; they provide many economic, environmental, and social benefits and significantly improve Cleveland's quality of life. Trees reduce the urban heat island effect and help cool the atmosphere, reduce stormwater flooding and environmental damages, improve water quality, mitigate air pollution and improve human health, enhance the quality of life through environmental justice, save money and the environment through energy conservation, enhance property values and increase spending at shops and restaurants, provide wildlife habitat and provide educational opportunities, and provide psychological and aesthetic benefits for citizens and visitors. The amount and distribution of urban tree canopy determines many of these economic, environmental, and social benefits. Planting trees purposefully (meeting a benefit need) will ensure trees provide the greatest benefits to the community. Tree planting programs in Cleveland, citywide or by individual neighborhood, should plant the "Right Tree in the Right Place for the Right Purpose".

Strategies for Purposeful Planting

For each tree planting project, desired outcomes should be defined so that all efforts and expenses will yield desired long-term benefits. If desired outcomes are based on the potential benefits trees provide, planting projects can more directly link to improvements in the quality of life in the city.

Davey Resource Group has developed this tree planting strategies guide based on data from the 2013 urban tree canopy analysis, demographic data, and i-Tree. Potential objectives of planting trees identified as needing improvement in Cleveland include existing tree canopy, stormwater retention, energy savings, urban heat island mitigation, human health, economic development potential, equity, use of available vacant land, large land ownership cooperation, and neighborhood support. As shown in Table 1, the results were ranked by neighborhood and also grouped into 3 categories that reflect the degree of need (Red suggests high need, yellow moderate need, and green low need) by neighborhood. For example, air quality improvements and asthma reduction are two social benefits of trees described in Table 1. Objective-based planting may mitigate air pollutants and yield lesser rates of asthma.

The sections that follow help illustrate potential needs by neighborhood. Tree planting activity that is guided by this objective-based information will help Cleveland strategically determine why and where tree planting efforts should be concentrated. Purposeful planting means that Cleveland's urban forestry partners will use this information to prioritize needs that can be improved through tree planting, match neighborhood needs to funders' missions, and work to narrow the gap between neighborhood canopy cover and the need for benefits.

Different species can provide more efficient benefits and the i-Tree Species tool can assist with selecting suitable tree species for the desired tree function. Table 2 lists the top 10% of tree species (out of 1,600 in i-Tree Species database) recommended for planting in Cleveland, Ohio. A more comprehensive list can be created in i-Tree Species, but not all listed species should be planted in the northeast region of Ohio. Special consideration should be made for planting tree species suited for the northeast region of Ohio. Each of the species listed in Table 2 are recommended in recommended Species Selection list provided in this plan (see Appendix A).

Table 1. Cleveland neighborhood canopy cover compared to purposeful planting objectives and the relative need for benefits.

Neighborhoods	Canopy	Relative Canopy	Stormwater	Energy Saved	Urban Heat Island	Human Health			Property Value Hikes	Median Household Income	Factors of Equity			
						Air Quality	Asthma Prevalence	Elderly Population			Population Density	Unemployment	Child Poverty	Equity
Bellaire-Puritas	15.14%	20.70%	21	24	6	30	10.9%	23	26	24	7	11	13	9
Broadway-Slavic Village	18.29%	25.10%	24	30	15	29	11.0%	25	30	12	3	29	18	20
Brooklyn Centre	24.05%	32.30%	22	22	18	22	12.5%	10	15	20	26	18	26	24
Buckeye-Shaker Square	25.38%	35.40%	3	18	34	17	14.3%	27	19	22	34	8	6	13
Buckeye-Woodhill	24.01%	33.10%	5	11	24	6	14.3%	15	17	4	28	34	32	34
Central	12.90%	18.40%	7	5	8	21	14.2%	13	9	1	13	33	34	32
Clark-Fulton	19.65%	28.70%	9	19	19	3	12.5%	11	5	19	32	24	19	26
Collinwood-Nottingham	13.56%	19.20%	19	21	5	27	10.5%	22	24	21	6	20	15	12
Cudell	16.02%	23.70%	14	12	7	1	14.7%	6	6	14	31	21	21	27
Cuyahoga Valley	4.86%	7.30%	33	2	2	25	14.7%	1	2	5	2	12	20	7
Detroit Shoreway	18.56%	27.30%	16	16	22	5	14.7%	20	13	16	25	17	8	16
Downtown	4.06%	7.80%	32	1	3	8	14.2%	4	1	29	8	7	2	3
Edgewater	29.60%	39.50%	25	10	30	4	14.7%	9	12	23	33	2	3	8
Euclid-Green	39.11%	49.80%	31	20	23	18	10.5%	7	29	33	24	15	12	11
Fairfax	17.68%	24.90%	10	8	14	13	14.2%	19	16	6	14	26	30	22
Glenville	25.69%	35.00%	18	32	28	32	10.5%	34	32	8	10	23	27	29
Goodrich-Kirtland Pk	8.48%	14.90%	27	3	4	2	14.2%	8	3	15	9	9	7	4
Hopkins	8.61%	16.90%	34	4	1	15	10.9%	2	4	25	1	14	33	14
Hough	24.16%	32.70%	8	23	31	24	14.2%	26	25	10	27	28	29	33
Jefferson	17.30%	24.40%	4	29	11	11	10.9%	24	23	31	15	5	24	18
Kamm's	33.61%	43.60%	28	34	29	34	10.9%	31	34	34	5	3	5	5
Kinsman	21.89%	28.50%	1	13	16	23	14.3%	18	21	3	19	32	31	30
Lee-Harvard	19.85%	25.90%	2	26	32	12	11.0%	29	20	30	22	19	23	21
Lee-Seville	20.72%	26.20%	26	17	10	10	11.0%	17	18	27	16	30	14	17
Mount Pleasant	22.45%	30.70%	6	28	33	26	11.0%	30	28	13	21	22	17	23
North Shore Collinwood	22.27%	30.80%	20	25	26	28	10.5%	28	27	28	20	13	9	15
Ohio City	22.43%	33.60%	13	9	21	20	14.7%	5	8	7	29	10	11	10
Old Brooklyn	22.32%	29.20%	23	33	17	33	12.5%	33	33	32	4	6	10	6
St.Clair-Superior	19.19%	27.30%	29	14	12	16	14.2%	12	14	9	17	27	16	19
Stockyards	16.16%	21.80%	12	15	13	7	12.5%	16	11	11	23	25	22	25
Tremont	16.55%	23.70%	15	7	9	9	14.7%	3	10	18	12	1	4	1
Union-Miles	21.94%	29.30%	17	31	25	31	11.0%	32	31	17	11	31	28	31
University	26.20%	37.60%	30	6	20	14	14.2%	14	7	2	18	4	1	2
West Boulevard	20.19%	28.60%	11	27	27	19	12.5%	21	22	26	30	16	25	28

Table 2. Top 10% of species for selected benefit functions for Cleveland, Ohio.

Tree Species	Streamflow Reduction	Building Energy Reduction	Wind Reduction	Air Temperature Reduction	UV Radiation Reduction	Overall Air Pollutant Removal	Specific Air Polutant Removal					Carbon Storage	Low VOC Emissions	Low Allergenicity
							Carbon Monoxide	Nitrogen Dioxide	Sulfur Dioxide	Ozone	Particulate Matter			
Abies concolor			X		X						X			
Abies nordmanniana			X								X			X
Acer x freemanii	X	X		X		X		X	X	X		X		
Aesculus flava	X	X		X		X	X	X	X	X		X		
Aesculus glabra	X	X		X		X	X	X	X	X				
Asimina triloba														X
Carpinus betulus						X	X			X			X	
Celtis laevigata		X			X		X			X		X		
Cercidiphyllum japonicum														X
Cladrastis kentukea												X		
Diospyros virginiana														X
Fagus sylvatica		X			X	X	X			X		X		
Halesia tetraptera							X						X	X
Ginkgo biloba	X	X						X	X			X		
Gymnocladus dioicus												X		
Liquidambar styraciflua	X	X		X				X	X					
Liriodendron tulipifera	X	X	X	X		X	X	X	X	X		X		
Magnolia acuminata	X	X	X	X		X		X	X			X		
Metasequoia glyptostroboides	X	X		X		X		X	X	X				
Ostrya virginiana						X				X				
Pinus rigida			X		X									
Pinus virginiana					X									
Platanus x acerifolia	X	X		X	X			X	X			X		
Quercus bicolor												X		
Quercus imbricaria												X		
Quercus macrocarpa					X							X		
Quercus meuhlenbergii					X							X		
Quercus palustris												X		
Quercus robur					X							X		
Quercus rubra					X							X		
Quercus shumardii	X	X		X				X	X			X		
Taxodium distichum	X							X	X					
Tilia americana	X	X	X	X		X	X	X	X	X		X		
Tilia cordata	X	X		X		X		X	X					
Tilia tomentosa	X	X		X		X	X	X	X	X				
Ulmus americana	X	X	X	X		X	X	X	X	X		X	X	
Ulmus parvifolia						X	X			X			X	
Zelkova serrata	X	X		X		X	X	X	X	X		X		

Relative Canopy

To help compare neighborhoods to each other and account for the vast differences in land use and neighborhood character, relative canopy is used. Relative tree canopy can be expressed as a percent of tree canopy that exists compared to what is possible. For example, while Cleveland's total tree canopy cover is 19% across all city land, its relative tree canopy cover equals 27% of what is possible (71% is theoretically possible). The relative canopy percentages by neighborhood are presented in Table 1 and mapped in Figure 3. The neighborhoods with the lowest amounts of relative tree canopy may warrant greater planning, financial, technical, and implementation assistance towards increasing canopy. Cleveland neighborhoods with the greatest potential for increased canopy include: Bellaire-Puritas, Central, Collinwood-Nottingham, Cudell, Cuyahoga Valley, Downtown, Goodrich-Kirtland Pk, Hopkins, Stockyards, and Tremont. Coincidentally, all of these neighborhoods have the lowest amount of tree canopy across all 34 neighborhoods. Two neighborhoods, Kinsman and Union-Miles, have above average tree canopy (19%) and high potential for increased canopy.

A large-growing tree provides up to eight times the benefits of a small-growing tree planted in the same environment. The benefits large trees provide can far exceed the initial cost and long-term maintenance needs they require. While planting small-growing trees may reduce occurrence of associated risk potential, the long-term benefits of planting large-growing trees should not be overlooked. Planting large-growing trees on public and private land within residential and industrial land uses of Cleveland may result in the greatest change in canopy.

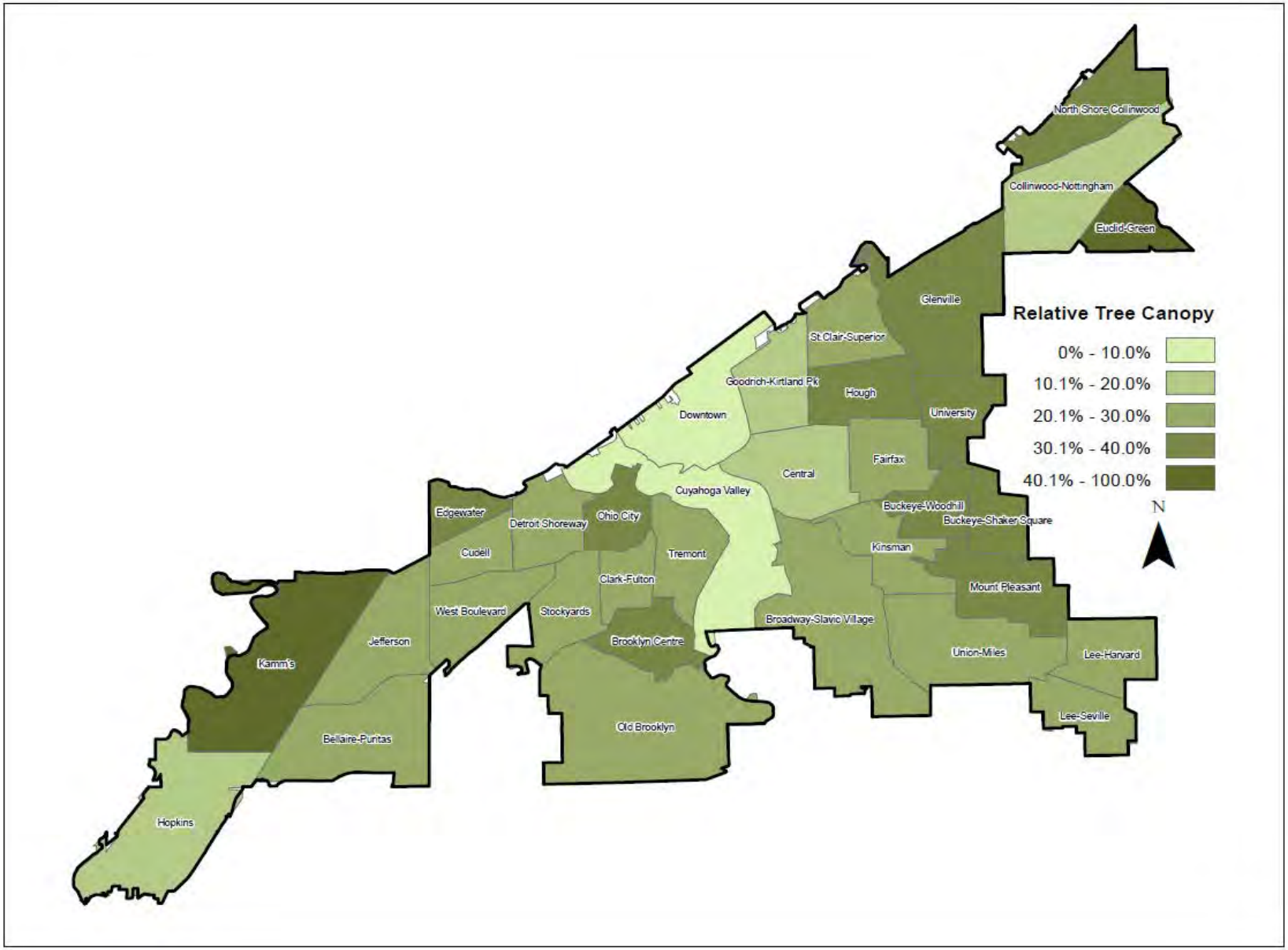

Figure 3. Relative tree canopy by neighborhood.

Stormwater Retention

The topography of the watershed, soil type and structure, and prevalence of impervious surfaces have an effect on stormwater, but trees play a major role too. Trees benefit stormwater management in urban areas by simply slowing the flow of stormwater during an average rain event. When rain does not hit impervious surfaces, it may soak into the soil where the water is filtered and becomes groundwater. In urban areas, there is a greater possibility in that the rainwater hits an impervious surface. The amounts of tree canopy and impervious surface within an urban watershed influences the quantity of stormwater that needs to be managed. Factoring in many of these considerations for the watershed, Figure 4 illustrates the need for stormwater management by neighborhood. Cleveland neighborhoods with the greatest need for increasing canopy, stormwater management, and decreasing impervious surfaces include: Buckeye-Shaker Square, Buckeye-Woodhill, Central, Clark-Fulton, Collinwood-Nottingham, Cudell, Detroit Shoreway, Fairfax, Glenville, Hough, Jefferson, Kinsman, Lee-Harvard, North Shore Collinwood, Ohio City, Stockyards, Tremont, Union-Miles, and West Boulevard. The neighborhoods with a high need for stormwater management may warrant financial, technical, and implementation assistance towards increasing canopy.

Trees reduce the volume and speed of rainwater during a rain event due to the amount of surface area in their trunk, branches, and leaves and their water-absorbing capabilities from the roots (directly) and surrounding soil (indirectly). Generally, planting large-growing trees creates the greatest stormwater management impact. There are a few tree species which perform this function best and the top 10% for Cleveland are listed in Table 3. Planting trees on public and private land within industrial, commercial, and institutional land uses of Cleveland may lead to the greatest change in water retention.

Table 3. Top 10% of species that can impact stormwater retention benefits for Cleveland, Ohio.

Species that retain rainwater best for improved performance in stormwater retention.
Acer x freemanii
Aesculus flava
Aesculus glabra
Ginkgo biloba
Liquidambar styraciflua
Liriodendron tulipifera
Magnolia acuminata
Metasequoia glyptostroboides
Platanus x acerifolia
Quercus shumardii
Taxodium distichum
Tilia americana
Tilia cordata
Tilia tomentosa
Ulmus americana
Zelkova serrata

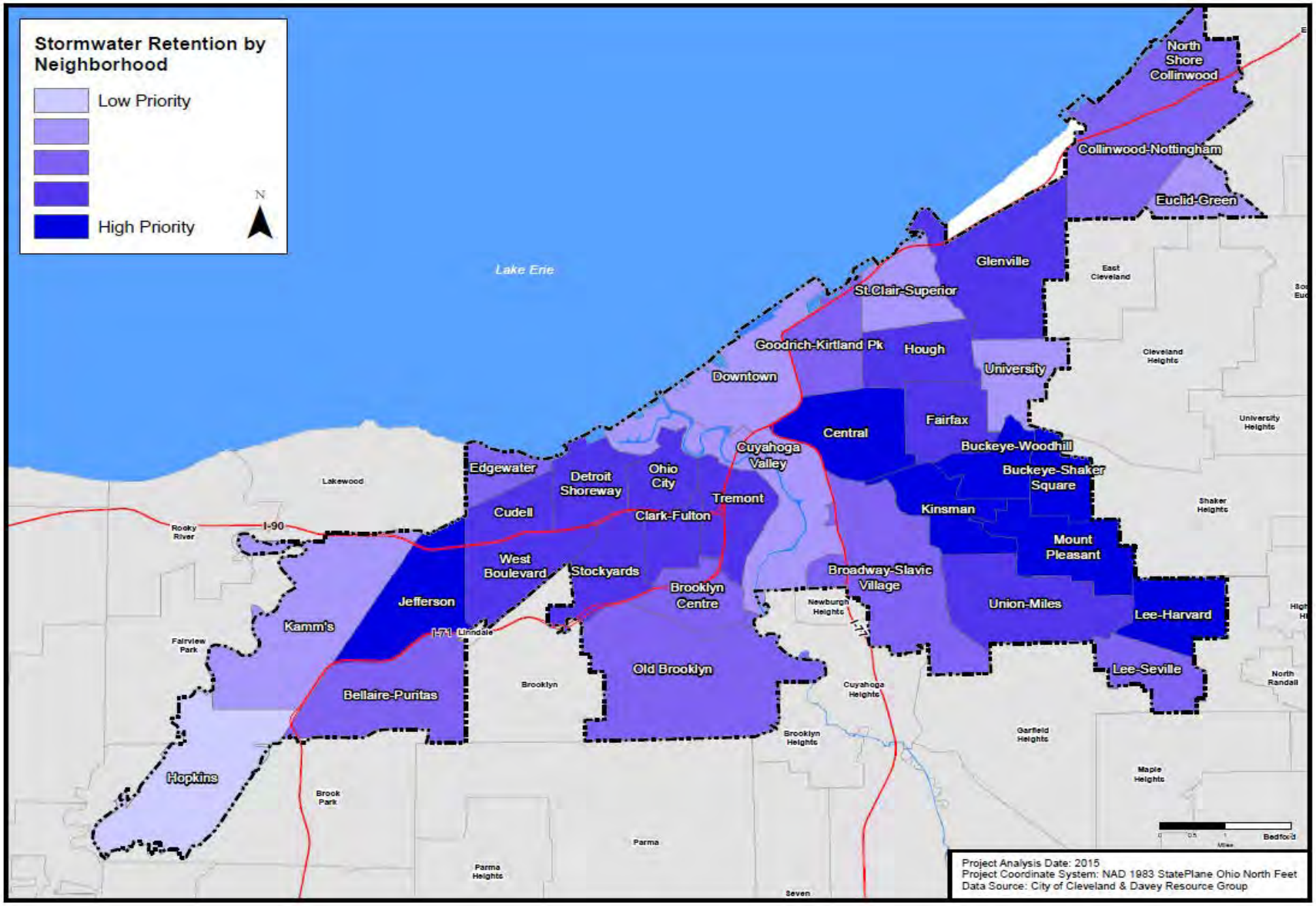

Figure 4. Stormwater retention needs by neighborhood.

Energy Savings

When trees are properly placed around houses, offices, and businesses, their shade and windbreak can reduce cooling and heating energy uses. Trees also reduce surrounding air temperatures by releasing water vapor, which further reduces the need for air conditioning. Factoring in the prevalence of real estate in correlation to the prevalence of canopy, Figure 5 illustrates estimated energy conservation benefits through tree canopy by neighborhood. Cleveland neighborhoods with the greatest need to increase canopy near buildings include: Buckeye-Woodhill, Central, Cudell, Cuyahoga Valley, Downtown, Edgewater, Fairfax, Goodrich-Kirtland Pk, Hopkins, Kinsman, Ohio City, St.Clair-Superior, Tremont, and University. The neighborhoods with a high need for energy conservation may warrant greater planning, and more financial and technical assistance to strategically implement more tree canopy.

Generally, planting large-growing trees will create the greatest impact because those trees provide the greatest amount of shade and wind block for air conditioned and heated spaces. The top 10% of species that perform this function the best for Cleveland are listed in Table 4. Planting trees on public and private land within residential, commercial, and institutional land uses of Cleveland may lead to the greatest change in energy savings.

Table 4. Top 10% of species that can improve energy savings for Cleveland, Ohio.

Species that reduce energy usage best for improved performance in energy savings.	Species best used to break penetrating winds for improved performance in energy savings.
Acer x freemanii	*Abies concolor*
Aesculus flava	*Abies nordmanniana*
Aesculus glabra	*Liriodendron tulipifera*
Celtis laevigata	*Magnolia acuminata*
Fagus sylvatica	*Pinus rigida*
Ginkgo biloba	*Ulmus americana*
Liquidambar styraciflua	*Tilia americana*
Liriodendron tulipifera	
Magnolia acuminata	
Metasequoia glyptostroboides	
Platanus x acerifolia	
Quercus shumardii	
Tilia americana	
Tilia cordata	
Tilia tomentosa	
Ulmus americana	
Zelkova serrata	

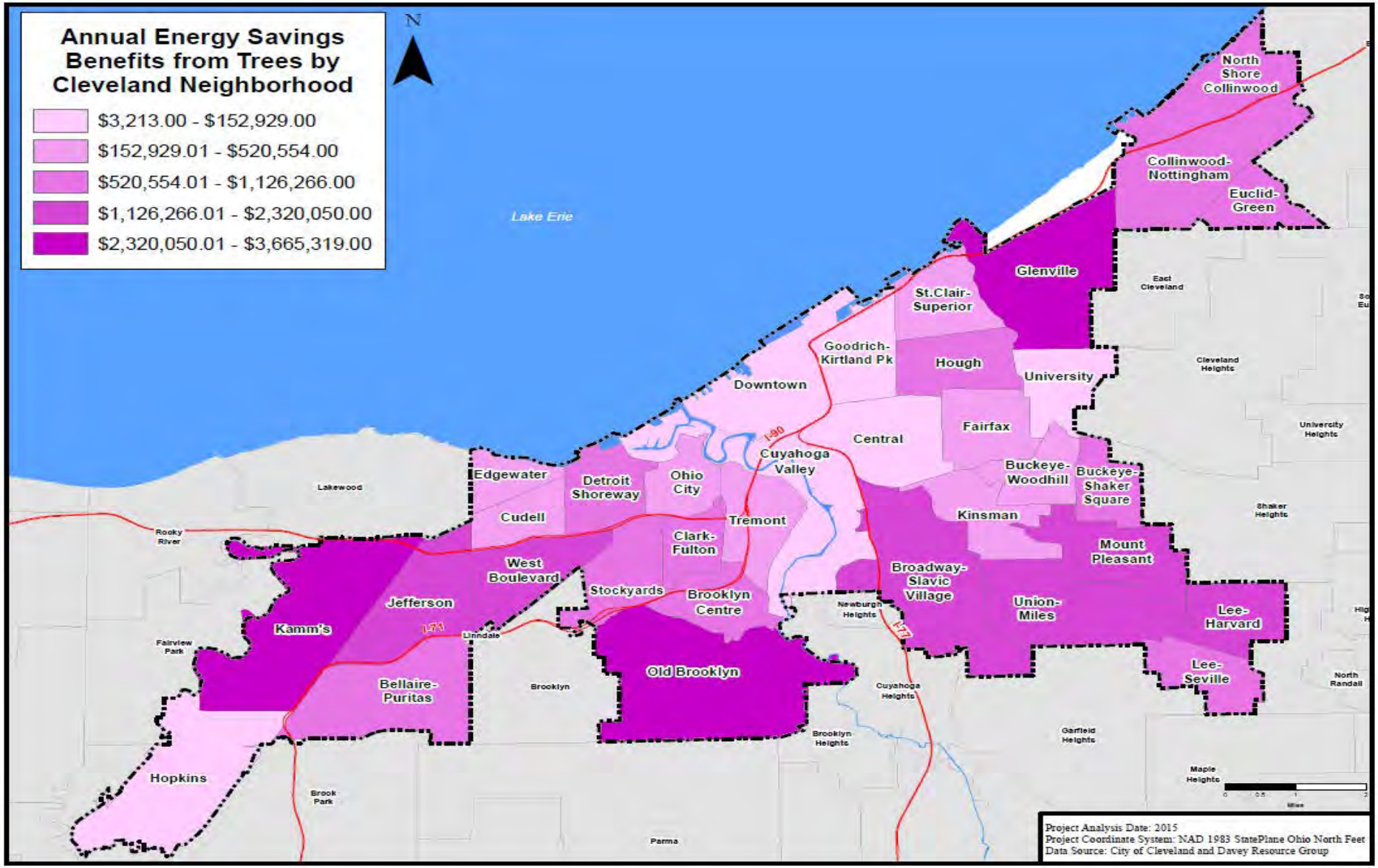

Figure 5. Energy savings benefits by neighborhood.

Mitigating Urban Heat Island Effect

Heat islands are caused by impervious surfaces including buildings, streets, driveways, and parking lots. Within one urban geographical area, large concentrations of impervious surface types and small concentrations of tree canopy cover negatively affect ambient air temperatures. When little to no shade is casted over heat absorbing surfaces, this causes higher temperatures and prolonged temperatures throughout the night. The following sunny day can compound the heat index because the air has not had the proper time to cool. Figure 7 illustrates where heat islands are greatest and lowest within Cleveland by neighborhood. Cleveland neighborhoods with the greatest need to reduce their heat island over impervious surfaces include: Collinwood-Nottingham, Cuyahoga Valley, Downtown, Goodrich-Kirtland Pk, and Hopkins. The neighborhoods with a high need to lower their heat island hot spots may warrant greater planning, and more financial and technical assistance to implement more tree canopy strategically.

Generally, planting large-growing trees will create the greatest impact because those trees will provide the greatest amount of shade over impervious surfaces. The top 10% of species that perform this function the best for Cleveland are listed in Table 5. Planting trees on public and private land within residential, recreational open spaces, and commercial land uses of Cleveland may lead to the greatest change in heat island.

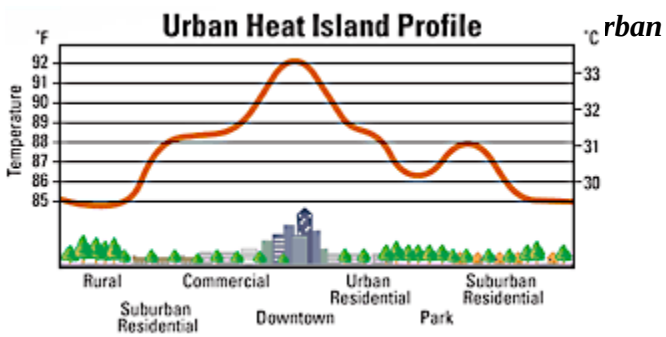

Figure 6. Urban heat island profile for typical urban-rural transect. (SOURCE)

Table 5. Top 10% of species that can mitigate urban heat island effect for Cleveland, Ohio.

Species that provide shade best for improved performance in cooling air temperatures.	Species that are best for improved performance in reducing UV radiation.
Acer x freemanii	*Abies concolor*
Aesculus flava	*Celtis laevigata*
Aesculus glabra	*Pinus rigida*
Liquidambar styraciflua	*Pinus virginiana*
Liriodendron tulipifera	*Platanus x acerifolia*
Magnolia acuminata	*Quercus macrocarpa*
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Ulmus americana	
Zelkova serrata	

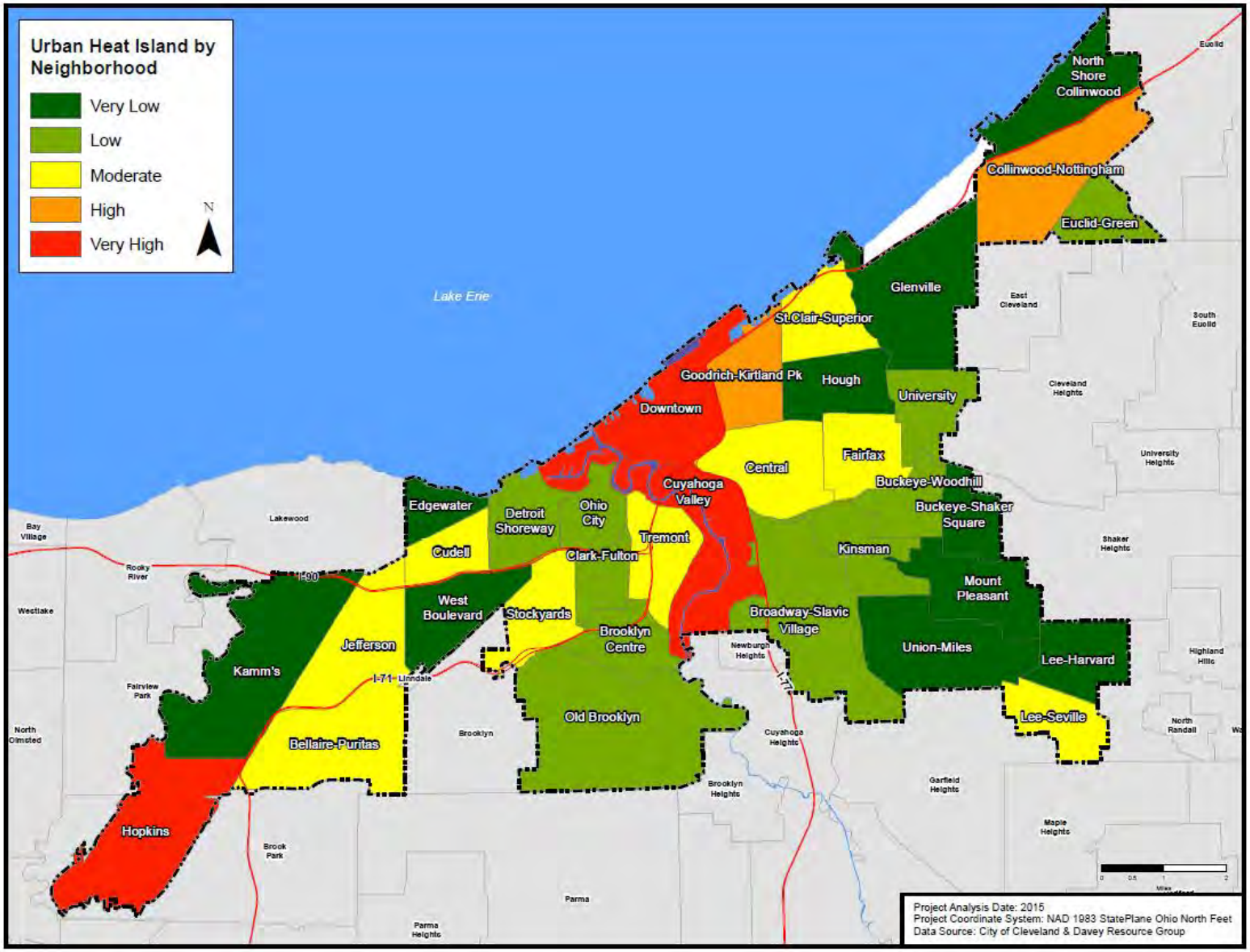

Figure 7. Urban heat island intensity by neighborhood.

Human Health

Trees create a healthier environment for people by improving air quality. Reductions in ozone, carbon, particulate matter, and other air pollutants lowers incidence of respiratory illnesses and hospital visits. The Cleveland neighborhoods with the greatest needs for air quality improvement include: Buckeye-Woodhill, Clark-Fulton, Cudell, Detroit Shoreway, Downtown, Edgewater, Edgewater, Stockyards, and Tremont. Additional consideration for increased canopy could be in neighborhoods where asthma rates are highest. The neighborhoods with a high need to improve air quality through increasing tree canopy are illustrated in Figures 8 and 9. These neighborhoods may warrant greater planning, along with additional financial, technical, and assistance in implementing more tree canopy strategically.

Generally, planting large-growing trees creates the greatest impact because those trees provide the most cooling effects, store the most carbon, collect the most pollutants, and produce the most oxygen. The top 10% of species that perform this function the best for Cleveland are listed in Table 6. Planting trees on public and private land within residential, recreational, and industrial land uses of Cleveland may lead to the greatest improvements in air quality, and thus, human health.

Additionally, trees largely influence the social health of the community. Trees create a natural calming effect on people and have been found to reduce incidence of domestic violence, crime, and abuse. Also, social ties with neighbors are strengthened because trees bring people outside and more frequent outdoor visits reinforce stronger bonds between neighbors. Trees benefit the neighborhood by making streets safer. Large-growing trees can cause moving vehicles to slow speeds. Tree-lined streets guard sidewalks and pedestrians from vehicles traveling off the road.

Table 6. Top 10% of species that positively impact human health for Cleveland, Ohio.

Species that best reduce air pollutants causing respiratory illness for improved performance in human health.	
Abies nordmanniana	*Ostrya virginiana*
Acer x freemanii	*Platanus x acerifolia*
Aesculus flava	*Quercus bicolor*
Aesculus glabra	*Quercus imbricaria*
Asimina triloba	*Quercus macrocarpa*
Carpinus betulus	*Quercus meuhlenbergii*
Carpinus betulus	*Quercus palustris*
Celtis laevigata	*Quercus robur*
Cercidiphyllum japonicum	*Quercus rubra*
Cladrastis kentukea	*Quercus shumardii*
Diospyros virginiana	*Taxodium distichum*
Fagus sylvatica	*Tilia americana*
Ginkgo biloba	*Tilia cordata*
Halesia tetraptera	*Tilia tomentosa*
Liquidambar styraciflua	*Ulmus americana*
Liriodendron tulipifera	*Ulmus parvifolia*
Magnolia acuminate	*Zelkova serrata*
Metasequoia glyptostroboides	

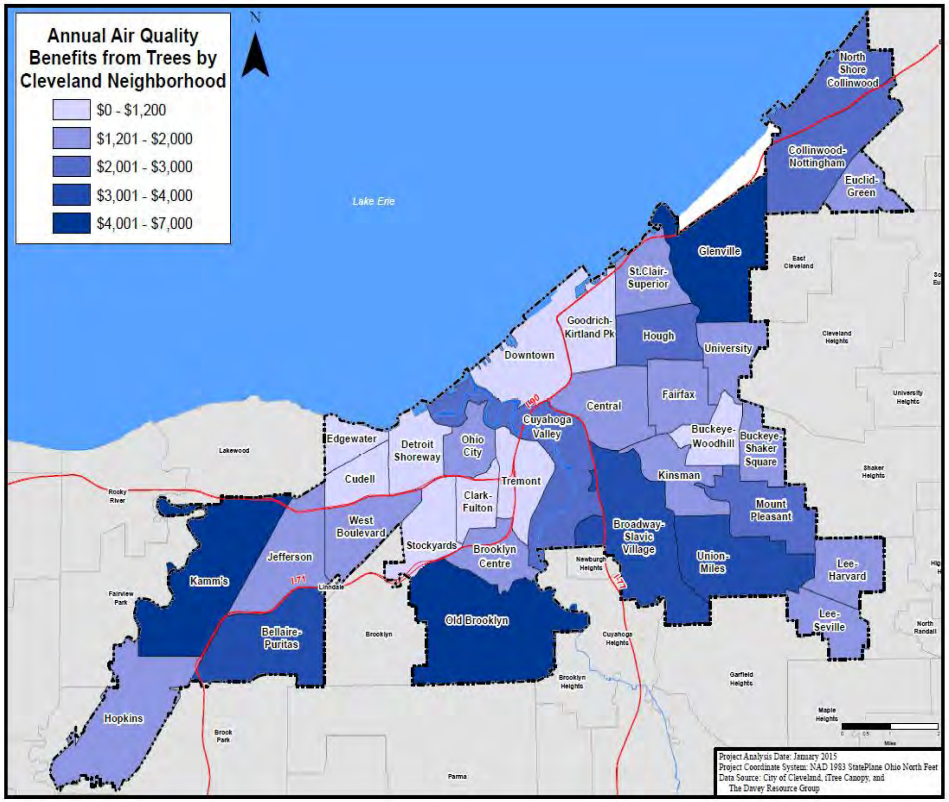

Figure 8. Air quality benefits by neighborhood.

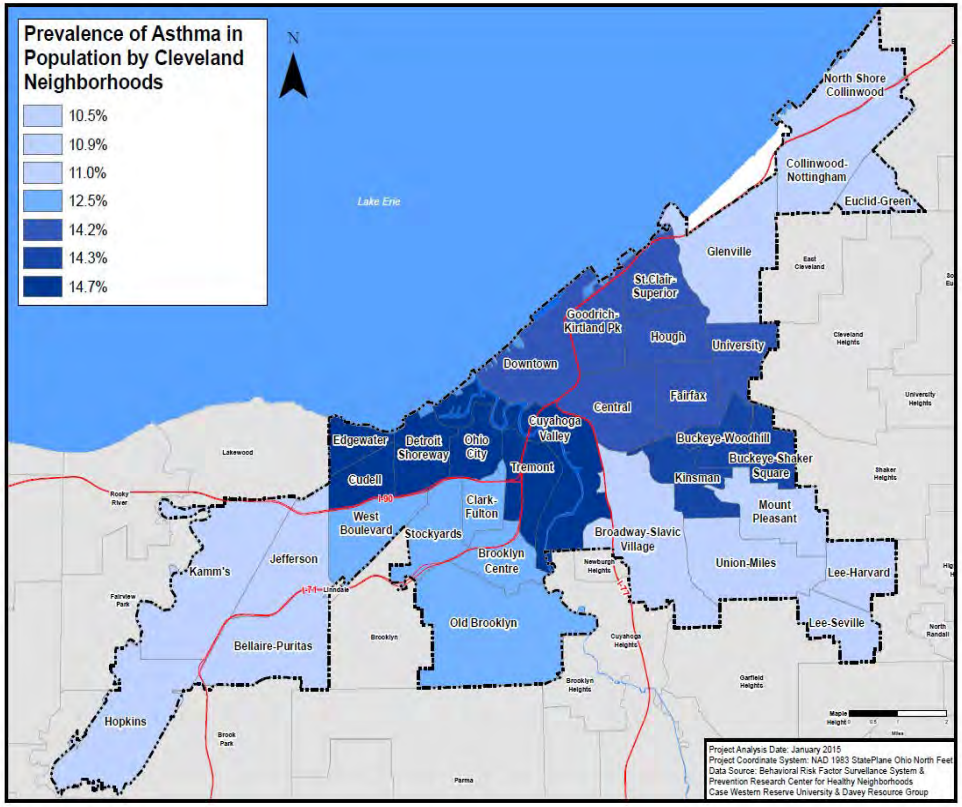

Figure 9. Asthma prevalence by neighborhood.

Economic Development Potential

Trees have an influence on a community's economy by way of job creation, worker productivity, frequency of shoppers and duration or time shopping, business or home vacancy prevalence, and property value increases. Studies show that the simple presence of trees around workers decreases the number of work days missed and soothes work related stress at a quicker rate than when comparing workers who do not see trees during the workday. The occurrence of vacant homes and businesses may be less due to the demand to live where trees are present in the landscape. Landscapes with trees also increase a buyer's willingness to pay more for a home than one without trees. Shoppers also spend more and potentially buy more merchandize or services in canopy covered commercial districts. Figures 10 illustrates where Cleveland may want to concentrate tree planting to increase property values. Cleveland neighborhoods with the greatest need to increase property values include: Brooklyn Centre, Buckeye-Woodhill, Central, Clark-Fulton, Collinwood-Nottingham, Cudell, Cuyahoga Valley, Detroit Shoreway, Downtown, Edgewater, Fairfax, Goodrich-Kirtland Pk, Hopkins, Ohio City, St.Clair-Superior, Stockyards, Tremont, and University. Neighborhoods with a high need to increase property values may warrant greater planning, and more financial and technical assistance to implement more tree canopy strategically.

Cleveland neighborhoods with the lowest average annual household income are illustrated in Figure 11 and include: Broadway-Slavic Village, Buckeye-Woodhill, Central, Cudell, Cuyahoga Valley, Detroit Shoreway, Fairfax, Glenville, Goodrich-Kirtland Pk, Hough, Kinsman, Mount Pleasant, Ohio City, St.Clair-Superior, Stockyards, and University. These neighborhoods may also warrant increased attention for tree planting based on the influence tree canopy can have economic development potential.

Planting a mix of large-growing and small- or medium-growing ornamental/flowering trees will create the greatest impact. Trees planted on public and private land within commercial, industrial, and institutional land uses of Cleveland may lead to the greatest changes in economic development.

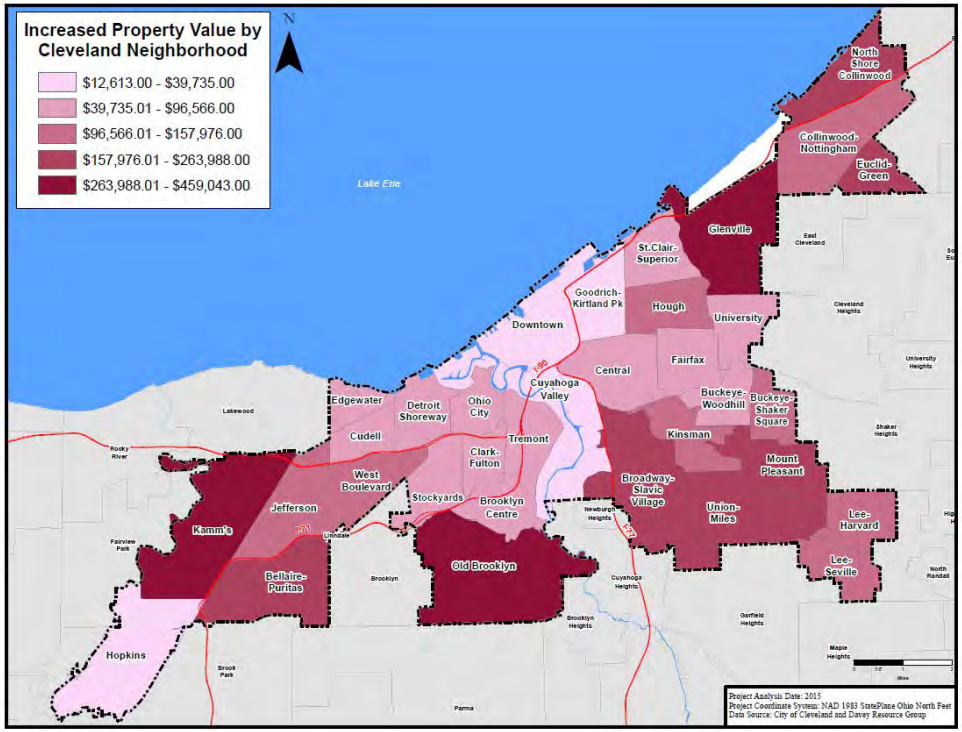

Figure 10. Property values increases attributed to canopy cover by neighborhood.

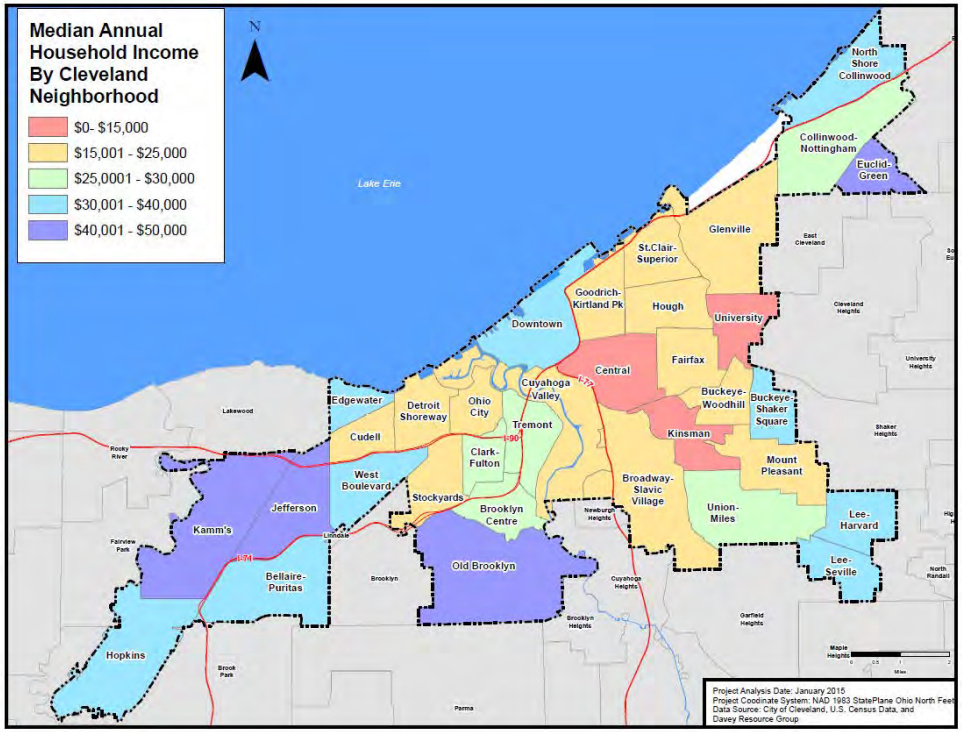

Figure 11. Median income by neighborhood.

Equity

An important part of tree planting is addressing the disparities in environmental justice. Equity in the urban forest is measured by the distribution of tree canopy benefits, specifically how those benefits influence population density, unemployment rates, and child poverty.

Inequality can be emphasized when one geographical area receives less canopy benefit than another, yet the need for canopy benefit is greater. With the guidance of Quentin Karpilow, Davey Resource Group utilized an equity ranking to help develop strategies for narrowing the gap in canopy, and thus benefits, at the neighborhood level. The equity ranking uses population density, unemployment rates, and child poverty rates to show the neighborhoods most in need of the benefits afforded by tree canopy (Figures 12-14). When aggregated, these equity indicators suggest where Cleveland may want to concentrate tree planting effort to lessen inequities in canopy cover (Figure 15). Cleveland neighborhoods with the greatest need to increase people's access to trees include: Broadway-Slavic Village, Brooklyn Centre, Buckeye-Woodhill, Central, Clark-Fulton, Cudell, Fairfax, Glenville, Hough, Kinsman, Lee-Harvard, Mount Pleasant, Stockyards, Union-Miles, and West Boulevard. The neighborhoods with a highest need for canopy-driven benefits may warrant greater planning, and more financial and technical assistance to implement more tree canopy strategically.

Planting a mix of large-growing and small- or medium-growing ornamental/flowering trees will create the greatest impact. The city, neighborhood organizations, and future funders could use the focus of tree benefits stated above to determine what tree species to plant and for what beneficial purpose. Trees planted on public and private land within residential, recreational, and vacant land uses of Cleveland may lead to the greatest changes in equity of environmental justice.

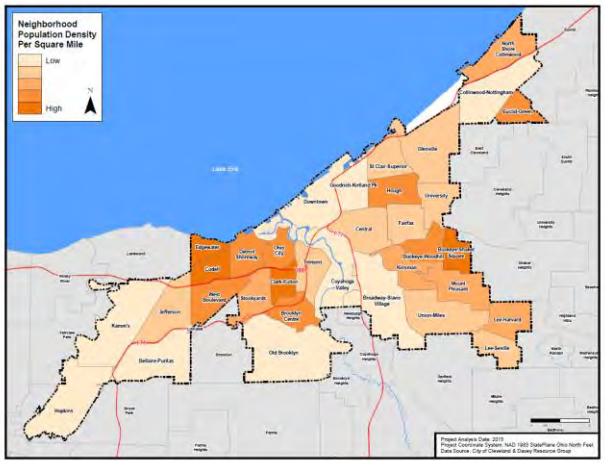

Figure 12. Population density by neighborhood.

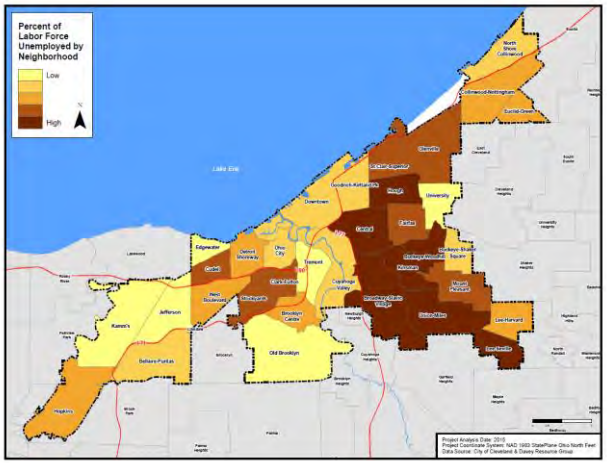

Figure 13. Unemployment rates by neighborhood.

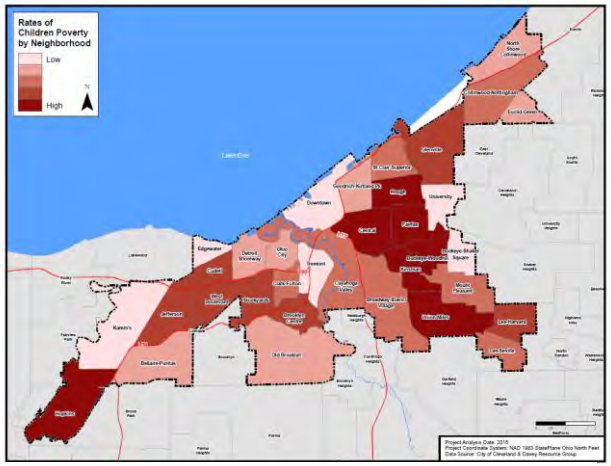

Figure 14. Property values increases attributed to canopy cover by neighborhood.

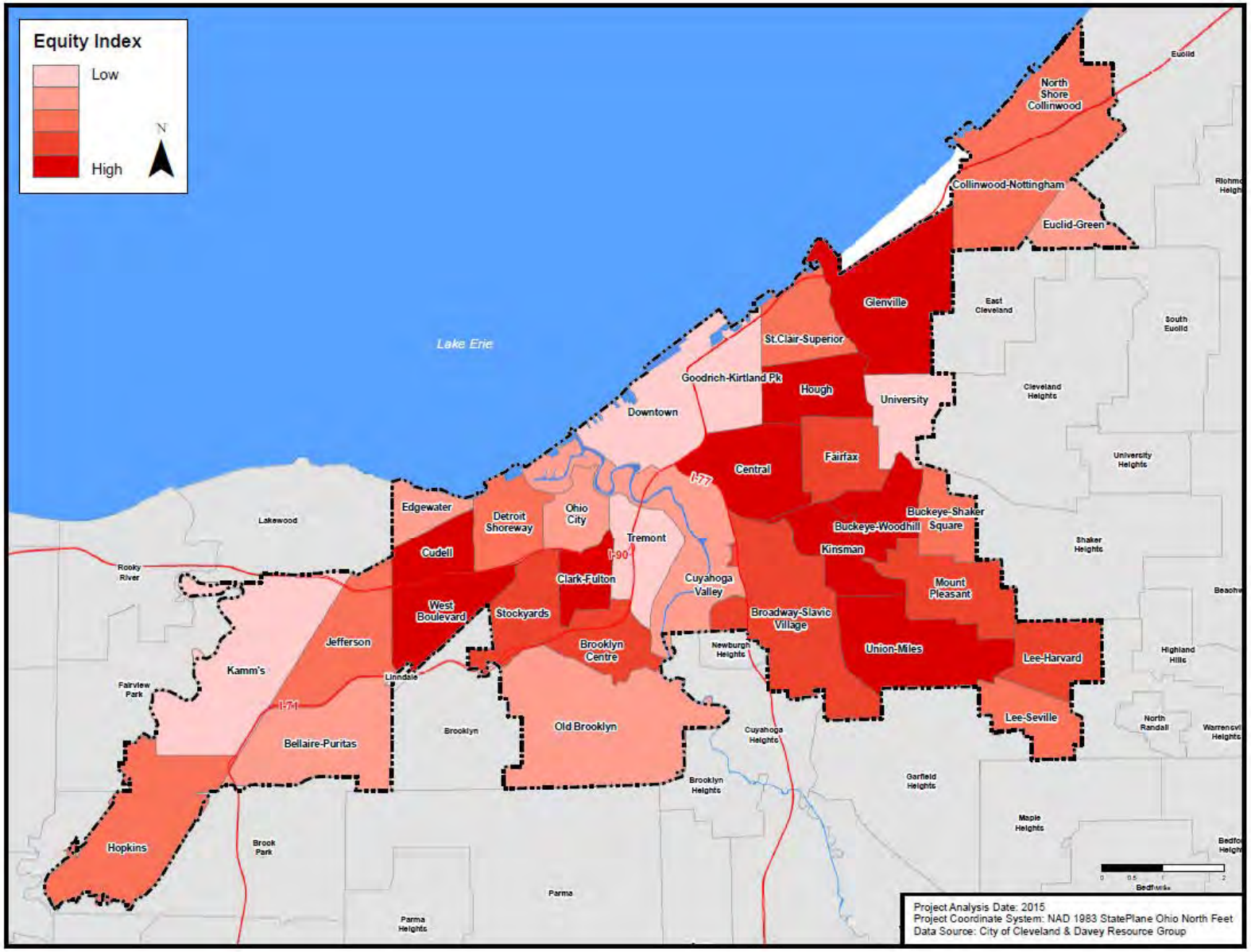

Figure 15. Equity index to indicate need for tree benefits by neighborhood.

Availability of Vacant Land

The urban ecosystem is extremely complex and diverse. Small, functional ecosystems together form a larger system, each of which may need to be managed differently. The overall health of the urban ecosystem depends on the ability of trees, plants, wildlife, insects, and humans to coexist as a whole. Often, the health and diversity of the overall canopy can be greatly improved by creating connections between multiple patches of forest. Planting vacant lands adjacent to contiguous canopy may help improve the distribution and composition of the canopy.

Davey Resource Group analyzed Cleveland's existing urban tree canopy for fragmentation. The analysis found the following:

- **862 acres of Core Canopy.** Tree canopy that exists within and relatively far from the forest/non-forest boundary (i.e., forested areas surrounded by more forested areas).
- **144 acres of Perforated Canopy.** Tree canopy that defines the boundary between core forests and relatively small clearings (perforations) within the forest landscape.
- **2,342 acres of Edge Canopy.** Tree canopy that defines the boundary between core forests and large non-forested land cover features. When large enough, edge canopy may appear to be unassociated with core forests.
- **6,159 acres of Patch Canopy**. Tree canopy that comprises a small forested area that is surrounded by non-forested land cover.

Using this forest fragmentation analysis, Davey Resource Group prioritized Cleveland's parcels of vacant land by adjacency to *core*, *edge*, *perforated*, and *patch* forests. Table 7 illustrates this prioritization of available land by land use and Figure 16 shows the availability of land by neighborhood. Neighborhoods with higher priority planting should plant native large-growing species within vacant parcels and determine whether parcels should be part of the maintained landscape (park-like area) or if natural forest regeneration should take place. Cleveland neighborhoods with the greatest potential to increase canopy by foresting vacant land include: Bellaire-Puritas, Broadway-Slavic Village, Brooklyn, Central, Collinwood-Nottingham, Cuyahoga Valley, Fairfax, Glenville, Hopkins, Hough, Kinsman, Old Brooklyn, and Union-Miles. The neighborhoods with a high potential to increase canopy through planting vacant land may warrant greater planning, and more financial and technical assistance to implement more tree canopy strategically.

Additionally, private landowners who own large tracts of land (over XXX acres) comprise 21% (11,092 acres) of all the land in Cleveland. Landowners are a mix of city, state, park, rail, civic, health, and utility organizations. The cooperation and partnerships with these organizations to plant trees on their properties will play a major role in reaching canopy goals. Large landowners could use the same principles as stated above to determine where and what to plant.

Planting a mix of large-growing and small- or medium-growing ornamental/flowering trees will create the greatest impact. The city, neighborhood organizations, and future funders could determine what tree species to plant for what beneficial purpose (maintained landscape versus natural area).

Table 7. Acres of Vacant Parcels by Land Use and Priority Level

General Land Use	Very Low Priority	Low Priority	Moderate Priority	High Priority	Very High Priority	Total
Agricultural	0	0	0	0	2	2
Commercial	122	246	109	250	221	947
Industrial	169	336	197	351	919	1,971
Institutional	12	20	14	14	23	84
Recreation/Open Space	6	4	1	3	47	61
Residential - Multifamily	43	102	61	133	227	565
Residential - Single Family	307	602	367	427	463	2,166
ROW	5	4	8	13	0	30
Transportation/Utilities	14	2	12	8	23	60
Total	679	1,317	768	1198	1,925	

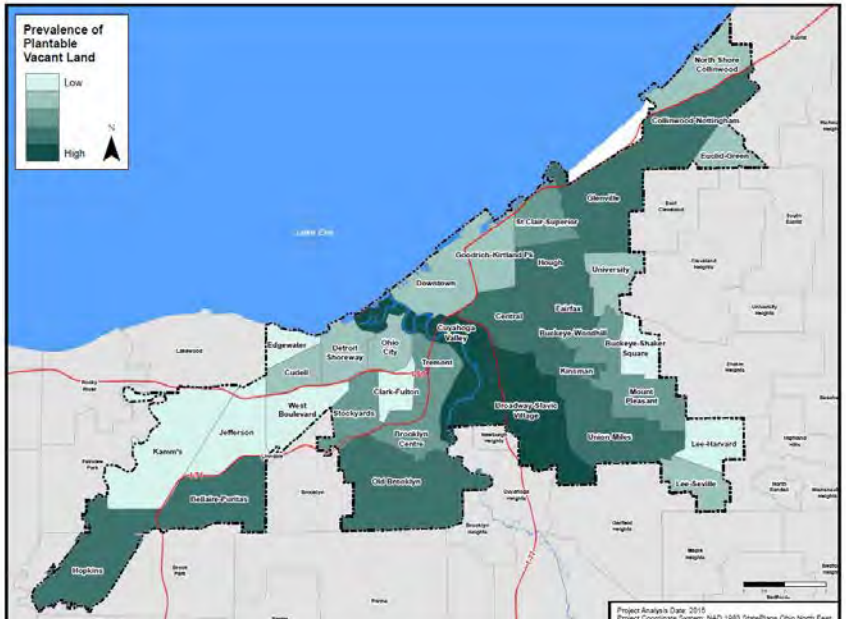

Figure 16. Prevalence of vacant land available for planting by neighborhood.

Conclusion

Achieving significant increases in canopy cover over the next 25 years may not be easy, which is why establishing canopy goals is essential for Cleveland. The City of Cleveland, Cleveland neighborhood groups, and future funders will need to work together in the development of new and innovative planting programs described in the action item section of this plan. Such planting programs are based on a centralized vision to achieve a canopy goal. The planting of street trees may encourage residents and business to plant trees on their property, a product of city leadership. The six neighborhoods with the highest need (Central, Clark-Fulton, Cudell, Fairfax, Stockyards, and West Boulevard) present the greatest potential for increased canopy cover. Neighborhoods can individually utilize these maps and data to strategically determine and prioritize tree planting needs. The investment of time and money in planting new trees and maintaining Cleveland's existing trees will more than pay for itself through the beneficial services that these trees provide.

Appendix N:

Climate Change and Urban Agriculture Literature Revew

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Urban areas in the Midwest will be impacted by climate change, exacerbating underlying socio-economic conditions. The main ways in which climate change will affect Cleveland is through heat waves, flooding, and other storm events. Urban agriculture has the potential to mitigate the urban heat island effect, and help the city adapt to a changing climate.

Urban agriculture consists of multiple forms of growing and producing food in urban areas such community gardens, school gardens, urban farms and even community supported agriculture (Raja et al. 2008). The activities range from growing fruits and vegetables, animal husbandry, bee keeping and creating value added products from raw produce (Raja et al. 2008). Though the food systems literature provides information on how urban agriculture contributes to the general well-being of society, there is very little evidence that documents urban agriculture's impact on the environment. Similarly, while the urban climate literature provides information on urban heat island abatement, urban agriculture is not typically considered as a land use to mitigate increased urban temperatures. This literature review investigates whether urban agriculture has the potential to reduce the urban heat island effect in Cleveland and Cuyahoga County, Ohio.

Urban agriculture's mitigation potential

To make the case for urban agriculture's potential to reduce urban heat island effect in urban spaces, we rely on literature that uses vegetation in mitigation scenarios. In most of these studies, vegetation simply refers to grass. Just as grass is capable of increasing local rates of evapotranspiration, providing a cooling effect or reflecting radiation from the sun, so is urban agriculture by its very nature of putting into the ground vegetation that provides the same environmental services.

Drawing from urban climate research we find that vegetation cools surfaces more efficiently than strategies that increase albedo (reflect instead of absorb radiation from the sun) (Rosenzweig, Solecki, and Slosberg 2006). The case study of Manhattan shows curbside planting to be the most effective cooling strategy per unit area of redevelopment (Rosenzweig, Solecki, and Slosberg 2006). A similar study in Nagoya, Japan found greening - planting with grass and alternatively planting a mix of trees and grass (30-70 ratio)-parking lots reduces spring and summer temperatures (Onishi et al. 2010). Urban temperatures decrease by 6.5°C in the spring and 8°C in the summer when parking lots are planted with grass and by 7.4°C and 9.3°C, respectively when planted with a mix of trees and grass (Onishi et al. 2010).

However the use of different strategies to reduce urban heat effect is context specific. In a tristate study –Atlanta, Philadelphia and Phoenix – analyzing heat related mortalities revealed that albedo enhancements were more efficient in arid areas like Phoenix and vegetative measures were more effective in humid regions like Philadelphia (Stone Jr et al. 2014). Overall the study found that a combination of vegetation and albedo enhancements offset projected heat related mortalities by 40-99% in all three study areas in a business as usual climate pathway for an average warm season and heat wave conditions in 2050 (Stone Jr et al. 2014).

Research also suggests that augmenting peri-urban areas has an effect on the temperatures in the City's core (Stone Jr et al. 2013). They found fully transitioning peri-urban areas around the city to a forested area to provide a cooling effect in a city's core. These results are suggestive that maintaining and protecting farmland in peri-urban areas will be more beneficial to urban climate management then progressing with suburban development (Qiu et al. 2013). Another mitigation benefit of urban vegetation is its pollution reduction properties. One of the effects of climate change has been a projected increase in urban aerosols and pollutants, which urban vegetation has been shown to reduce in densely populated areas like Newark and Camden, NJ (Solecki et al. 2005).

Additionally urban organic waste can be diverted to urban farms reducing land fill volume and emissions from landfills. Landfills constitute 18% of the United States methane emissions – third most significant contributor of methane emissions annually (EPA, 2015). Much effort has been spent on capturing methane on site and transforming it into an energy source. However diversion of organic waste away from landfills is more beneficial as it is more cost effective and will reduce greenhouse gas emissions. Urban farms can be instrumental in city wide curbside composting programs. The increased organic matter in the soils will improve soil hydrology and increase water retention properties (O'Neal et al. 2005).

While it is currently unsupported, the researchers also hypothesize that the carbon sequestration properties of agriculture will apply to urban agriculture. Urban agriculture's smaller size and non-mechanized production system saves it from the pitfalls of industrialized agriculture and hence mean emissions from small scale urban agriculture enterprises are probably offset by its mitigation properties.

Urban agriculture's adaptive potential

Beyond its urban heat and pollution reduction properties, urban agriculture can also play a role in flood and storm water management. The Midwest is expected to experience heavy precipitation events that will exacerbate poorly maintained CSO systems causing contamination of waterways and localized flooding events. As more and more precipitation is lost as runoff from built up spaces – as much as five time more precipitation is lost as runoff in urban spaces than in forested areas (EPA 2015), it reduces the rate of groundwater recharge adversely affecting water supply in arid regions and regions that rely primarily on groundwater (Barlage et al. 2002). Runoff increases the stress that city sewers face under storm events. Surface runoff from urban systems is one of the leading causes of lake and estuary health impairment in the Unites States (EPA 2015).

Research has shown vegetation and augmenting roofs as green spaces can help reduce surface runoff and reduce pressure on CSO's during precipitation events (Stovin 2010, Gómez-Baggethun and Barton 2013). Urban agriculture has been overlooked in this regard but we apply research from green roofs – roofs that have been retrofitted with soil layers and plants to intercept and hold precipitation – to illustrate urban agriculture's potential in storm water management.

Given that the structure and design of green roofs are similar to that of urban agriculture, it is appropriate to draw from this literature to demonstrate urban agriculture's potential beyond increasing food security. Green roofs intercept and store water, returning it to the atmosphere through evaporation and/or transpiration as would crop cover in urban agriculture (Stovin 2010, Carter and Jackson 2007).

Research into green roofs and ground vegetation shows that these measures are conducive to storm water management, and groundwater recharge. Green roofs reduced peak flow volumes by as much as 26% in a study in Athens, GA (Carter and Jackson 2007). Carter and Jackson (2006) also find that green roofs in the study had the same precipitation interception potential as forested areas. Similar results emanate from research in the U.K where vegetated roofs have been shown to retain as much as 34% of the precipitation on average over 11 precipitation events in the spring of 2006 (Stovin 2010). In the same study Stovin (2010) demonstrated a 59.6% reduction in peak flows using vegetated green roof technology.

Another experimental study in Detroit highlights the runoff attenuation property of vegetated green roofs (VanWoert et al. 2005). In all experimental setups the vegetated beds retained more precipitation – almost twice the amount than gravel beds - over the 14 months than the gravel beds (VanWoert et al. 2005). The vegetation also slowed down flow of runoff

which reduced the risks of flood events downstream (VanWoert et al. 2005). Evidence from research in Dayton, Ohio suggests that increasing vegetation reduced runoff into the city's storm sewer systems by as much as 7% (Sanders 1986). Sanders (1986) also finds that when existing vegetation is removed, runoff from storm events can increase by 2% in the city of Dayton. A study in Sweden found ground vegetation helped reduce runoff significantly. Without vegetation the city was losing up to 60% of precipitation as runoff – in vegetated areas only 5-15% of precipitation was lost as runoff, the remainder was intercepted and evaporated through natural process or infiltrated the soil (Bernatzky 1983). The reduced peak flows and runoff are important factors in abating flood events and sedimentation (Bernatzky 1983).

Increasing food security: Drawing from food systems literature we find urban agriculture provides numerous opportunities to increase food security within urban environments (Dubbeling and de Zeeuw 2011, Corrigan 2011, Armstrong 2000, Lovell 2010). The most famous example comes from Havana, Cuba where its urban gardens are documented to supply the city with 8,500 tons of agricultural produce, 4 million dozens of flowers, 7.5 million eggs, and 3,650 tons of meat (Altieri et al. 1999). Urban farming developed as a social response to alleviate incomes loses from trade embargos when the socialist bloc fell (Altieri et al. 1999). While urban farms do not produce all the food and nutritional requirements of the city, the farms buffer the city population against economic shocks and supply residents with a steady flow of nutrients. Qualitative assessment of urban agriculture's effect on food security in the United States has also produced similar results (Corrigan 2011, Armstrong 2000). A study of community gardens in Baltimore, Maryland showed that food security of all individuals involved in the community garden was improved (Corrigan 2011). The gardeners reported they obtain almost all their vegetables from the gardens and have not visited the markets for years (Corrigan 2011). The garden produces excess fruits and vegetables which is donated by gardeners to various service organizations in Baltimore – hence contributing to improving food security of not just the gardeners but other vulnerable populations in the city (Corrigan 2011).

Similarly survey of twenty rural and urban community gardens in upstate New York showed that the most prevalent reason for participation in the garden was access to fresh foods (Armstrong 2000). The gardens also served as the primary food source for low income households (Armstrong 2000). A quantitative analysis of urban agriculture and its impact on nutrition in 15 countries across Africa, Asia, Latin America and Europe showed that the presence of urban agriculture was associated with higher levels of calorie availability and greater dietary diversity (Zezza and Tasciotti 2010). The literature highlights that most of those engaged in urban agriculture come from low socio-economic backgrounds (Zezza and Tasciotti 2010, Corrigan 2011). In many instances urban agriculture offers individuals an opportunity to generate additional income. Zoning and garden policy prohibits selling produce in many localities (Armstrong 2000).Which is why strong linkages between urban agriculture and income generation has not been demonstrated empirically. Zezza and Tasciotti (2010) found that while urban agriculture shored up food security, there was minimal impact on income generation from these activities. Similarly in upstate New York very few gardeners in the study sold their produce, many were prohibited from doing so and others were more interested in growing food for personal consumption rather than retail (Armstrong 2000). However additional income that is generated by urban agriculture provides increased resiliency in times of economic and climatic shocks. The cross-section of studies presented illustrate the importance of urban agriculture to vulnerable urban populations by diversifying their food sources, increasing access to more healthful and nutritious food – especially in inner cities where choices are limited – and providing alternative sources of food during economic lulls and scarcity.

Urban agriculture: Beyond environmental services

Provision of environmental services in mitigating and adapting to climate impacts is only half the picture – benefits of urban farming transcends environmental flows. Engagement in urban farming has been shown to improve social cohesion, reclaim vacant lots to build positive and productive spaces within neighborhoods and provide numerous health benefits (Poulsen et al. 2014, Bellows, Brown, and Smit 2003, Brown and Jameton 2000, Brown et al. 2004, Hung 2004, Wakefield et al. 2007). Urban farming spaces offer communities a platform to build "a sense of unity", strengthen social bonds and reconstruct a positive narrative of their neighborhoods (Poulsen et al. 2014). This process of engagement and reclaiming neighborhoods brings with it a sense of pride and social empowerment (Poulsen et al. 2014). In neighborhoods marked by blight, turning vacant lots into productive spaces is useful in spurring economic investment (Raja et al. 2008).

As more people engage in gardening it brings more "eyes on the streets", creating positive and safe places within violent neighborhoods. Having a safe space for youths in these neighborhoods is especially important to counter the cycle of violence and poverty (Poulsen et al. 2014, Hung 2004). Urban farming spaces are also instrumental in improving health and nutrition of gardeners (Armstrong 2000, Bellows, Brown, and Smit 2003, Brown and Jameton 2000). Research has indicated that those who participate in gardening and growing food are more likely to eat more fruits and vegetables, and be more willing to try new foods than those who do not (Alaimo et al. 2008, Ober Allen et al. 2008, Lautenschlager and Smith 2007, Pothukuchi 2004). The literature also indicates gardening enhances physical and mental well-being as it triggers illness prevention and healing responses (Bellows, Brown, and Smit 2003, Brown and Jameton 2000). Urban farm programming have also been instrumental in developing youth self-efficacy and knowledge of food and nutrition (Pothukuchi 2004, Hung 2004). All in all urban agriculture presents to planners a low regret strategy that has a positive net effect on communities and their well-being.

Urban agriculture: A no regret strategy for climate mitigation and adaptation

The synthesis clearly demonstrates urban agriculture deserves recognition within the climate management regime for its mitigation and adaptation properties. The IPCC called on urban areas to use low regret strategies to deal with storm water management and urban heat abatement (Revi et al. 2014). Urban agriculture is clearly a winner. Urban agriculture is a no regrets measure that can help cities attend to multiple challenges. Cities do not need to invest in infrastructure to institute urban farming – most cities are teeming with interest from community groups to take up gardening. What cities need is a regulatory framework that is conducive to urban agriculture. This constitutes allowing urban agriculture to be a permitted land use in the city, recognizing the city's commitment to urban agriculture in its comprehensive plans, putting in place the necessary institutional support to fast track applications for use of vacant land for the purposes of growing food. For the purposes of climate management urban agriculture needs to be articulated within the CAP as a mitigation and adaptation measure to ensure the implementing agencies do not preclude it on the basis of an ongoing activity. Using Cleveland as an example the researchers demonstrate how one city is turning its problems into opportunities.

Cleveland's efforts in integrating urban agriculture in city planning

City of Cleveland occupies the northeast portion of Cuyahoga County – the most populous county in Ohio (Mayor's Office of Sustainability 2013). The city has lost approximately 50% of its population since 1950, with further population decreases persisting (Cleveland City Planning Commission 2007). More recently, Cleveland's population decreased further by 1.7% - dropping from 396, 697 in 2010 to 390,113 by 2013 (U.S. Census Bureau 2015). The population decline

creating high levels of vacancy has led to 17,000 vacant lots in the City encompassing 3,300 acres (Cleveland City Planning Commission 2007). The city is predominantly African American (53%), where median household income averages around $26, 217 and 35% live in poverty (U.S. Census Bureau 2015). Studies also demonstrate food insecurity to be a problem – 18.2% of Cuyahoga county residents were food insecure (Cuyahoga County Job and Family Services 2014) and the Cleveland food bank estimated 332,420 individuals in its service area to be in need. Given these statistics, social vulnerability ranks high.

Cleveland has been important in the evolution of planning practice. In a dispute involving Euclid – a suburb of Cleveland and Ambler reality, zoning first found legal standing (Korngold 2000). In Euclid v. Ambler (1926) the Supreme Court ruled in favor of Euclid declaring zoning ordinances were an act of police power that have been delegated to local jurisdictions for the protection of public welfare as required by the doctrine of nuisance (Korngold 2000). Almost a century later Cleveland recognizing the importance of urban agriculture to its urban fabric became the first municipality to recognize urban agriculture as a permitted land use (Cleveland/Cuyahoga County Food Policy Coalition). Currently Cleveland has more than 185 community gardens and 22 market gardens (Cleveland/Cuyahoga County Food Policy Coalition). Cleveland is also served by a food policy council since 2007: the Cleveland – Cuyahoga county food policy coalition. Support for urban agriculture is detailed in its zoning ordinances.

Zoning Ordinances

Cleveland is a home rule jurisdiction hence local government legislation, ordinances and policies have the greatest weight of the law. Cleveland gained national spotlight when it became the first city in the United States in 2007 to create an "Urban Garden District" (Cleveland/Cuyahoga County Food Policy Coalition) – the first zoning designation for urban gardens as captured in Section 336 of the city's zoning code - to "ensure that urban garden areas are appropriately located and protected to meet needs for local food production, community health, community education, garden-related job training, environmental enhancement, preservation of green space, and community enjoyment on sites for which urban gardens represent the highest and best use for the community."

The ordinance safeguards the parcels developed as gardens/farms from development requiring all future development proposals to be scrutinized by the public through a public dialogue process (2007). Though this does not assure permanence it puts in place safeguards that give gardener's tenure of the land more security. Tenure is a tenacious issue in urban agriculture which Cleveland has tried to support to the advantage of the farmers/gardeners. The city has also allocated resources to promote food production while the Cuyahoga Land Bank has given the residents 120 vacant lots to use for this purpose (Cleveland/Cuyahoga County Food Policy Coalition).

In 2010, Cleveland updated its zoning code allowing agriculture to become a permitted land use in all residential districts (2010). Sale of produce from farm stands in residential districts is permitted but is a conditional land use subject to approval from the Board of Zoning appeals (2010). The updated ordinance also permits composting onsite and the sale of value added products – processed value added products are subject to oversight from the Department of Health (2010). There is a height restriction of 15 feet for all farm infrastructure – sheds, greenhouses, coops, cages, beehives, hoop houses, cold frames, barns, rain barrels, composting, farm stands (2010).

The keeping of chickens, ducks, rabbits, goats, pigs, sheep and bees is regulated as a special use (2010, 2009). Section 347 governs the number of each of these animals that can be kept on residential properties and the required space requirements for each. The ordinance

allows for the slaughtering of chickens, ducks and rabbits on site but not sheep, goats and pigs (2009). For those with bee hives, the ordinance requires supply of fresh water on site (2009).

Cleveland is additionally currently considering legislating an Urban Agriculture Overlay (UAO) District (City of Cleveland). The language in the proposed UAO District combines the permitted uses of agriculture in residentially zoned areas with that of the urban garden district. The new overlay district will make it possible for parcels zoned residential or other wise to be used for urban farming (City of Cleveland). In the garden district keeping of animals, slaughtering and composting is restricted (City of Cleveland). Working with the food policy council Cleveland agreed to remove the $1 million commercial liability clause for the use of land bank lots (Cleveland/Cuyahoga County Food Policy Coalition). The Food policy council also worked with Cleveland Division of Water works to develop an urban agriculture water policy that secures water supply at low costs for Cleveland's urban farms and gardens (Cleveland/Cuyahoga County Food Policy Coalition). Cleveland has secured urban agriculture as a permitted land use and put in the necessary institutional supports through these measures promoting large scale agriculture within the city above and beyond most other rustbelt cities.

Comprehensive plan

Despite Cleveland's overt support for urban agriculture and a systemic view of food, the comprehensive plan has no mention of either. The plan calls for preserving land for community gardens but leaves room for speculation if that includes large scale urban farming efforts currently underway in Cleveland such as: Ohio City Farm, Stanard Farm, Kinsman Farm and Chateau Hough to name a few. While zoning codifies land uses, the comprehensive plan directs development and leverages dollars for development. Without clear articulation of urban agriculture and food systems in the plan, the comprehensive plan is a missed opportunity to establish Cleveland as a clear front runner in innovative planning.

Climate Action Planning in Cleveland

Cleveland is in the process of updating its climate action plan. Cleveland's CAP is innovative because it includes adaptation along with mitigation goals and recognizes urban agriculture as both a mitigation and adaptation measure ((Mayor's Office of Sustainability 2013). Inclusion of adaptation is considered innovative since evidence suggests municipal governments prioritize mitigation over adaptation despite evidence suggesting it is easier to get public buy in for adaptation – mitigation tends to include regulating industry and commerce while adaptation involves working with the public to increase resiliency (Baynham and Stevens 2014). Research shows cities preclude adaptation from plans due to lack of resources, information and expertise (Richardson and Horton, 2010). However given the increase in extreme events and high likelihood of the trend continuing throughout this century it is pertinent cities prepare to adapt.

In terms of mitigation Cleveland has pledged to reduce GHG by 80% below baseline emissions by 2050, with interim goals of 16% reduction by 2020 and 40% reduction by 2030 (Mayor's Office of Sustainability 2013). The plan additionally recognizes land based drivers of climate change and has a dedicated chapter on land use mitigation options. Stone et al (2012) suggest without integrating land-based drivers of climate change, CAP's will have little success in reducing warming in urban areas. The CAP does not state goals related to adaptation, however adaptation is integrated along with mitigation in each of its 6 focus areas: energy efficiency & green building, advanced & renewable energy, sustainable mobility, waste reduction & resource conservation, sustainable land use & clean water and community engagement & public health. Each measure is labelled as one or the other and where appropriate it is indicated that the action fulfills both goals.

The CAP recognizes scaling up local food production as an adaptation and mitigation action – Action 28 in the CAP. Mitigation under action 28 constitutes reduction of emissions from urban agriculture's sequestration properties and a reduction in food miles in transporting food into the city (Mayor's Office of Sustainability 2013). Adaptation is not explicitly referenced; while the action describes increased food access for city residents (determinant of food security), and storage and filtering of water, it does not explicitly describe these actions as being adaptive. This trend is visible throughout the plan – mitigation aspects are spelt out but adaptive aspects of the actions are not.

Takeaway for planning efforts

Synthesis of the literature along with Cleveland's experience in climate management details how urban agriculture can be a permitted land use. Political support for urban agriculture can be leveraged by demonstrating its multi-functionality as highlighted in this literature review. Urban agriculture is a low-regret strategy that can easily be implemented provided an enabling regulatory framework such as Cleveland's exists. More so the review points out planners need to pay attention to both aspects of climate management – mitigation and adaptation.

1. *Planners should be planning to mitigate and adapt urban environments to climate change:* All evidence points to a warming climate despite current and future efforts to reduce emissions. The inevitably of climate impacts is upon us as described in the review. In the U.S., cities have been the first to answer this call to action. While much progress has been in the development of CAP's or emission reduction plans, adaptation for the most part has been overlooked. The review demonstrates an urgency to act and protect the citizenry which cannot be achieved without actions for adaptation being articulated in the CAP's. Community action could bring about some adaptation but the scale and cost of most adaptation actions require long term planning.
2. *Urban agriculture is a low regret strategy for both mitigation and adaptation:* Adaptation measures can be expensive to institute especially when cities have the dual burden of mitigation and adaption. Low cost strategies that address both needs are critical for climate management within urban areas especially in resource poor cities. Urban agriculture embodies all of these aspects and has strong community support in most cities in the United States. Urban agriculture has been tried and tested unlike new technology, cities have guidelines that can help lay the ground work.
3. *Urban agriculture requires regulation not infrastructure:* While the city does not need to invest in expensive infrastructure it does need to create an enabling regulatory environment. Urban agriculture needs to be codified – CAP's can push for codification if it does not already exist – permitting process should be in place, tenure and liability issues need to be ironed out and water supply secured for local production of food. Cleveland has been at the forefront of the urban agriculture movement and other cities can use their experience to their advantage. Cleveland's CAP is also exemplary providing a roadmap for the next generation of CAP's to use.

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