Chapter 8: Environment and Health

Introduction

Overview

In the past three chapters, NOACA staff have illustrated how the evolution of the region's transportation network shaped the economy, housing, and land use for Northeast Ohio. This chapter focuses on the relationships between the same transportation network and the region's environment (water quality, air quality, and resilience to climate change) and health. As NOACA serves the region for both transportation and environmental planning, this plan integrates transportation, air quality, and water quality in a manner consistent with the priorities of NOACA as an Areawide agency.[1]

Within this chapter are several discussions centered on the equity and environmental justice outcomes of planning related to water quality, air quality, and climate resilience. Proposed future transportation scenarios will affect the region's air and water resources both directly and indirectly. Planning for the future requires consideration of strategies to develop resilience to, and mitigation for, regional effects of climate change.

What Role Can NOACA Play?

One of the five goals specified in NOACA's vision statement is "enhance quality of life." Embedded within the achievement of that goal are the attributes of the natural environment and human health. Furthermore, there are numerous objectives under this and other goals in NOACA's Regional Strategic Plan that specifically address them:

- Foster collaboration on issues of transportation, air and water quality that will lead to greater regional cohesion and cooperation on other issues of regional concern
- reduce energy use and improve air quality
- reduce greenhouse gas emissions
- engage in regional efforts to control stormwater, protect and improve water quality, and control development in floodplains
- enhance the public's access to and enjoyment of the region's parks, cultural assets and recreational activities
- preserve agricultural lands, open space and important habitat areas, woodlands, and wetlands
- promote healthy and active living

NOACA strives to fulfill its vision through attainment of these objectives. While NOACA does not, and cannot, regulate environmental quality within and across Northeast Ohio jurisdictions, staff can certainly inform its Board and community stakeholders about the impacts of local decisions. NOACA can also apprise the public about current conditions and both their causes and relationships to one another.

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[1] Areawide Councils of Governments act as the lead planning agencies in 24 Ohio counties (those with large urban populations). These Areawide Agencies prepare and approve the 208 Plan in their counties. The State of Ohio prepares and maintains the 208 Plan applicable in the remaining 64 counties. The Governor then certifies the entire 208 Plan via submission to US EPA for their approval (accessed 4.17.2021 from Ohio EPA (https://www.epa.ohio.gov/dsw/mgmtplans/208index)).

Environmental Justice and Equity

"Environmental Justice" is the federally mandated embodiment of the concept of equity among communities. Equity can only be achieved with the involvement of all stakeholders in decision making, especially when they bear the impacts that result from policies, programs, and projects. Negative impacts of development, industry, and natural processes disproportionately harm select communities, which results in reduced quality of life across income levels and ethnicities. While this chapter focuses on environmental quality and health outcomes related to air and water resources, environmental justice reflects equity on a broader scale and is central to *eNEO2050*. This section examines these issues and also reflects on the different perspectives of those who live inside and outside Environmental Justice Areas, per NOACA's Regional Survey (see Chapter 4).

Environmental Justice and Water Quality

As part the engagement process, the NOACA Regional Survey (Chapter 4) asked respondents whether they agreed or disagreed with the following two statements: 1) "The water I drink is clean," and 2) "The water in Northeast Ohio's rivers and lakes is clean." Tables 8-1 through 8-4 illustrate respondents' level of agreement or disagreement with these two statements. For each set of responses, the survey consultant broke out the responses by: 1) whether respondents lived inside or outside an Environmental Justice area, and 2) the income/race group to which respondents belonged.

Table 8-1. NOACA Regional Survey Response to Statement "The Water I Drink is Clean" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: The water I drink is clean	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	**2,431**	**1,163**	**1,233**
Strongly Agree (5)	39.12%	32.24%	45.99%
Somewhat Agree (4)	36.36%	35.43%	37.15%
Neutral (3)	15.14%	19.17%	11.27%
Somewhat Disagree (2)	6.58%	9.54%	3.57%
Strongly Disagree (1)	2.80%	3.61%	2.03%
	100%	*100%*	*100%*
MEAN	4.02	3.83	4.21
Monthly Investment in cleaner water	$13.56	$15.93	$10.88

Table 8-2. NOACA Regional Survey Response to Statement "The Water I Drink is Clean" (by Income/Race Group)

		The water I drink is clean			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	2,431	1,218	537	220	239
Strongly Agree (5)	39.12%	45.16%	33.33%	31.82%	29.41%
Somewhat Agree (4)	36.36%	37.44%	37.24%	33.64%	32.77%
Neutral (3)	15.14%	11.49%	17.69%	21.36%	21.85%
Somewhat Disagree (2)	6.58%	4.52%	7.82%	8.64%	10.92%
Strongly Disagree (1)	2.80%	1.40%	3.91%	4.55%	5.04%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	4.02	4.20	3.88	3.80	3.71
Monthly Investment in cleaner water	$13.56	$10.12	$13.03	$19.45	$22.74

Tables 8-1 and 8-2 show there is general agreement in Northeast Ohio that consumed water is clean; however, there are some differences in the strength of that agreement, as indicated by the mean response scores in the tables. Table 8-1 shows stronger agreement from respondents outside Environmental Justice Areas (83% agree) than respondents inside Environmental Justice Areas (66% agree). Table 8-2 shows strongest agreement (83%) among respondents classified as "higher-income white" and weakest agreement (62%) among respondents classified as "lower-income nonwhite."

Table 8-3. NOACA Regional Survey Response to Statement "The Water in Northeast Ohio's Rivers and Lakes is Clean" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: The water in Northeast Ohio's rivers and lakes is clean	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	2,429	1,163	1,231
Strongly Agree (5)	13.22%	12.55%	13.89%
Somewhat Agree (4)	34.71%	30.18%	38.83%
Neutral (3)	27.34%	28.03%	27.05%
Somewhat Disagree (2)	17.83%	20.03%	16.08%
Strongly Disagree (1)	6.92%	9.20%	4.14%
	100%	*100%*	*100%*
MEAN	3.29	3.17	3.42
Monthly Investment in cleaner rivers and lakes	$13.57	$15.49	$11.30

Table 8-4. NOACA Regional Survey Response to Statement "The Water in Northeast Ohio's Rivers and Lakes is Clean" (by Income/Race Group)

		The water in Northeast Ohio's rivers and lakes is clean			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	2,429	1,217	537	220	239
Strongly Agree (5)	13.22%	13.72%	10.06%	15.45%	14.64%
Somewhat Agree (4)	34.71%	40.92%	32.03%	26.36%	23.01%
Neutral (3)	27.34%	25.88%	30.35%	24.09%	27.20%
Somewhat Disagree (2)	17.83%	15.78%	20.11%	21.36%	23.43%
Strongly Disagree (1)	6.92%	3.70%	7.45%	12.73%	11.72%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	3.29	3.45	3.17	3.10	3.05
Monthly Investment in cleaner water	$13.57	$10.39	$12.46	$17.77	$22.91

Tables 8-3 and 8-4 show there is less agreement in Northeast Ohio that regional surface waters are clean, compared with drinking water. Furthermore, there are differences in the strength of that agreement, as indicated by the mean response scores in the tables. Table 8-3 shows stronger agreement from respondents outside Environmental Justice Areas (53% agree) than respondents inside Environmental Justice Areas (43% agree). Table 8-4 shows strongest agreement (55%) among respondents classified as "higher-income white" and weakest agreement (38%) among respondents classified as "lower-income nonwhite." Nearly as many lower-income nonwhite respondents disagree (35%) with this statement as agree. The takeaway from these four tables is that: 1) Northeast Ohio respondents feel regional surface waters are not as clean as their drinking water; and 2) there is a substantial difference in perception toward water quality based on income and race.

Everyone lives in a watershed. Levels of protection for water resources within a watershed vary based on location and surrounding land uses. Several watersheds and subwatersheds within Northeast Ohio suffer from a legacy of pollution from industrial and urban sources. These legacies negatively impact both urban and rural Environmental Justice Areas. For urban communities, water quality concerns often focus on point source pollution at known discharge locations connected to industry and utilities. While these concerns also exist within suburban and rural communities, non-point source pollution (e.g. stormwater runoff) is of high concern. Newly or recently developed areas with significant increases in impervious surface exacerbate the polluting effects of rainfall that carries pollutants into nearby streams, rivers, and lakes. If not mitigated, runoff pollution may also impact the urban areas frequently downstream from suburban and rural headwaters.

The good news is that Northeast Ohio individuals believe they can positively influence their water quality through individual actions. The NOACA Regional Survey asked respondents whether their individual actions can improve both drinking water and surface water quality (see Tables 8-5 through 8-8).

Table 8-5. NOACA Regional Survey Response to Statement "Actions I Take as An Individual can Improve Drinking Water in Northeast Ohio" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: Actions I take as an individual can improve drinking water in Northeast Ohio	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	**2,431**	**1,163**	**1,233**
Strongly Agree (5)	24.72%	22.87%	26.12%
Somewhat Agree (4)	33.69%	32.93%	34.55%
Neutral (3)	29.04%	29.92%	28.47%
Somewhat Disagree (2)	7.73%	14.27%	6.97%
Strongly Disagree (1)	4.81%	8.77%	3.89%
	100%	*100%*	*100%*
MEAN	3.66	3.59	3.72

Table 8-6. NOACA Regional Survey Response to Statement "Actions I Take as An Individual can Improve Drinking Water in Northeast Ohio" (by Income/Race Group)

		Actions I take as an individual can improve drinking water in Northeast Ohio			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	**2,431**	**1,217**	**537**	**220**	**239**
Strongly Agree (5)	24.72%	25.80%	22.35%	25.45%	23.01%
Somewhat Agree (4)	33.69%	35.09%	34.45%	30.91%	29.71%
Neutral (3)	29.04%	26.95%	31.47%	27.73%	33.47%
Somewhat Disagree (2)	7.73%	8.55%	6.33%	9.09%	6.69%
Strongly Disagree (1)	4.81%	3.62%	5.40%	6.82%	7.11%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	3.66	3.71	3.62	3.59	3.55

Tables 8-5 and 8-6 show there is general agreement in Northeast Ohio that individuals feel empowered to improve the quality of drinking water through their actions. Table 8-5 shows slightly stronger agreement from respondents outside Environmental Justice Areas (61% agree) than respondents inside Environmental Justice Areas (56% agree). Table 8-6 also shows slightly stronger agreement among respondents classified as "higher-income white" (61% agree) than among respondents classified as "lower-income nonwhite" (53% agree).

Table 8-7. NOACA Regional Survey Response to Statement "Actions I Take as An Individual can Improve Northeast Ohio's Rivers and Lakes" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: Actions I take as an individual can improve Northeast Ohio's rivers and lakes	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	2,431	1,163	1,233
Strongly Agree (5)	27.77%	26.05%	28.95%
Somewhat Agree (4)	36.90%	34.65%	39.01%
Neutral (3)	25.50%	27.86%	23.52%
Somewhat Disagree (2)	6.62%	7.65%	5.84%
Strongly Disagree (1)	3.21%	3.78%	2.68%
	100%	*100%*	*100%*
MEAN	3.79	3.72	3.86

Table 8-8. NOACA Regional Survey Response to Statement "Actions I Take as an Individual can Improve Northeast Ohio's Rivers and Lakes" (by Income/Race Group)

		Actions I take as an individual can improve Northeast Ohio's rivers and lakes			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	2,431	1,218	537	219	239
Strongly Agree (5)	27.77%	28.65%	26.82%	31.05%	22.18%
Somewhat Agree (4)	36.90%	39.33%	36.69%	31.51%	32.22%
Neutral (3)	25.50%	22.74%	27.56%	26.48%	34.31%
Somewhat Disagree (2)	6.62%	6.98%	5.59%	6.85%	5.44%
Strongly Disagree (1)	3.21%	2.30%	3.35%	4.11%	5.86%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	3.79	3.85	3.78	3.79	3.59

Tables 8-7 and 8-8 further demonstrate there is general agreement in Northeast Ohio that individuals feel empowered to positively influence the quality of the region's rivers and lakes through their own actions as individuals. Table 8-7 shows slightly stronger agreement from respondents outside Environmental Justice Areas (68% agree) than respondents inside Environmental Justice Areas (61% agree). Table 8-8 also shows slightly stronger agreement among respondents classified as "higher-income white" (68% agree) than among respondents classified as "lower-income nonwhite" (54% agree).

Environmental Justice and Air Quality

The NOACA Regional Survey asked respondents whether they agreed or disagreed with the following statement: "The outdoor air where I live is clean." Tables 8-9 and 8-10 illustrate respondents' level of agreement or disagreement with this statement. For each set of responses, the survey consultant broke out the responses by: 1) whether respondents lived inside or outside an Environmental Justice area; and 2) the income/race group to which respondents belonged.

Table 8-9. NOACA Regional Survey Response to Statement "The Air Where I Live is Clean" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: The outdoor air where I live is clean	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	**2,432**	**1,164**	**1,233**
Strongly Agree (5)	29.19%	22.16%	35.85%
Somewhat Agree (4)	43.46%	41.24%	45.99%
Neutral (3)	17.48%	22.85%	12.25%
Somewhat Disagree (2)	7.61%	10.22%	5.11%
Strongly Disagree (1)	2.26%	3.52%	0.81%
	100%	*100%*	*100%*
MEAN	3.90	3.68	4.11
Monthly Investment in cleaner air	$12.73	$14.84	$10.32

Table 8-10. NOACA Regional Survey Response to Statement "The Air Where I Live is Clean" (by Income/Race Group)

		The outdoor air where I live is clean			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	**2,432**	**1,218**	**537**	**220**	**239**
Strongly Agree (5)	29.19%	32.68%	27.00%	22.73%	21.76%
Somewhat Agree (4)	43.46%	47.87%	39.85%	39.09%	36.82%
Neutral (3)	17.48%	13.22%	20.86%	22.27%	25.52%
Somewhat Disagree (2)	7.61%	5.25%	9.68%	11.82%	10.88%
Strongly Disagree (1)	2.26%	0.99%	2.61%	4.09%	5.02%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	3.90	4.06	3.79	3.65	3.59
Monthly Investment in cleaner air	$12.73	$9.29	$11.99	$19.78	$21.55

Tables 8-9 and 8-10 show there is general agreement in Northeast Ohio that outdoor air is clean; however, there are some differences in the strength of that agreement, as indicated by the mean response scores in the tables. Table 8-9 shows stronger agreement from respondents outside Environmental Justice Areas (72% agree) than respondents inside Environmental Justice Areas (63% agree). Table 8-10 shows strongest agreement among respondents classified as "higher-income white" (81%) and weakest agreement among respondents classified as "lower-income nonwhite" (59%).

Air pollution is a global burden, one that the World Health Organization (WHO) has called the greatest environmental health risk.[2] But that burden is not borne equally, and it plays out through existing structural inequities. There is a clear connection between land-use patterns and individual exposure to air pollution. The durability of land-use patterns prolongs the impacts of land-use decisions for decades (see Chapter 7). The Interstate Highway System (see Chapter 6) disproportionately harmed low-income and minority neighborhoods, displacing thousands of families and damaging local economic and cultural networks.[3] Consequently, displaced racial minorities are three times more likely to live in neighborhoods adjacent to the most heavily trafficked roads.[4] In some instances, highway construction literally cemented racial segregation through physical barriers such as urban freeways.[5]For decades, the built transportation network has contributed to and sometimes even exacerbated racial segregation. There have been severe impacts on pollution exposure and public health. Cities (e.g., Cleveland) with higher levels of segregation[6] suffer from higher levels of air pollution, and that pollution tends to harm minority populations disproportionately.[7] Communities of color are also more likely to be near locally unwanted land uses, such as landfills and hazardous waste facilities. Decision makers often site these facilities in areas with higher concentrations of racial minorities because such areas exhibited lower land values and local residents had less power to block such decisions.[8] The result is a disproportionately negative impact from air pollution on low-income and minority communities.

These disparities in exposure to air pollution all but ensure that the health burden is borne unequally as well. Whereas non-Hispanic whites are exposed to 17% less pollution than their

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[2] Diarmid Campbell-Lendrum and Annette Prüss-Ustün, Department of Public Health, Environmental and Social Determinants of Health, World Health Organization; "Climate change, air pollution and noncommunicable diseases," *Bulletin of the World Health Organization* (2019). 97:160-161.
[3] D.N. Archer, "'White Men's Roads through Black Men's Homes': Advancing Racial Equity through Highway Construction," *Vanderbilt Law Review* 73, no. 5 (2020), 1259-1330.
[4] G.M. Rowangould, "A census of the US near-roadway population: Public health and environmental justice considerations," *Transportation Research Part D* 25 (2013), 59-67.
[5] K.M. Kruse, *White Flight: Atlanta and the Making of Modern Conservatism* (Princeton, NJ: Princeton University Press, 2004). D. Kerr, *Derelict Paradise: Homelessness and Urban Development in Cleveland, Ohio* (Amherst, MA: University of Massachusetts Press, 2011), 107-108.
[6] William H. Frey, "Black-white segregation edges downward since 2000, Census shows," Brookings Institution, Dec. 17, 2018; https://www.brookings.edu/blog/the-avenue/2018/12/17/black-white-segregation-edges-downward-since-2000-census-shows/ (accessed March 16, 2021). R. Morello-Frosch & B.M. Jesdale, "Separate and Unequal: Residential Segregation and Estimated Cancer Risks Associated with Ambient Air Toxics in U.S. Metropolitan Areas," *Environmental Health Perspectives* 114, no. 3 (2006), 386-393.
[7] R. Morello-Frosch & B.M. Jesdale, "Separate and Unequal: Residential Segregation and Estimated Cancer Risks Associated with Ambient Air Toxics in U.S. Metropolitan Areas," *Environmental Health Perspectives* 114, no. 3 (2006), 386-393.
[8] P. Mohai & R. Saha, "Which came first, people or pollution? Assessing the disparate siting and post-siting demographic change hypotheses of environmental injustice," *Environmental Research Letters* 10 (2015), 11508.

consumption patterns produce, minorities (especially blacks and Latinos) endure pollution levels 56% and 63% higher than their consumption, respectively.[9] The disparity is even greater for mobile emissions. Neighborhoods with the highest shares of minority residents had nitrogen dioxide (NO_2) levels 2.7 times higher than neighborhoods with the lowest shares of minority residents in 2010.[10] Though pollution levels have fallen nationally by 73% since passage of the Clean Air Act (CAA) in 1970, these disparities have not improved. The racial gap in NO_2 levels has actually grown to 2.7 from 2.5 in 2000, even as average NO_2 concentrations fell by 37%.[11] Nationally, the Census tracts with the highest levels of fine particulate matter ($PM_{2.5}$) in 1981 remained the most heavily polluted in 2016 (similarly true for the least polluted tracts).[12]

Air pollution is most acutely harmful to vulnerable groups in Northeast Ohio. Children suffer significant health impacts from pollution exposure, even during the prenatal period based on pollution exposure endured by pregnant women. Children may suffer long-term effects from this *in utero* exposure, including higher rates of chronic illnesses such as asthma. Air pollution is also an underappreciated factor behind racial disparities in birth outcomes and infant mortality rates, one of Northeast Ohio's most acute public health crises.[13] Researchers estimate that $PM_{2.5}$ pollution is responsible for 3.3% of preterm births in the U.S., which imposes $760 million in medical costs and $4.3 billion in lost productivity among these children. Pollution can affect educational outcomes through increased absenteeism, decreased concentration, and reduced academic performance. In these ways, exposure to pollution from a young age can set children up to struggle throughout their lives. A recent study found that children exposed *in utero* to pollution from toxic sites earn 28% lower wages, are 50% more likely to depend on public assistance, are 112% more likely to drop out of high school, and are 1.5 times more likely to be disabled than their siblings who were born in different locations. The effects are particularly acute for low-income and minority (especially black and Latino) children, who are more than twice as likely to live downwind of a toxic site.

The elderly and people with existing health conditions also bear a heavy toll from air pollution, as it can exacerbate these underlying issues, reduce their quality of life, and shorten their life expectancies. Unsurprisingly, air pollution is also uniquely harmful to people of color. Black Americans are three times more likely to die from $PM_{2.5}$ exposure as the average American.[14] The economic, environmental and health costs of Northeast Ohio's air pollution is significant; improved air quality can make the region a more attractive, equitable place to live and work.

Once again, an element of good news is that Northeast Ohioans believe they can positively influence their environmental outcomes, such as improving outdoor air quality through individual

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[9] C.W. Tessum, et al. "Inequity in consumption of goods and services adds to racial–ethnic disparities in air pollution exposure," *PNAS* 116, no. 13 (2019), 6001-6006.
[10] L.P. Clark, D.B. Millet, and J.D. Marshall, "Changes in Transportation-Related Air Pollution Exposures by Race-Ethnicity and Socioeconomic Status: Outdoor Nitrogen Dioxide in the United States in 2000 and 2010," *Environmental Health Perspectives* 125, no. 9 (2017), 097012.
[11] Ibid.
[12] J. Colman, I. Hardman, I. Shimshack, and J. Voorheis, "Disparities in $PM_{2.5}$ air pollution in the United States," *Science* 369, no. 6503 (2020), 575-578. Should the 2.5 be subscript? If the original has it regular type, then leave as regular type.
[13] B. Bekkar, S. Pacheco, & R. Basu, "Association of Air Pollution and Heat Exposure with Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review," *JAMA Open Network* 3, no. 6 (2020), e208243.
[14] M.S. Qian Di, et al., "Air Pollution and Mortality in the Medicare Population," *New England Journal of Medicine* 376, no. 26 (2017), 2513-2522.

actions. The NOACA Regional Survey asked respondents whether they agreed that their individual actions can improve outdoor air quality (see Tables 8-11 and 8-12).

Table 8-11. NOACA Regional Survey Response to Statement "Actions I Take as an Individual can Improve Outdoor Air in Northeast Ohio" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: Actions I take as an individual can improve outdoor air in Northeast Ohio	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	**2,431**	**1,164**	**1,232**
Strongly Agree (5)	30.07%	28.87%	31.33%
Somewhat Agree (4)	36.73%	35.74%	37.82%
Neutral (3)	24.43%	25.86%	22.97%
Somewhat Disagree (2)	6.05%	6.53%	5.60%
Strongly Disagree (1)	2.71%	3.01%	2.27%
	100%	*100%*	*100%*
MEAN	3.85	3.81	3.90

Table 8-12. NOACA Regional Survey Response to Statement "Actions I Take as an Individual can Improve Outdoor Air in Northeast Ohio" (by Income/Race Group)

		Actions I take as an individual can improve outdoor air in Northeast Ohio			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	**2,431**	**1,218**	**537**	**220**	**239**
Strongly Agree (5)	30.07%	30.95%	30.73%	29.55%	25.94%
Somewhat Agree (4)	36.73%	38.83%	36.31%	31.82%	32.64%
Neutral (3)	24.43%	22.41%	24.39%	27.27%	30.96%
Somewhat Disagree (2)	6.05%	5.83%	5.59%	8.64%	6.69%
Strongly Disagree (1)	2.71%	1.97%	2.98%	2.73%	3.77%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	3.85	3.91	3.86	3.77	3.70

Tables 8-11 and 8-12 show there is general agreement in Northeast Ohio that individual actions can make a positive difference on outdoor air quality' however, Table 8-11 shows slightly stronger agreement from respondents outside Environmental Justice Areas (69% agree) than respondents inside Environmental Justice Areas (65% agree). Table 8-12 shows strongest agreement among respondents classified as "higher-income white" (70%) and weakest agreement among respondents classified as "lower-income nonwhite" (59%).

Environmental Justice and Climate Resilience

The NOACA Regional Survey provided respondents several statements about climate change and, for each, asked whether they agreed or disagreed:

1. Climate change is real.
2. Human behavior contributes to climate change.
3. Northeast Ohio is prepared for climate change.
4. My efforts to help will contribute to doing something about climate change.

Table 8-13 illustrates respondents' level of agreement or disagreement with these statements across NOACA's primary geographic units. Tables 8-14 through 8-17 illustrate respondents' level of agreement or disagreement with the first two statements, with responses broken out by: 1) whether respondents lived inside or outside an Environmental Justice area; and 2) the income/race group to which respondents belonged.

Table 8-13. NOACA Regional Survey Responses to Statements about Climate Change (by Geographic Unit)

	Agreement			
Climate Change *5 = Highest* *1 = Lowest*	**Climate change is real**	**Human behavior contributes**	**NEO is prepared for climate change**	**My efforts will help**
Cleveland	4.25	3.93	2.90	3.70
Cuyahoga	4.16	4.13	2.76	3.80
Lorain	4.04	4.00	2.70	3.65
Lake	4.04	4.04	2.76	3.69
Medina	3.89	3.81	2.84	3.51
Geauga	3.92	4.15	2.78	3.80
NOACA Region	4.11	4.04	2.79	3.72

Table 8-13 shows general agreement among respondents that: 1) Climate change is real; and 2) Human behavior contributes to climate change. Although there is some variation in strength of agreement among geographic units on both statements, regional scores average higher than 4.00. It is interesting to note that the City of Cleveland respondents agree most strongly with the first statement, while Geauga County respondents agree most strongly with the second statement. Medina County respondents, on the other hand, agree the least with both statements. Table 8-13 also shows general agreement among respondents that individual efforts can make a positive difference toward action about climate change. Again, Medina County respondents agree the least.

Despite agreement about the reality of the problem, Table 8-13 also shows respondents do not agree that Northeast Ohio is prepared for climate change. This disagreement is not very strong, but the sentiment is consistent across geographic units and marks a substantial gap between

problem recognition and confidence in the future. These responses help frame the problem of climate change for policy makers and elected officials in Northeast Ohio.

Table 8-14. NOACA Regional Survey Responses to Statement "Climate Change is Real" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: Climate change is real	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	**2,432**	**1,164**	**1,233**
Strongly Agree (5)	52.10%	55.58%	48.82%
Somewhat Agree (4)	20.89%	20.19%	21.49%
Neutral (3)	17.43%	16.15%	18.65%
Somewhat Disagree (2)	5.30%	5.07%	5.52%
Strongly Disagree (1)	4.28%	3.01%	5.52%
	100%	*100%*	*100%*
MEAN	4.11	4.20	4.03
Monthly Investment to reduce climate change	$14.15	$15.68	$12.34

Table 8-15. NOACA Regional Survey Responses to Statement "Climate Change is Real" (by Income/Race Group)

		Climate change is real			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	**2,432**	**1,218**	**537**	**220**	**239**
Strongly Agree (5)	52.10%	50.25%	54.75%	59.55%	48.12%
Somewhat Agree (4)	20.89%	20.03%	22.35%	21.82%	19.67%
Neutral (3)	17.43%	18.47%	14.90%	12.27%	22.59%
Somewhat Disagree (2)	5.30%	6.16%	3.35%	6.36%	5.02%
Strongly Disagree (1)	4.28%	5.09%	4.66%	0	4.60%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	4.11	4.04	4.19	4.35	4.02
Monthly Investment to reduce climate change	$14.15	$11.38	$13.39	$18.17	$20.56

Tables 8-14 and 8-15 reiterate general agreement in Northeast Ohio that climate change is real; however, there are some differences in the strength of that agreement, as indicated by the mean response scores in the tables. Table 8-14 shows stronger agreement from respondents inside Environmental Justice Areas (76% agree) than respondents outside Environmental Justice Areas (70% agree). Interestingly, Table 8-15 shows strongest agreement among respondents classified as "higher-income nonwhite" (81%) and weakest agreement among respondents classified as "lower-income nonwhite" (58%).

Table 8-16. NOACA Regional Survey Responses to Statement "Human Behavior Contributes to Climate Change" (Environmental Justice Areas versus Non-Environmental Justice Areas)

		COLUMNS: Human behavior contributes to climate change	
	NOACA Region	NOACA Environmental Justice Areas	Non-EJ
BASE	**2,428**	**1,161**	**1,232**
Strongly Agree (5)	47.08%	47.46%	47.16%
Somewhat Agree (4)	25.08%	24.72%	25.08%
Neutral (3)	17.42%	17.48%	17.29%
Somewhat Disagree (2)	5.64%	5.86%	5.36%
Strongly Disagree (1)	4.78%	4.48%	5.11%
	100%	*100%*	*100%*
MEAN	4.04	4.05	4.04

Table 8-17. NOACA Regional Survey Responses to Statement "Human Behavior Contributes to Climate Change" (by Income/Race Group)

		Human behavior contributes to climate change			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Non-white	Lower-income Non-white
BASE	**2,428**	**1,217**	**537**	**220**	**237**
Strongly Agree (5)	47.08%	47.66%	48.79%	51.36%	37.55%
Somewhat Agree (4)	25.08%	26.46%	22.53%	22.73%	26.16%
Neutral (3)	17.42%	16.02%	18.06%	17.73%	22.78%
Somewhat Disagree (2)	5.64%	4.77%	5.96%	5.91%	8.44%
Strongly Disagree (1)	4.78%	5.09%	4.66%	2.27%	5.06%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	4.04	4.07	4.05	4.15	3.83

Tables 8-16 and 8-17 reiterate general agreement in Northeast Ohio that human behavior contributes to climate change; however, there are some differences in the strength of that agreement, as indicated by the mean response scores in the tables. While Table 8-16 shows the same level of agreement from respondents inside Environmental Justice Areas and respondents outside Environmental Justice Areas (72% agree). Interestingly, Table 8-17 illustrates some differences. Table 8-17 indicates strongest agreement among respondents classified as "higher-income white" and "higher-income nonwhite" (74%) and weakest agreement among respondents classified as "lower-income nonwhite" (64%).

Although no area is immune from the negative effects of a changing climate, these effects will impact different communities disproportionately. Just as other negative environmental impacts

tend to fall more on low-income and minority neighborhoods, the same will be true for climate change. The impacts of climate change and climate-related hazards express themselves through existing socioeconomic disparities.

Two of the key facets of residential development patterns in Northeast Ohio— outward migration and racial segregation—both exacerbate the impacts of rising temperatures. While sprawling regions experienced 14.8 more extreme heat days in 2005 than in 1956 that number was only 5.6 for compact regions.[15] Segregation also exposes communities to higher levels of extreme heat. Blacks, Asians, and Latinos are, respectively, 52%, 32%, and 21% more likely to live in areas with limited tree cover and high levels of impervious surfaces.[16] The harmful effects of discriminatory zoning and land-use patterns can linger for decades; redlined neighborhoods are 2.6˚C (4.7˚C) hotter than non-redlined neighborhoods.[17] In addition to amplifying heat, lower levels of tree cover and greater impervious surface area also increase the risks of flooding during heavy precipitation events. Extreme heat takes a particularly heavy toll on black mothers, dramatically raising the incidence of pregnancy complications and preterm births.[18] Failing to tackle the climate crisis risks could widen existing inequities in Northeast Ohio.

As demonstrated earlier in Table 8-13, NOACA Regional Survey respondents disagree that Northeast Ohio is prepared for climate change. Interestingly, those communities most vulnerable to climate change impacts disagree less about the region's lack of preparation than those in better positions to withstand climate change impacts. Table 8-18 shows 22% of respondents inside Environmental Justice Areas agree Northeast Ohio is prepared for climate change, compared with only 17% outside Environmental Justice Areas (45% of both groups disagree with this statement). Table 8-19 shows 31% of lower-income nonwhite respondents agree Northeast Ohio is prepared for climate change, compared with only 16% of higher-income white respondents.

Table 8-18. NOACA Regional Survey Responses to Statement "Northeast Ohio is Prepared for Climate Change" (Environmental Justice Areas versus Non-Environmental Justice Areas)

	COLUMNS: **Northeast Ohio is prepared for climate change**

[15] B. Stone, J.J. Hess, & H. Frumkin, "Urban form and extreme heat events: are sprawling cities more vulnerable to climate change than compact cities?" *Environmental health perspectives* 118, no. 10 (2010), 1425–1428.
[16] B.M. Jesdale, R. Morello-Frosch, & L. Cushing, "The racial/ethnic distribution of heat risk-related land cover in relation to residential segregation," *Environmental health perspectives* 121, no. 7 (2013), 811–817.
[17] J.S. Hoffman, V. Shandas, & N. Pendleton, "The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas," *Climate* 8, no.1 (2020).
[18] J. Kim, A. Lee, & M. Rossin-Slater, "What to Expect When it Gets Hotter: The Impacts of Prenatal Exposure to Extreme Heat on Maternal Health," *NBER Working Paper No. w26384* (2019), https://ssrn.com/abstract=3472819 (accessed April 8, 2021). B. Bekkar, S. Pacheco, & R. Basu, "Association of Air Pollution and Heat Exposure with Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review," *JAMA Open Network* 3, no. 6 (2020), e208243.

	NOACA Region	NOACA Environmental Justice areas	Non-EJ
BASE	**2,429**	**1,162**	**1,232**
Strongly Agree (5)	7.16%	8.09%	6.17%
Somewhat Agree (4)	12.68%	14.03%	11.28%
Neutral (3)	45.08%	42.77%	47.48%
Somewhat Disagree (2)	21.74%	21.43%	22.40%
Strongly Disagree (1)	13.34%	13.68%	12.66%
	100%	*100%*	*100%*
MEAN	2.79	2.81	2.76

Table 8-19. NOACA Regional Survey Responses to Statement "Northeast Ohio is Prepared for Climate Change" (by Income/Race Group)

		Northeast Ohio is prepared for climate change			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	**2,429**	**1,216**	**537**	**219**	**239**
Strongly Agree (5)	7.16%	5.51%	6.70%	10.50%	11.72%
Somewhat Agree (4)	12.68%	10.86%	12.48%	17.35%	18.83%
Neutral (3)	45.08%	49.84%	43.20%	33.79%	41.42%
Somewhat Disagree (2)	21.74%	23.11%	21.79%	22.37%	15.06%
Strongly Disagree (1)	13.34%	10.69%	15.83%	15.98%	12.97%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	2.79	2.77	2.72	2.84	3.01

Fortunately, NOACA Regional Survey results show that respondents generally agree their individual efforts can make a difference. This is true both inside and outside Environmental Justice Areas (see Table 8-20); however, Table 8-21 indicates weaker agreement with this statement among lower-income nonwhites (51%) compared with other income/racial groups, where 60-65% agree. This may suggest that lower-income nonwhite groups still feel less empowered to make a difference and they have to rely on other organizations and leadership to mitigate climate change impacts.

Table 8-20. NOACA Regional Survey Responses to Statement "My Efforts to Help will Contribute to Doing Something about Climate Change" (Environmental Justice Areas versus Non-Environmental Justice Areas)

	COLUMNS:

		My efforts to help will contribute to doing something about climate change	
	NOACA Region	NOACA Environmental Justice areas	Non-EJ
BASE	**2,430**	**1,163**	**1,232**
Strongly Agree (5)	29.01%	30.18%	27.92%
Somewhat Agree (4)	31.40%	29.75%	32.87%
Neutral (3)	27.61%	29.06%	26.14%
Somewhat Disagree (2)	6.79%	7.05%	6.66%
Strongly Disagree (1)	5.19%	3.96%	6.41%
	100%	*100%*	*100%*
MEAN	3.72	3.75	3.69

Table 8-21. NOACA Regional Survey Responses to Statement "My Efforts to Help will Contribute to Doing Something about Climate Change" (by Income/Race Group)

		My efforts to help will contribute to doing something about climate change			
	NOACA Region	Higher-income White	Lower-income White	Higher-income Nonwhite	Lower-income Nonwhite
BASE	**2,430**	**1,217**	**536**	**220**	**239**
Strongly Agree (5)	29.01%	27.86%	29.66%	35.45%	24.27%
Somewhat Agree (4)	31.40%	32.70%	33.77%	26.36%	26.78%
Neutral (3)	27.61%	26.54%	25.37%	27.73%	35.98%
Somewhat Disagree (2)	6.79%	7.07%	6.34%	7.27%	8.37%
Strongly Disagree (1)	5.19%	5.83%	4.85%	3.18%	4.60%
	100%	*100%*	*100%*	*100%*	*100%*
MEAN	3.72	3.70	3.77	3.84	3.58

Regional Water Quality

NOACA is the federally designated areawide water quality management planning agency (Areawide) under Section 208 of the Clean Water Act.[19] NOACA plans for the five-county Northeast Ohio Lake Erie Basin (NEOLEB) area. In 2020, the NOACA Board adopted a new *Clean Water 2020* plan. *Clean Water 2020*, along with NOACA's 2017 Water Quality Strategic Plan and the Agency's Overall Work Plan (OWP) guide NOACA's water quality planning efforts.

Water Quality Plans

Water Quality Strategic Plan

[19] Cornell Law School, Legal Information Institute, 33 United States Code (U.S.C.) Section 1288, Areawide Waste Treatment Management, https://www.law.cornell.edu/uscode/text/33/1288 (accessed November 20, 2020).

NOACA's *Water Quality Strategic Plan* (*WQSP*) establishes a consensus-driven mission, goals, objectives, and strategies to guide the staff-supported work of the agency. Approved in 2017, the *WQSP* builds on current land-use and employment trends that affect water resources and infrastructure in both rural and urban communities.

In response to water quality threats, NOACA staff collaborated with stakeholders and the public to develop the following goals of the Water Quality Strategic Plan:

1. Support Work to Restore and Protect Lake Erie and the Region's Freshwater Assets
2. Promote Water's Value as a Regional Driver of Economic Competitiveness
3. Identify and Inform Communities and Organizations about Regional Impacts of Local Water Infrastructure Decisions
4. Advance the Philosophy of "One Water" through NOACA's 208 Planning Process
5. Within NOACA's Internal Structure, Consider and Address Potential Water Quality Impacts of Transportation Projects

Clean Water 2020

Clean Water 2020 is NOACA's wastewater management and water quality plan under Section 208 of the Clean Water Act (CWA).[20] The plan focuses on the protection and restoration of water resources in a region where the population has slowly declined while it has spread out over a larger area. This pattern of lower density and a larger development footprint results in higher funding demands from fewer people both to construct new infrastructure and to maintain existing, aging infrastructure. *Clean Water 2020* emphasizes optimization of existing infrastructure, minimization of development impacts associated with sanitary sewer extensions, protection of regional water quality improvements, support for watershed planning, protection and restoration of critical water resources, and support for efforts to manage stormwater runoff and on-site sewage treatment systems.

The following goals framed the development of *Clean Water 2020*:

Goal 1: Optimize investment in existing infrastructure to support existing and infill development and not encourage new development on greenfield sites.
Goal 2: Provide a framework for locally determined development density that mitigates water quality impacts.
Goal 3: Protect regional water quality gains and guide implementation measures to improve water resources that do not yet meet designated uses.
Goal 4: Support programs that address stormwater and sewage treatment systems management.
Goal 5: Protect and restore valuable water resource areas.
Goal 6: Support watershed planning activities that address point and nonpoint source pollution.
Goal 7: Educate local decision makers on regional water quality management issues.
Goal 8: Create a plan that can meet future water quality needs of Northeast Ohio.
Goal 9: Educate and solicit support for implementation of Clean Water 2020.
Goal 10: Allow flexibility in the plan to adapt to changes in future water quality needs of Northeast Ohio.

[20] Ibid.

The result is that *Clean Water 2020* is a dynamic resource that will guide Northeast Ohio through the next 20 years of wastewater management and water quality planning.

Water Quality Conditions

Since the Ohio Environmental Protection Agency (Ohio EPA) began to monitor water quality nearly 50 years ago, there has been considerable progress in the protection and restoration of water resources in Northeast Ohio. Regulations have dramatically curtailed discharge and effluent from pipes ("point" source pollution). The Cuyahoga River and the other large rivers (Black, Rocky, Chagrin, and Grand Rivers) have realized improved water quality and aquatic life conditions. Public wastewater treatment plant (WWTP) owners continue to reinvest in their facilities to maintain and improve nutrient removal processes. More than $3 billion dollars are programmed over the next several years to reduce combined sewer overflows (CSOs) in the region.[21] Numerous watershed groups actively focus on the development and implementation of plans to protect and restore water resources. Urban communities reduce impacts from stormwater runoff through enforcement of new US EPA regulations. Local health districts (LHDs) expanded their home sewage programs in areas not serviced by sanitary sewers.

Even so, local water quality problems persist, and new issues have moved to the forefront over time. Rapid exurban development, partly enabled by the region's automobile-centric transportation polices, contributes to current Northeast Ohio water quality conditions. Drinking water and wastewater infrastructure continues to expand into new areas, while the region's population slowly declines. Lake Erie's water quality had historically improved from the reduction in point source pollution, but more recently has wavered due to nonpoint source pollution from suburban, agricultural, and rural area stormwater runoff. This increased nutrient load to Lake Erie and other interior lakes leads to seasonal harmful algal blooms (HABs). HABs produce toxins that contaminate drinking water and hinder recreational opportunities.[22]

Water Resource Concerns

The quality of water resources in Northeast Ohio is the product of the natural landscape and human activities. The top five causes of impairments that affect aquatic life in Northeast Ohio are impacted habitats, sedimentation/siltation, natural flow changes, presence of metals, and high levels of nutrients. The top five sources that cause these impairments are impacted streams, stormwater runoff from developed areas, natural processes, opportunistic bacteria, and agricultural impacts. Transportation policies and decisions on water and wastewater infrastructure influence the region's development patterns that link to many of the causes and sources of stream impairments. Specifically, Northeast Ohio's sprawling development patterns have increased both impervious (hard) surfaces and the amount of wastewater infrastructure to serve a smaller population. Outmigration patterns also remove customers from existing urban sewerage systems and disturb groundwater recharge areas.

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[21] I DIDN'T SEE THIS ON THE WEBSITE LINK YOU PROVIDED. City of Elyria, "Combined Sewer Overflow," http://www.cityofelyria.org/department/wastewater/ combined-sewer-overflow/ (accessed April 8, 2021). United States and State of Ohio v. City of Euclid, Consent Decree, Case 1:11-cv-01783-JG (United States District Court for the Northern District of Ohio Eastern Division, 2008). City of Lakewood, "Combined Sewer Overflow Long-Term Control Plan Executive Summary" (Lakewood: Metcalf & Eddy of Ohio, May 2006); http://www.onelakewood.com/pdf/2007_SewerProject_LTCP_Executive_Summary.pdf (accessed April 8, 2021).CAN'T REACH THE WEBSITE TO CHECK.

[22] Alliance for the Great Lakes, "Lake Erie Algae Blooms: Polluting Our Drinking Water," https://greatlakes.org/campaigns/lake-erie-algae-blooms/ (accessed April 8, 2021).

The conversion of natural areas or agricultural lands to residential, industrial, or commercial development increases the impervious surfaces (e.g., roads, parking lots, roofs, sidewalks, etc.). From 2001 to 2016, impervious surface cover has increased in multiple Northeast Ohio Watershed Assessment Units (WAUs) (Figures 8-1 and 8-2). Multiple studies have shown increasing imperviousness harms water quality. Impervious surfaces increase the amount and speed of water runoff and lead to increased erosion and unstable streams. More runoff also brings more pollutants (e.g., nutrients, metals, bacteria, etc.) to the local waterways. Runoff over hot impervious surfaces can increase the water temperature in local waterways and deplete the dissolved oxygen for aquatic life.[23] Figure 8-3 presents the attainment status of waterways within Environmental Justice Areas along with the subwatershed imperviousness percentage. Waterways within subwatersheds characterized by higher impervious cover are more likely to result in nonattainment. Figure 8-3 also shows waterways within identified Environmental Justice Areas are also more likely to be impaired.

Figure 8-1. Northeast Ohio Impervious Surface Cover (2001)

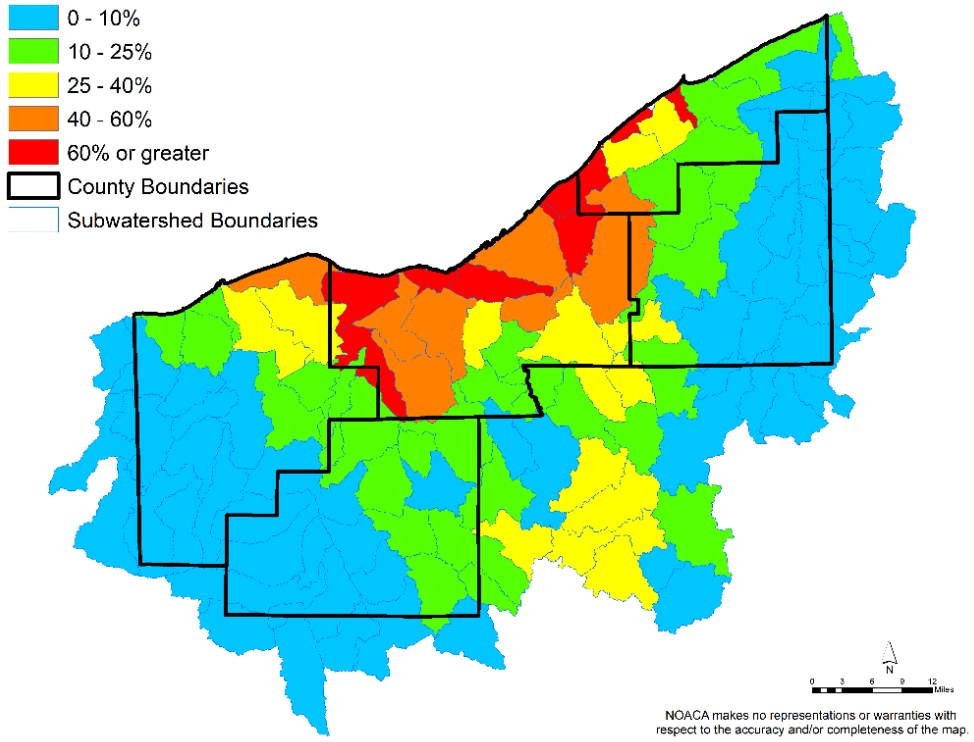


Figure 8-2. Northeast Ohio Impervious Surface Cover (2016)

[23] Ohio EPA, "Ohio 2020 Integrated Water Quality Monitoring and Assessment Report," May 2020, https://epa.ohio.gov/Portals/35/tmdl/2020intreport/2020_Final_IR_CompleteReport_May2020.pdf (accessed April 8, 2021).

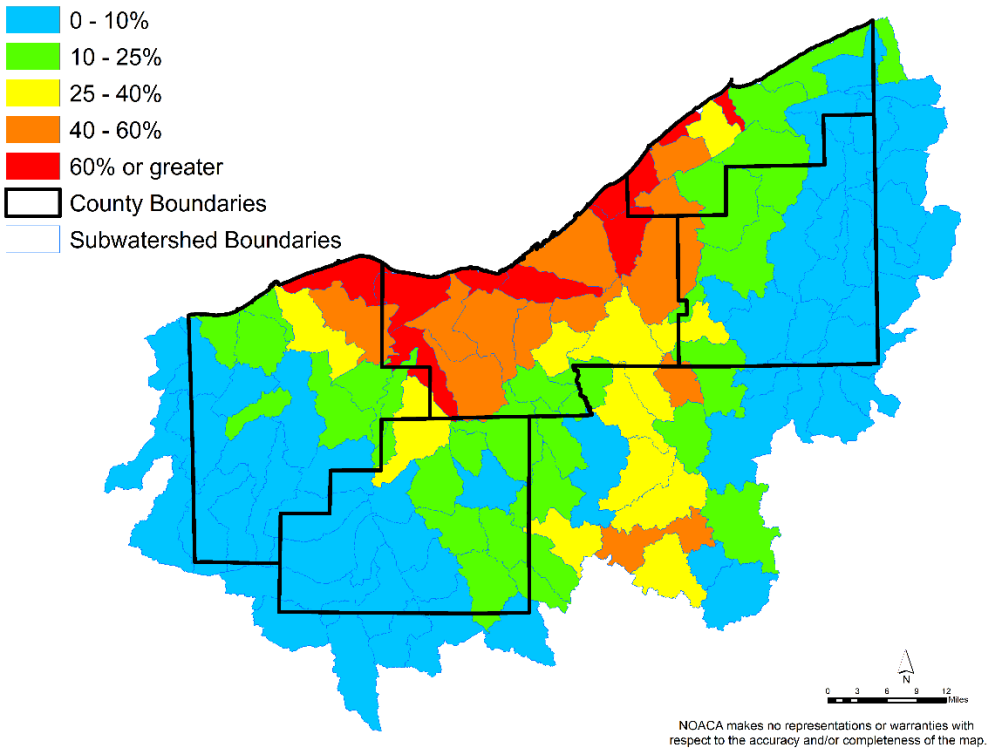
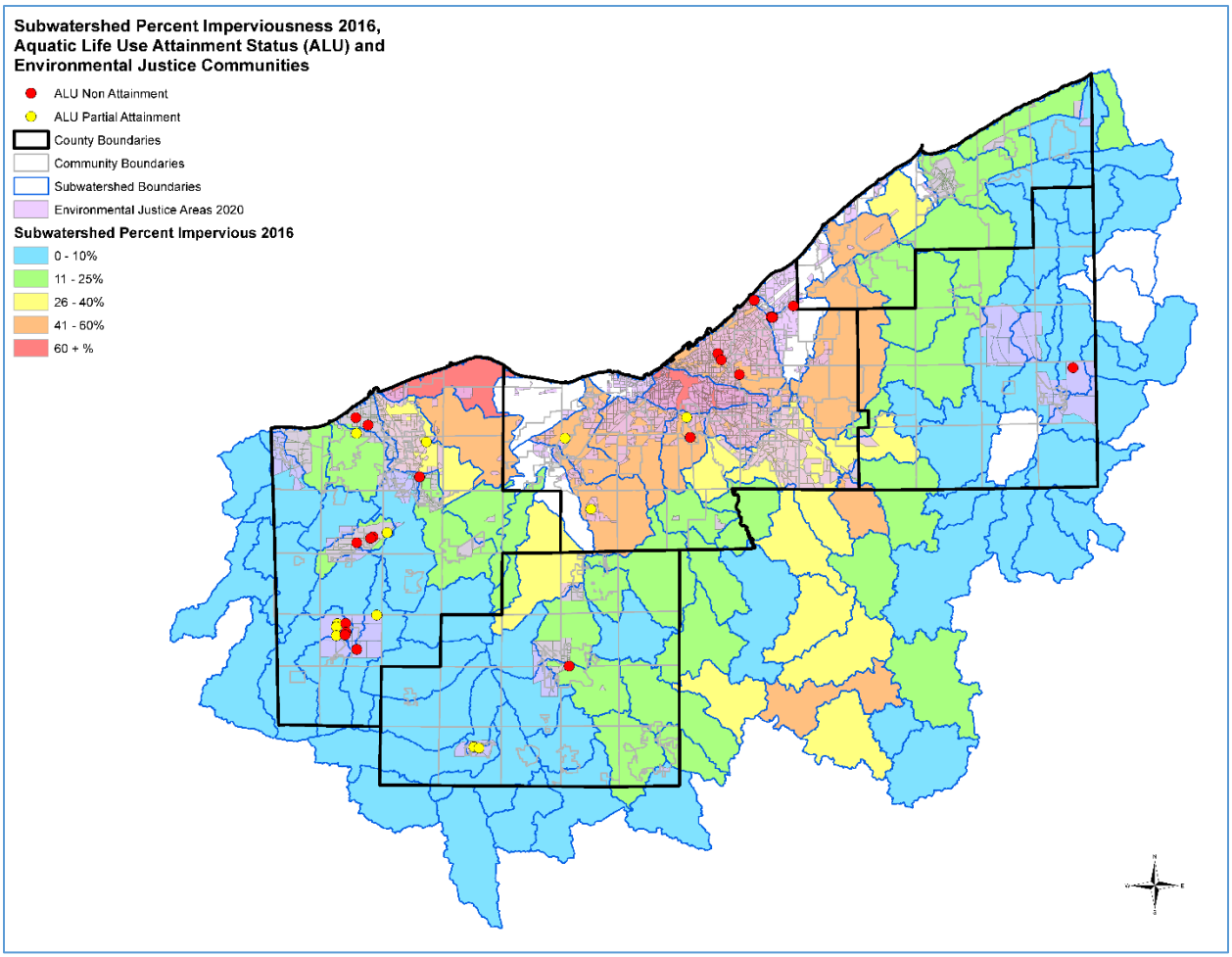


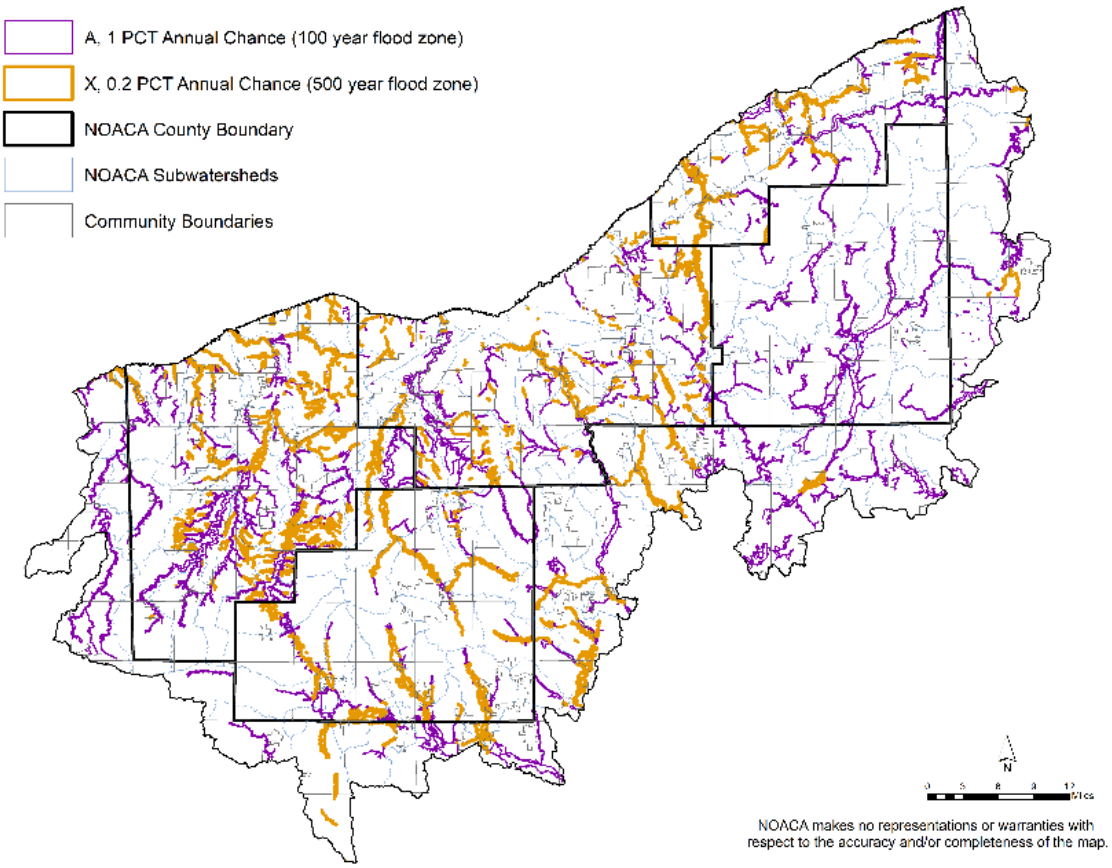
Figure 8-3. Northeast Ohio Subwatershed Percent Imperviousness (2016)



The development of urban and suburban areas, enabled by automobile-centric transportation policies and investments in water and wastewater infrastructure, can result in increased flooding. Two of the future transportation scenarios identified by NOACA staff—1 (MAINTAIN) and 2 (CAR), which continue to support travel by car—are likely to result in continued expansion of low density development (see Chapter 9). Increased imperviousness and reduction of natural open space and riparian vegetation generally increases the size and number of floods for a region. Expanded flood hazards from greater impervious surfaces may amplify the need for communities to repair, move, or redesign existing infrastructure such as roads, bridges, culverts and stormwater management structures.[24] Figure 8-4 shows the region's flood hazard areas and places most vulnerable to increased flooding from development.

Figure 8-4. Northeast Ohio FEMA Flood Hazard Areas

[24] C.P. Konrad, "Effects of Urban Development on Floods," U.S. Geological Survey Fact Sheet 076-03, https://pubs.usgs.gov/fs/fs07603/ (accessed April 8, 2021).



Wastewater Management

Infrastructure decisions enable development on undeveloped land as well as reinvestment in the urbanized areas. These infrastructure decisions do not just include transportation but also wastewater management decisions. When it comes to these infrastructures, urbanized and rural areas have different needs. Adequate conveyance and treatment of wastewater is critical for watershed health. In Northeast Ohio, wastewater from residential and commercial establishments flow to a major wastewater treatment plant (WWTP), a communal system, or individual onsite sewage treatment system (OSTS) of various sizes. Figure 8-5 and Table 8-22 illustrate and quantify the general areas served by sanitary sewers, areas planned to be served by sanitary sewers, and area served by OSTS for the foreseeable future.

Figure 8-5. Northeast Ohio Sanitary Sewer Plan Map

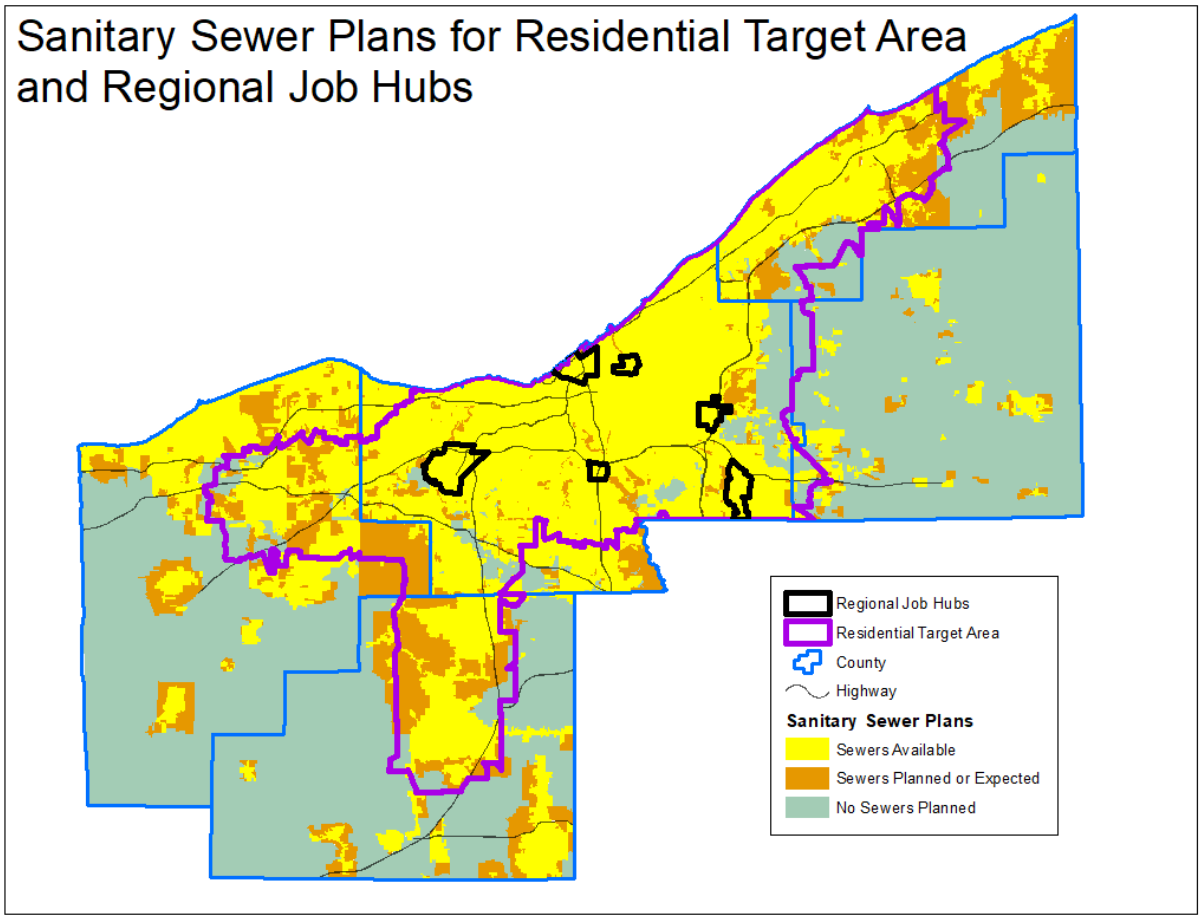


Table 8-22. Northeast Ohio Sanitary Sewer Plan Distribution

eNEO2050 - Sewer Planning Areas and Residential Target Areas								
	NOACA Region		**Residential Target Areas**			**Non-Residential Target Areas**		
Sanitary Sewer Plans	**Total Area**	**% of Region**	**Total Area**	**% of Area**	**% of Region**	**Total Area**	**% of Area**	**% of Region**
Sewers Available	724.771	35.9%	523.670	70.6%	25.9%	201.101	21.5%	10.0%
Sewers Planned or Expected	269.502	13.3%	129.477	17.5%	6.4%	140.024	11.0%	6.9%
No Sewers Planned	1025.042	50.8%	88.648	12.0%	4.4%	936.393	73.3%	46.4%
Total	2019.314		741.796		36.7%	1277.518		63.3%

The placement of wastewater infrastructure plays a critical role in enabling the disbursement of population, businesses and services, as well as the disbursement of population, businesses and services play a critical role the placement of wastewater infrastructure. Developers interested in undeveloped land frequently approach communities, counties, water districts and NOACA to secure sewer extension to their planned developments. At this point, the region faces the challenge of managing threats to water quality posed by both aging infrastructure in declining areas and new infrastructure in growing areas. The shift in population away from the urban core places a greater financial burden on remaining sewer system customers to pay for the maintenance of the older sewage systems. This financial burden is even greater for customers who are connected to systems under state or federal orders to address combined sewer overflows (CSO) to prevent raw sewage from entering local waterways.

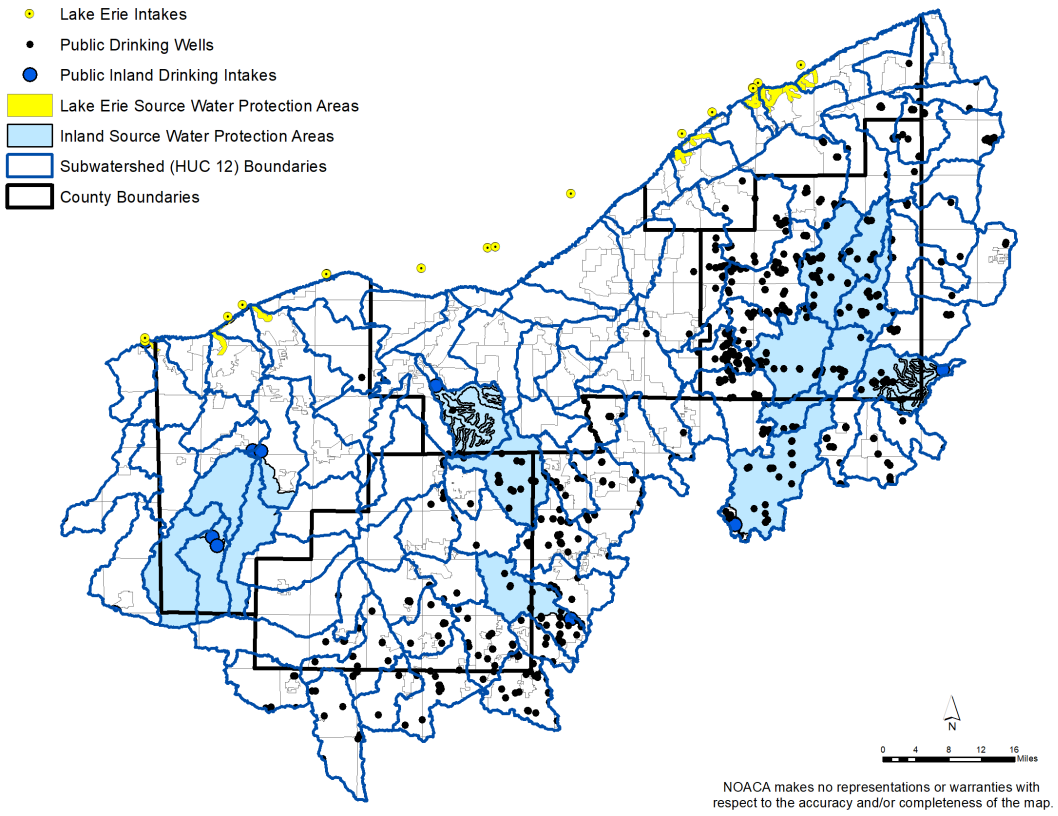
Groundwater Resources

The increase in impervious surfaces from the region's development patterns also impacts the region's groundwater. Additional impervious surface from development reduces the area where water can infiltrate into the ground. The lack of groundwater recharge can lead to a lowering of the groundwater table. Streams, lakes, wetlands, and other water resources feed (connect) to the groundwater table. Groundwater primarily maintains the base flow (sustained flow without direct runoff) for most streams.[25]

Many properties and communities rely on groundwater at their primary drinking water source (Figure 8-6). If development continues the current pattern of expansion, more of the region's population may be reliant on groundwater in the future. Future transportation scenarios 1 and 2 present this possibility and would likely result in higher percentages of impervious surface, which may result in increased vulnerability for groundwater contamination (see Chapter 9 for a description of the scenarios). Common groundwater pollution sources are industry; fertilizers; failing sewage treatment systems; construction sites; and runoff of oil, gas, and salt from roads and other impervious surfaces. In scenarios 3 and 4, the areas targeted to attract residents and jobs are within currently developed portions of the region, which may slow the expansion of impervious surface and preserve natural open space (see Chapter 9).

[25] U.S. Geological Survey (USGS), "Surface Runoff and the Water Cycle," https://www.usgs.gov/special-topic/water-science-school/science/surface-runoff-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects (last accessed January 29, 2021).

Figure 8-6. Northeast Ohio Source Water Intakes and Protection Areas



Regional Air Quality

National Ambient Air Quality Standards (NAAQS) and Attainment Status

In 1970, the United States Congress passed its first round of amendments to the existing federal Clean Air Act (CAA), which laid out a framework to control air pollution at the federal, state, and local levels. Because transportation accounts for a significant portion of air pollution, the 1977 Clean Air Act Amendments (CAAA) introduced the concept of transportation conformity. Under this provision, a region's transportation plans, programs, and projects cannot interfere with the region's air quality goals.[26] MPOs such as NOACA must demonstrate that their long-range transportation plans (LRTPs) and Transportation Improvement Plans (TIPs) conform to these goals through a process known as a conformity determination.[27]

Since its passage, the CAA has significantly enhanced air quality in the U.S. From 1970 to 2019, ambient concentrations of the six criteria air pollutants declined by 77% nationwide, even as the economy grew by 285% and vehicle miles traveled (VMT) nearly doubled.[28] This decline

[26] 42 C.F.R. §7506 (c)(2).
[27] FHWA, *Transportation Conformity: A Basic Guide for State and Local Officials* (Washington, DC: FHWA, 2010); https://www.fhwa.dot.gov/environment/air_quality/conformity/guide/ (accessed April 8, 2021).
[28] US EPA, "Air Quality Trends," https://www.epa.gov/air-trends/air-quality-national-summary (accessed April 8, 2021).

in pollutant concentrations has also reduced the associated health burden of air pollution. In 1997, US EPA concluded that, from 1970 to 1990, the CAA prevented approximately 205,000 premature deaths and generated $22.2 trillion in economic benefits.[29] US EPA also concluded that the 1990 CAAA would prevent 230,000 premature deaths by 2020.[30]

Historically, Northeast Ohio has struggled with poor air quality, due in part to its reliance on heavy industry and the use of coal to produce electricity. While the smokestacks from facilities such as steel mills, oil refineries, and coal-fired power plants long dominated the landscape in the region, mobile emissions have actually been the primary source of air pollution in Northeast Ohio since at least 1990. On-road vehicles continue to generate a plurality (31.6%) of criteria pollutant emissions. Additionally, two of the pollutants most closely linked to mobile emissions—ozone (O_3) and fine particulate matter ($PM_{2.5}$)—have declined by smaller margins. As Table 8-23 illustrates, while the region's air quality has improved dramatically over the past 50 years, this rate of improvement has slowed since 2010, which mirrors the national trend.[31]

Table 8-23. Change in Concentrations of Criteria Air Pollutants in Northeast Ohio, 1990-2019[32]

Pollutant Type	1990-2019	2000-2019	2010-2019
Carbon Monoxide (CO)	-65%	-71%	-34%
Nitrogen Dioxide (NO_2) (1-hour)	-48%	-26%	-22%
Ozone (O_3) (Eight-Hour)	-16%	-7%	-8%
PM_{10} (24-hour)	-5%	+33%	+70%
$PM_{2.5}$ (annual)	n/a	-37%	-12%
Sulfur Dioxide (SO_2) (1-hour)	-84%	-65%	-52%

Source: US EPA

The CAA (40 C.F.R. § 50) requires the US EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. US EPA has created NAAQS for six criteria air pollutants. Regions that do not comply with these standards are designated as nonattainment areas. Northeast Ohio is currently a marginal nonattainment area for the 2015 ozone (O_3) NAAQS (see Table 8-24).

[29] US EPA, *The Benefits and Costs of the Clean Air Act, 1970 to 1990—Retrospective Study* (Washington, D.C.: US EPA, 1997), https://www.epa.gov/sites/production/files/2015-06/documents/contsetc.pdf (accessed April 8, 2021).
[30] US EPA, *Benefits and Costs of the Clean Air Act 1990-2020, the Second Prospective Study* (Washington, D.C.: US EPA, 2011), https://www.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act-1990-2020-second-prospective-study (accessed April 8, 2021).
[31] Z. Jian et al., "Unexpected slowdown of US pollutant emission reduction in the past decade," *Proceedings of the National Academy of Sciences* 115, 20 (2018), 5099-5014.
[32] US EPA, "Air Trends," http://www.epa.gov/airtrends/index.html (accessed April 8, 2021).

Table 8-24. Summary of Nonattainment Status for Northeast Ohio[33]

Pollutant		Averaging Time	Level	Attainment Status	Counties in Nonattainment
Carbon Monoxide (CO)		8-hour	9 ppm	Maintenance	N/A
		1-hour	35 ppm		N/A
Lead (Pb)		Rolling 3-month average	0.15 µg/m^3	Maintenance	N/A
Nitrogen Dioxide (NO_2)		1-hour	100 ppb	Unclassifiable/ Attainment	N/A
		Annual	53 ppb	Unclassifiable/ Attainment	N/A
Ozone (O_3)		8-hour	70 ppb	Marginal Nonattainment	Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, Summit
Particle Pollution	$PM_{2.5}$	Annual	12 µg/m^3	Maintenance	N/A
		24-hour	35 µg/m^3	Maintenance	N/A
	PM_{10}	24-hour	150 µg/m^3	Maintenance	N/A
Sulfur Dioxide (SO_2)		1-hour	75 ppb	Maintenance	N/A

Source: US EPA

Lead Contamination

Ambient and indoor air pollution impose substantial costs within Northeast Ohio, as described in subsequent sections. But these costs stretch beyond just health impacts. Perhaps the greatest environmental justice challenge facing the NOACA region is lead contamination, particularly among children in communities of color with aging housing stock. The use of lead-based paint was commonplace in residential settings prior to its prohibition in 1978. Due to its history as a hub for the paint and coatings industry, Northeast Ohio has a significant legacy lead pollution problem. While lead-based paint does not pose an acute health threat if it is properly sealed, that is often not the case in the older housing stock within the region's legacy cities. There is no safe level of lead in the human body, and children are most at risk. Lead can harm human health in a number of ways. Increasing from the 5th to 95th percentile of blood lead levels (BLLs) is associated with a loss of 6.9 IQ points among children; the majority of this decrement occurs at levels below 10 micrograms per deciliter (µg/dL), which health officials had previously considered safe.[34]

[33] US EPA, "Nonattainment Areas for Criteria Pollutants (Green Book)," https://www.epa.gov/green-book (accessed April 8, 2021).

[34] Bruce P. Lanphear, Richard Hornung, Jane Khoury, Kimberly Yolton, Peter Baghurst, David C. Bellinger, Richard L. Canfield, Kim N. Dietrich, Robert Bornschein, Tom Greene, Stephen J. Rothenberg, Herbert L. Needleman, Lourdes Schnaas, Gail Wasserman, Joseph Graziano, and Russell Roberts,

Elevated BLLs are also linked to behavioral and mental health problems. Because lead remains in the body, its health effects can linger and exacerbate throughout the course of one's life.

The social and economic costs of lead contamination are enormous. Each child in Northeast Ohio who develops elevated BLL incurs an array of additional costs due to lost economic output and ongoing health-care and social service demands. According to one study, elevated BLLs in the U.S. caused $165–233 billion in lost lifetime earnings, $25–35 billion in foregone tax revenue, $30–146 million in special education expenses, $11–53 billion in additional health-care costs, and $11.6 billion in additional indirect costs.[35] Conversely, the benefits of lead remediation are vast and outweigh the costs by orders of magnitude. Every $1 invested in lead paint hazard control measures generates $17-221 in total benefits.[36] The potential benefits for Northeast Ohio are apparent, as more than 10% of children in Cuyahoga County (more than 25% in the City of Cleveland) have elevated BLLs by the age of five.[37]

Because lead is more likely to be found in older housing stock and infrastructure, it is disproportionately likely to harm residents of our legacy urban areas, and they are disproportionately likely to be low-income and minority. This is why Cleveland enacted a 2019 law to reduce the number of children exposed to lead, and in 2020 followed up by committing funding to the effort.[38] This is another example of the need to address and eradicate poverty and racism to positively impact the region and improve quality of life and economic outcomes for all.

Major Sources of Air Pollution in Northeast Ohio

Broadly speaking, there are two main types of air pollutants—primary and secondary. Primary pollutants are emitted directly into the atmosphere from a given source and retain their same, basic chemical form. Two common primary pollutants are carbon monoxide (CO) and sulfur dioxide (SO_2). Secondary pollutants, in contrast, undergo a chemical change once they enter the atmosphere. Ozone (O_3) is a secondary pollutant; it is formed when nitrogen oxide (NO_x) combines with volatile organic compounds (VOCs) and oxygen in the lower atmosphere.

Table 8-25 outlines the contribution of mobile sources (highway and off-highway vehicles) to each of the criteria pollutants in Northeast Ohio. These include key primary pollutants (CO, PM_{10}, $PM_{2.5}$, and SO_2) and precursors for secondary pollutants of concern (NO_x and VOCs). As the charts indicate, transportation is a significant source of several pollutants, specifically CO, NO_x, $PM_{2.5}$, and VOCs.

Table 8-25. Share of Mobile Emissions for Criteria Pollutants in Northeast Ohio (2017)

"Low-level environmental lead exposure and children's intellectual function: an international pooled analysis," *Environmental health perspectives*, 113,no. 7, (2005), 894-899.

[35] Elise Gould, "Childhood lead poisoning: conservative estimates of the social and economic benefits of lead hazard control," *Environmental health perspectives* 117, no. 7 (2009), 1162-1167.

[36] Ibid.

[37] Elizabeth Anthony, Stephen Steh, Meghan Salas Atwell, M. & Rob Fischer, *Early Childhood Lead Exposure in Cuyahoga County and the Impact on Kindergarten Readiness* (Cleveland, OH: Mandel School of Applied Social Sciences, Case Western Reserve University, 2019).

[38] Robert Higgs, "Cleveland City Council Approves $5M to Help Landlords Tackle Lead Paint Problem in Dwellings," *Cleveland.com*, Aug. 21, 2020; https://www.cleveland.com/cityhall/2020/08/cleveland-city-council-approves-5m-to-help-landlords-tackle-lead-paint-problems-in-dwellings.html (accessed April 8, 2021).

Pollutant		Total Emissions (Tons)	Mobile Emissions (Tons)	Highway Vehicles Emissions (% Total)	Non-Highway Vehicles Emissions (% Total)
CO		337,061	243,884	38.5%	33.9%
O_3	NO_x	49,387	37,305	48.2%	28.3%
	VOCs	91,873	20,430	12.6%	9.6%
Particle Pollution	PM_{10}	33,817	3,072	6.2%	2.9%
	$PM_{2.5}$	12,553	1,857	7.4%	7.4%
SO_2		5,373	333	3.2%	3.1%

Source: US EPA, "2017 National Emissions Inventory Report," https://gispub.epa.gov/neireport/2017/ (accessed April 8, 2021).

Air Quality Trends and Analysis

Each year, NOACA produces its Air Quality Trends Report, which provides a comprehensive overview of air quality in Northeast Ohio and how the region performs on each of the NAAQS. Through this annual report, NOACA provides up-to-date information on how pollution levels change over time, which informs public education and policy making throughout the region.

NOACA plays a major role in the analysis of both the impacts of the region's transportation investments on greenhouse gas (GHG) emissions and climate resilience, and what actions the region should take to reduce emissions in order to achieve climate goals. The agency already completes an annual GHG emissions inventory for each of its five counties, and it has the capacity to provide detailed technical support to member communities. As part of its recently adopted New or Modified Highway Interchange Projects Policy, NOACA will analyze how new or modified highway interchanges will influence equity measures and regional GHG emissions. This policy goes beyond existing transportation conformity requirements and will better inform the agency as it evaluates potential highway projects. NOACA also has the unique capacity to explore how changes to the transportation network may influence mobile emissions and public health in Northeast Ohio.

Social and Economic Costs of Air Pollution

Air pollution is connected to a host of health issues, including respiratory illnesses (e.g., asthma, bronchitis, and emphysema); pre- and neonatal health risks, including low birthweight, premature birth, and infant mortality; stroke; heart disease, including heart attacks; behavioral conditions, such as attention deficit hyperactivity disorder (ADHD); cognitive issues, including IQ decrements and dementia; lung cancer; and premature death.[39] To quantify these impacts for Northeast Ohio, NOACA used US EPA's Co-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.[40] Table 8-26 details the total costs and certain public health impacts of all air

[39] For further information on the public health effects of air pollution, consult the US EPA's *Integrated Science Assessments* on the criteria air pollutants at https://www.epa.gov/isa (accessed June 15, 2020).
[40] US EPA, Co-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool, https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool (accessed April 8, 2021).

pollutants emitted in the NOACA region during 2016. Table 8-27 details such costs and impacts of pollutants emitted just from mobile sources.

Table 8-26. Public Health Impacts of Air Pollutant Emissions in the NOACA Region in 2016

Type of Impact	Incidence	Total Cost (2016 $)
Mortality (low estimate)	639 deaths	$6.8 billion
Mortality (high estimate)	1,439 deaths	$15.3 billion
Infant Mortality	4 deaths	$41.2 million
Nonfatal heart attacks (low estimate)	60 heart attacks	$9.9 million
Nonfatal heart attacks (high estimate)	546 heart attacks	$89.8 million
Respiratory Hospital Admissions	136 admissions	$4.9 million
ER Visits for Asthma	284 visits	$159,913
Minor Restricted Activity Days	381,132 days	$33.1 million
Lost Work Days	63,606 days	$12.7 million
Asthma Exacerbations	12,975 attacks	$952,894
Total Health Costs (low estimate)[a]	$6.9 billion	
Total Health Costs (high estimate)[a]	$15.5 billion	

[a]Total costs do not include all health impacts and are therefore greater than the sum of the individual impacts.
Source: NOACA estimates using US EPA's COBRA model

Northeast Ohio has directly benefited from the long-term decreases in pollutant levels. One recent analysis found that, since 1970, air quality improvements associated with the CAA have extended the average life expectancy of people within the region by 2.3 years.[41] More recent reductions in pollution concentrations have also improved public health. Due largely to regulations on tailpipe emissions, transportation-related NO_2 pollution has fallen considerably. As a result, the number of childhood asthma cases in the NOACA region fell by 42.6% from 2000 to 2010.[42]

Table 8-27. Public Health Impacts of Mobile Emissions in the NOACA Region in 2016

Type of Impact	Incidence	Total Cost (2016 $)

[41] Michael Greenstone, "The Connection between Cleaner Air and Longer Lives," *The New York Times*, Sept. 24, 2015; http://www.nytimes.com/2015/09/25/upshot/the-connection-between-cleaner-air-and-longer-lives.html?_r=1 (accessed November 1, 2019).
[42] Raed Alotaibi, Mathew Bechle, Julian D. Marshall, Tara Ramani, Josias Zietsman, Mark J. Nieuwenhuijsen, and Haneen Khreis, "Traffic related air pollution and the burden of childhood asthma in the contiguous United States in 2000 and 2010," *Environment International* 127 (2019), 858-867.

Mortality (low estimate)	51 deaths	$545.5 million
Mortality (high estimate)	116 deaths	$1.2 billion
Nonfatal heart attacks (low estimate)	5 heart attacks	$747,410
Nonfatal heart attacks (high estimate)	44 heart attacks	$7.3 million
Respiratory Hospital Admissions	11 admissions	$387,187
ER Visits for Asthma	23 visits	$12,733
Minor Restricted Activity Days	30,464 days	$2.6 million
Lost Work Days	5,077 days	$1.0 million
Asthma Exacerbations	1,023 attacks	$75,174
Total Health Costs (low estimate)[a]	$554.5 million	
Total Health Costs (high estimate)[a]	$1.3 billion	

[a]Total costs do not include all health impacts and are therefore greater than the sum of the individual impacts.
Source: NOACA estimates using US EPA's COBRA model

Air Pollution Costs by Future Transportation Scenario

NOACA staff evaluated each of the four *eNEO2050* future transportation scenarios to see how they influence mobile emissions, pollution exposure, and public health in each of the region's zip codes (see Chapter 9 for the scenarios). This provides a more fine-grained understanding of the ways that transportation investments may influence quality of life within the region. It also better informs NOACA's efforts to enhance equity and minimize ongoing environmental justice disparities. Staff used US EPA's MOtor Vehicles Emissions Simulator, version 2014a (MOVES2014a) and COBRA to complete this analysis. The aggregate regional public health costs of each scenario are given in Table 8-28.

Table 8-28. Total Public Health Costs of Mobile Emissions by *eNEO2050* Scenario (2050)

Type of Impact	MAINTAIN	CAR	TRANSIT	TOTAL

Mortality (low estimate)	12 deaths	12 deaths	12 deaths	12 deaths
Mortality (high estimate)	27 deaths	27 deaths	27 deaths	28 deaths
Nonfatal heart attacks (low estimate)	1 heart attack	1 heart attack	1 heart attack	1 heart attack
Nonfatal heart attacks (high estimate)	11 heart attacks	11 heart attacks	11 heart attacks	11 heart attacks
Respiratory Hospital Admissions	3 admissions	3 admissions	3 admissions	3 admissions
ER Visits for Asthma	5 visits	5 visits	5 visits	5 visits
Minor Restricted Activity Days	6,629 days	6,650 days	6,680 days	6,841 days
Lost Work Days	1,118 days	1,121 days	1,126 days	1,154 days
Asthma Exacerbations	227 attacks	228 attacks	229 attacks	235 attacks
Total Health Costs (low estimate)[a]	$133.2 million	$133.6 million	$134.2 million	$137.4 million
Total Health Costs (high estimate)[a]	$296.6 million	$297.5 million	$299 million	$306.2 million

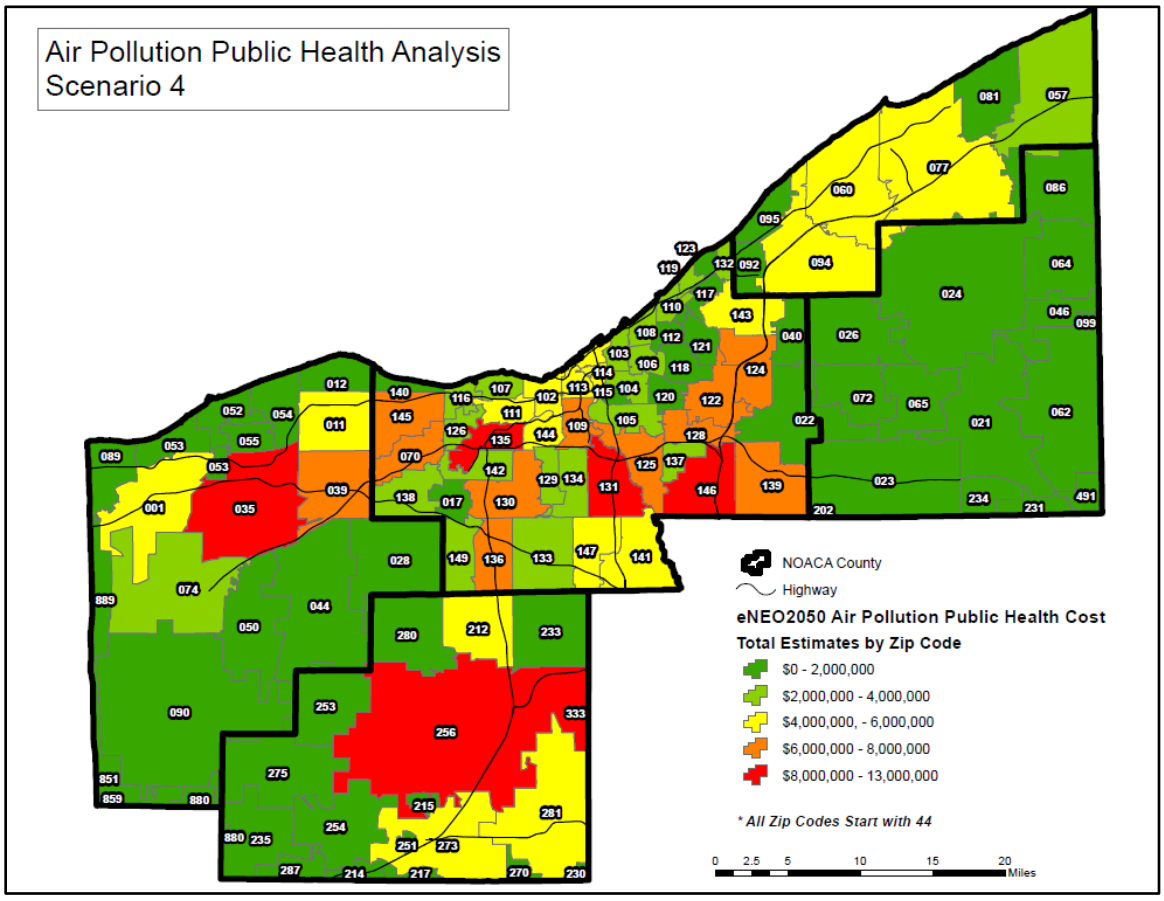
[a]Total costs do not include all health impacts and are therefore greater than the sum of the individual impacts.
Source: NOACA estimates using US EPA's COBRA model and US EPA's MOtor Vehicles Emissions Simulator, version 2014a (MOVES2014a)

As Table 8-28 illustrates, the differences in total public health costs among the four scenarios are small, with the maximum difference (between MAINTAIN and TOTAL) of just 3.1%. But, while the differences among the scenarios are small, the difference between the scenarios and the 2016 baseline (Table 8-27) is stark. Premature mortality and total public health costs may each fall by 76% from baseline. As the tiny difference in costs among the scenarios attests, anticipated changes to federal mobile emissions standards account for these improvements. Tier 3 emissions standards (79 FR 23414), which came into effect in 2017, will cut emissions of NO_x and VOCs by 80%, relative to the Tier 2 standards implemented in 2000. They would also reduce particle pollution emissions by 70% and the sulfur content of gasoline by 60%. When Tier 3 standards fully come into effect in 2025, new passenger vehicles will be up to 99% cleaner than vehicles manufactured before the 1970 CAAA.[43] As new vehicles gradually replace older models with higher rates of tailpipe emissions, air pollution from mobile sources will decline dramatically in Northeast Ohio. Nevertheless, none of the scenarios fully mitigates the health impacts of mobile emissions. Tailpipe emissions will remain for vehicles with internal combustion engines, as will non-exhaust emissions (i.e., particles from brake and tire wear) from both internal combustion engine vehicles and fully electric vehicles.[44]

[43] US EPA, "History of Reducing Air Pollution from Transportation in the United States," https://www.epa.gov/transportation-air-pollution-and-climate-change/accomplishments-and-success-air-pollution-transportation (accessed April 8, 2021).
[44]Currently, non-exhaust emissions of $PM_{2.5}$ account for 57.8% of mobile particle pollution in the NOACA region. While exhaust emissions of $PM_{2.5}$ should fall by nearly 60% through 2050, non-exhaust emissions will remain the same or potentially even increase, as heavier electric vehicles and light-duty trucks make up a larger share of the vehicle fleet. While technological improvements, such as enhancements in

Figure 8-7 illustrates the distribution of mobile emissions health costs by zip code under the TOTAL scenario; this distribution remains almost perfectly constant across the four scenarios. NOACA staff derived the map from VMT data by zip code. Staff then converted those VMTs to mobile emissions, with data derived from MOVES2014a.[45] Next, staff entered those emissions data into the COBRA model to develop total health costs for each zip code in the region. The map below shows a fairly broad distribution of impacts across Northeast Ohio.

Figure 8-7. Distribution of Mobile Emissions Health Costs by Zip Code for *eNEO2050* Scenario #4 (TOTAL) (2050)



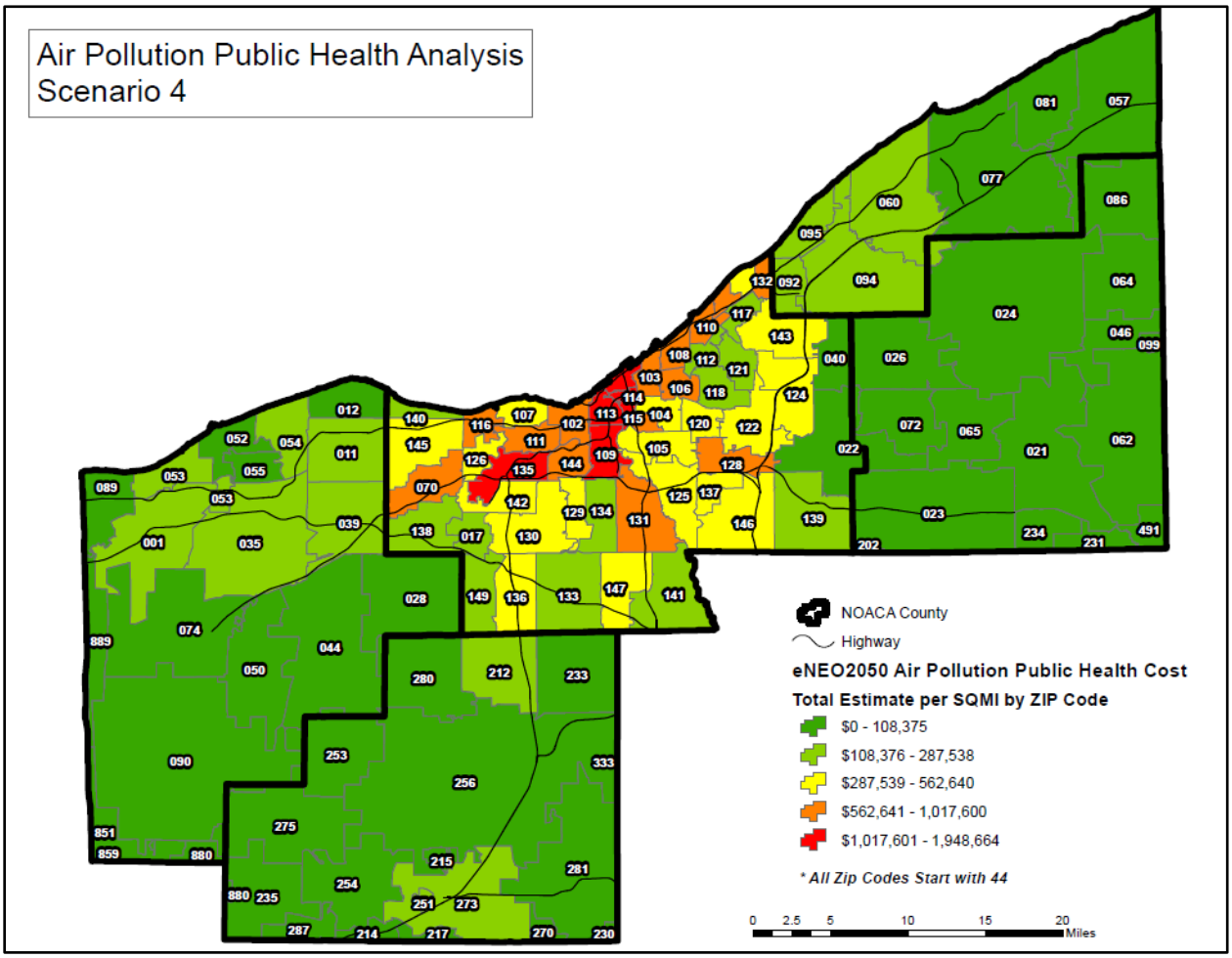
This distribution changes when staff control for the size of different zip codes. The highest aggregate costs occur in Medina County's 44256 zip code because it is the largest in the area. This zip code is 131.2 square miles, more than 96 times the size of the region's smallest zip code (Medina County's 44251), which is only 1.4 square miles. To account for this discrepancy, NOACA staff divided the total health costs of mobile emissions for each zip code by the total area, in square miles, to obtain an area-adjusted quotient. NOACA staff discovered a far higher share of the health costs would occur in the region's EJ areas when they controlled for area (Figure 8-8).

regenerative braking, can help temper some of the issue, VMT reduction remains the only guaranteed way to cut further particle pollution from the region's vehicles.

[45] US EPA, MOtor Vehicles Emissions Simulator (MOVES), version 2014a, https://www.epa.gov/moves/moves-versions-limited-current-use (accessed April 8, 2021).

Downtown Cleveland zip codes 44115, 44113, and 44114, which are the third, eighth, and thirteenth smallest zip codes by area, respectively, become the three highest ranking zip codes for health costs per unit area.

Figure 8-8. Distribution of Health Costs per Unit Area by Zip Code in *eNEO2050* Scenario #4 (TOTAL) (2050)



Accounting for area also makes it clear that the distribution of the health impacts of mobile emissions will differ across the four scenarios. Because Scenarios 3 (TRANSIT) and 4 (TOTAL) result in more people, economic activity, and VMT in the urban core, the associated health effects also become more concentrated in a smaller number of core communities, most of which are home to EJ areas. Shifting from Scenario 1 to 4, for instance, increases health costs in 45.1% of zip codes; these zip codes are home to 56.5% of the region's population. More than half (51%) of the zip codes where health costs increase are located in the City of Cleveland, including all 10 zip codes with the largest increases and 16 of the top 20. As a result, Scenarios 3 and 4 create additional environmental justice concerns that the region must address to promote equity and improve quality of life for low-income and minority communities.

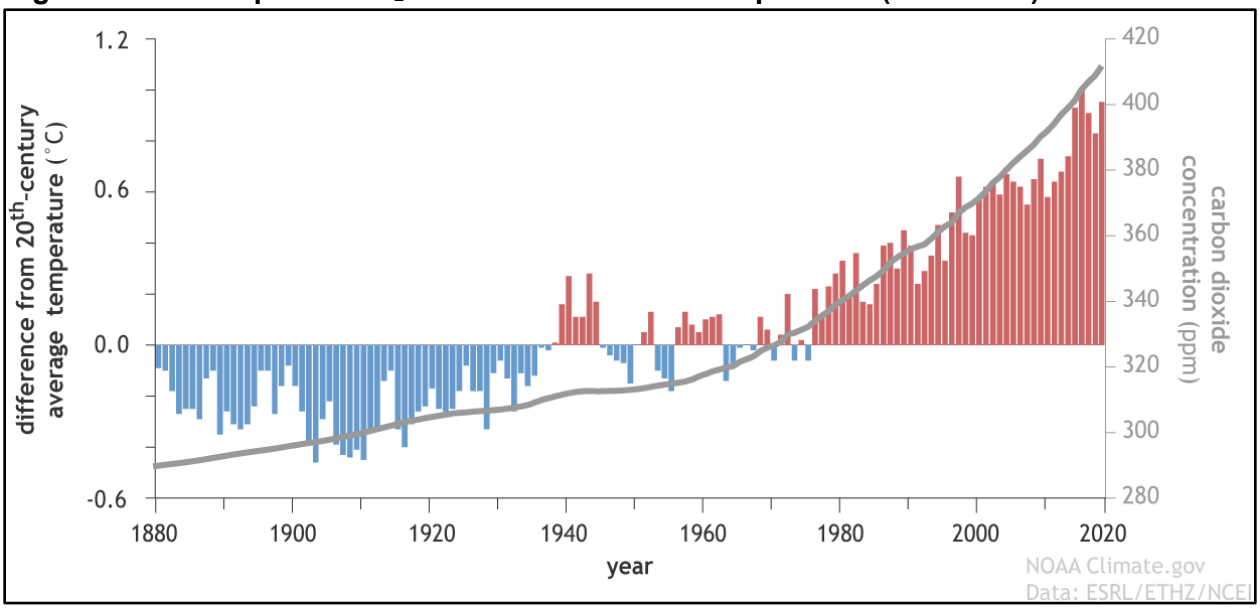
Climate Resilience

Greenhouse Gas Emissions and Climate Change

Climate change is a global phenomenon that includes any significant shift in the climate that lasts for extended periods of time. Global warming, which refers to the observed increase in average global surface temperatures over the past several decades, is one facet of climate change.[46] Other components include changes in precipitation, wind patterns, the cryosphere, and extreme weather events. Over the past century, humans have released large amounts of CO_2 and other greenhouse gases (GHGs) into the atmosphere. Most of these emissions have come from the combustion of fossil fuels, such as coal, natural gas, and oil; however, land-use changes, such as deforestation and agriculture, are also major contributors, both due to direct emissions and the elimination of carbon sinks (which pull carbon out of the atmosphere and sequester it), such as forests. According to the Intergovernmental Panel on Climate Change (IPCC), human activities have increased atmospheric concentrations of GHGs to their highest levels in at least 800,000 years, and human actions are the dominant cause of changes to the global climate since the mid-20th century.[47]

GHGs act like a form of atmospheric insulation, trapping energy in the atmosphere and increasing global temperatures. GHGs allow ultraviolet radiation from the sun to enter the atmosphere; however, because they trap infrared radiation, they prevent a portion of that energy from escaping back into space. Though GHGs make up a tiny fraction of the composition of the atmosphere (0.04%), they can significantly affect the global climate. As a result, global average surface temperatures have increased by approximately 1ºC since 1880.[48] Figure 8-9 shows the strong correlation between the increase in CO_2 concentrations and global temperatures.

Figure 8-9. Atmospheric CO_2 and Earth's Surface Temperature (1880-2019)[49]



[46] US EPA, "Climate Change: Basic Information," https://19january2017snapshot.epa.gov/climatechange/climate-change-basic-information_.html (accessed April 8, 2021).
[47] Intergovernmental Panel on Climate Change, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva: IPCC, 2014); http://www.ipcc.ch/report/ar5/syr/ (accessed April 8, 2021).
[48] Ibid.
[49] Rebecca Lindsey, "If carbon dioxide hits a new high every year, why isn't every year hotter than the last?" https://www.climate.gov/news-features/climate-qa/if-carbon-dioxide-hits-new-high-every-year-why-isn%E2%80%99t-every-year-hotter-last (accessed April 8, 2021).

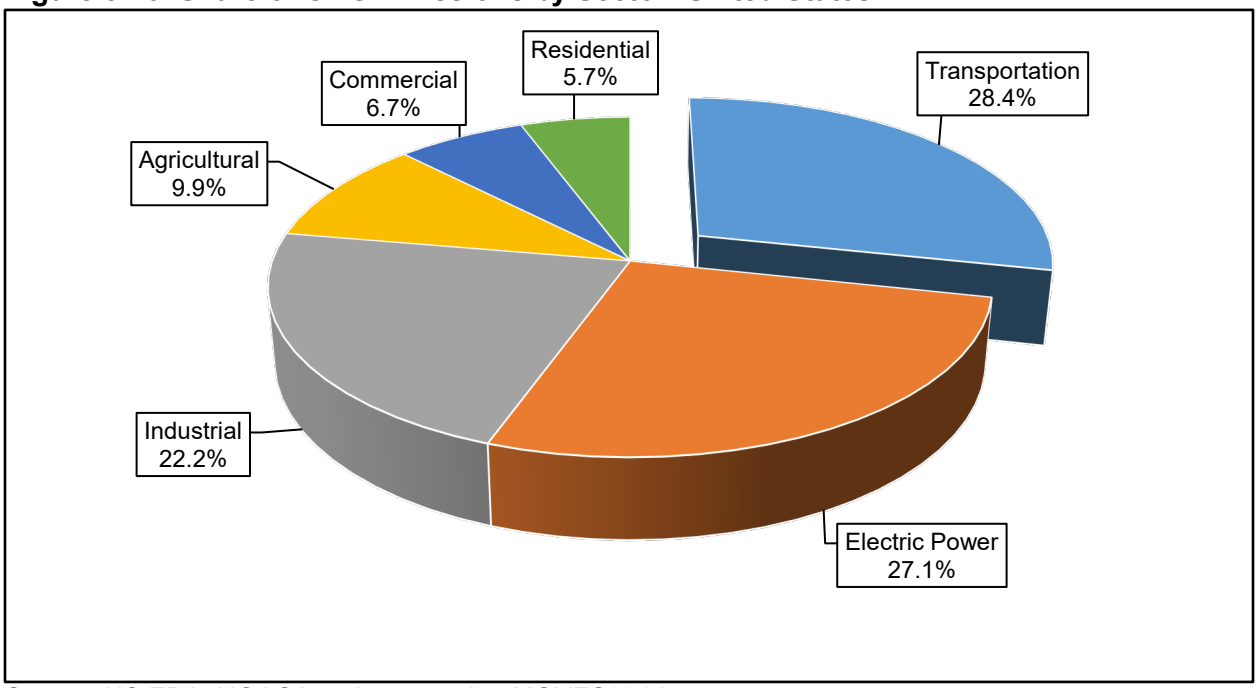
Although CO_2 is not a criteria air pollutant, US EPA has taken steps to regulate GHG emissions under the Clean Air Act. In its 2007 ruling in *Massachusetts v. EPA,* the U.S. Supreme Court ruled that GHGs, including CO_2, are pollutants covered by the Act.[50] The Court ordered the US EPA to determine whether GHGs contribute to air pollution and pose a threat to human health. US EPA issued its "endangerment finding" on December 7, 2009, ruling that GHGs exacerbate air pollution and threaten human health and welfare (74 FR 66496). In December 2015, leaders of 196 countries adopted the Paris Agreement, which commits the international community to hold the increase in global temperatures "to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C."[51] To remain below 2°C, global GHG emissions must peak by 2030, decline approximately 40-70% by 2050 (compared to 2010 levels), and reach near-zero levels by 2100.[52] To meet these benchmarks, emissions will need to decline by approximately 2.7% and 7.6% per year to keep warming below 2°C and 1.5°C, respectively.[53]

Relationship between Transportation and Climate Change

As Figure 8-10 shows, transportation is the leading source of GHG emissions in the U.S. at 28.4%. It overtook the electric power sector in 2016, and projections indicate its share of emissions will grow further as coal continues to play a smaller role in electricity production. Similarly, transportation accounts for around one-quarter of total GHG emissions in Northeast Ohio.[54] Transportation sector GHG emissions vary by county. Regionally, transportation accounted for more than 8.7 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) during 2019 (Figure 8-11). While Cuyahoga County accounted for the largest share of total emissions (57.2%), this was lower than its share of the regional population (60.3%). In turn, both Geauga and Medina Counties made up a higher share of GHGs than their share of population. These numbers highlight the fact that individuals living in suburban and exurban areas tend to produce more GHGs from transportation. Northeast Ohio residents produced 4.3 tons of on-road CO_2e per capita during 2019, below the national average of 4.8. The per capita totals ranged from a low of four tons per capita in Cuyahoga County to a high of 5.6 tons per capita in Medina County.

[50] *Massachusetts v. EPA*, 127 S. Ct. 1438 (2007).
[51] *Paris Agreement,* United Nations Framework Convention on Climate Change (UNFCCC), Dec., 12, 2015, FCCC/CP/2015/10/Add.1.
[52] IPCC, *Climate Change 2014*, 20.
[53] United Nations Environment Programme (UNEP), *Emissions Gap Report 2019* (Nairobi: UNEP, 2019); https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf?sequence=1&isAllowed=y (accessed April 8, 2021).
[54] GreenCityBlueLake Institute (GCBL), *Inventory: Northeast Ohio greenhouse gas emissions* (Cleveland: GreenCityBlueLake, 2012); http://www.gcbl.org/files/resources/ghgfinal2.pdf (accessed April 8, 2021).

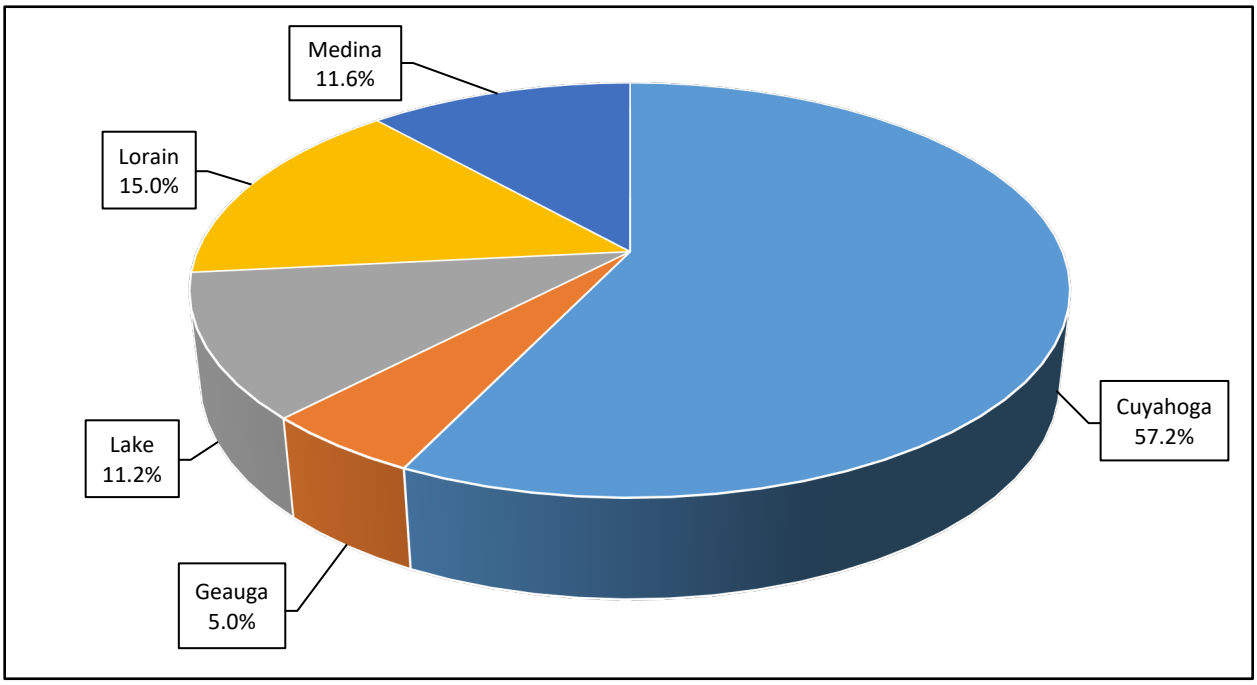
Figure 8-10. Share of GHG Emissions by Sector- United States[55]



Source: US EPA; NOACA estimates using MOVES2014a.

[55] US EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2018* (Washington, D.C.: US EPA, 2020), https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf (accessed April 8, 2021).

Figure 8-11. Share of On-Road GHG Emissions in Northeast Ohio in 2019 by County



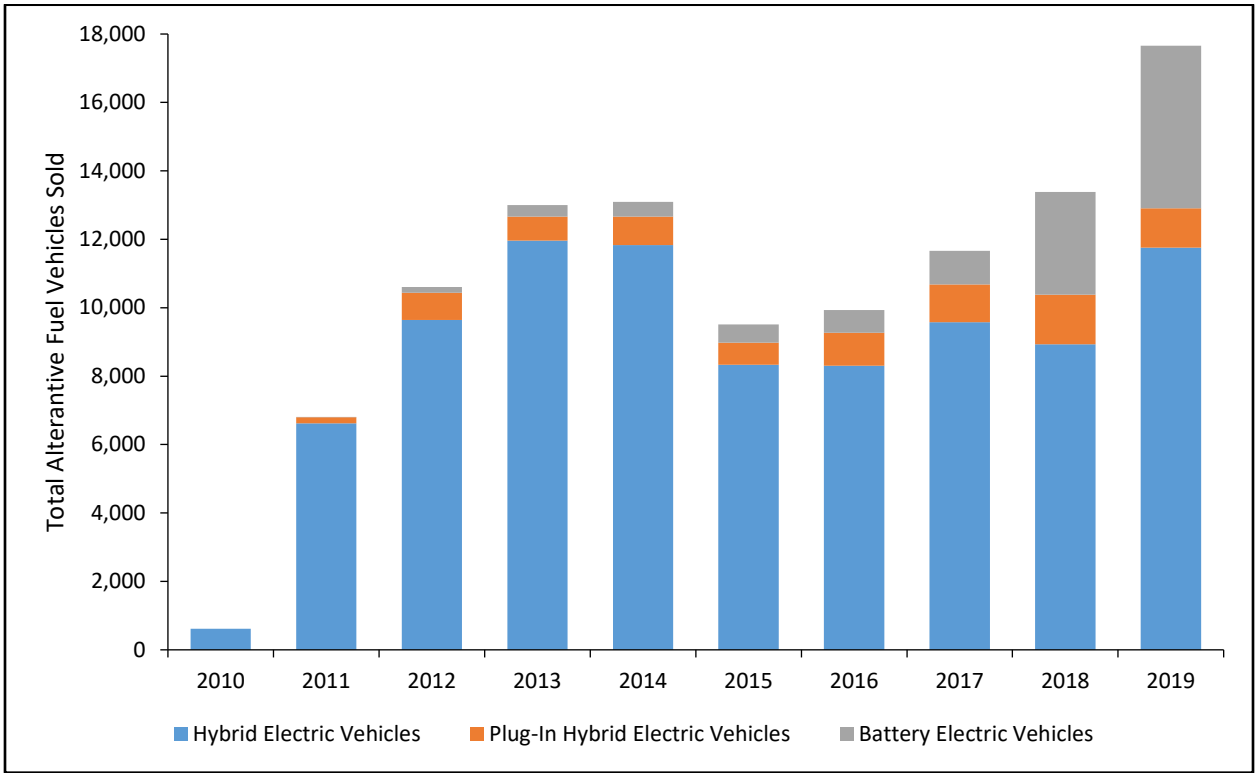
On-road GHG emissions are a function of four main variables: travel mode choice, fuel efficiency, vehicle fuel type, and total VMT. From 2014 to 2018, 89.3% of commuters drove private automobiles to work in Northeast Ohio. In turn, teleworking, transit, walking, and biking accounted for 4.2%, 3.1%, 2.4%, and 0.3%, respectively.[56] In 2019, the average fuel efficiency of the passenger vehicle fleet in the NOACA region was 21.23 miles per gallon (MPG), equivalent to 419 grams per mile (g/mi) of CO_2.[57] While the region's vehicle fleet has become more efficient, it still falls short of the national passenger vehicle fleet, which had an average fuel economy of 22.2 mpg during 2019.[58] Nationally, model year (MY) 2019 passenger vehicles had an average fuel efficiency of 24.9 miles per gallon (MPG), equivalent to 356 grams per mile (g/mi) of CO_2. This was an improvement of 10.1% from a decade earlier, when MY2010 vehicles averaged 22.6 mpg (394 g/mi).[59] This trend should continue as vehicles continue to become more efficient overall. The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule calls for the passenger vehicle fleet to increase fuel average fuel economy to 40.4 MPG and reduce CO_2 emissions per mile to 202 grams by 2026 (85 FR 24174). While these standards will reduce GHG emissions considerably over the lifespan of these vehicles, they would also result in 867-923 additional $MMTCO_2e$ compared to the standards they replaced.

The overwhelming majority of on-road vehicles in Ohio have internal combustion engines fired by fossil fuels, though the number of alternative fuel vehicles has begun to increase slowly. In 2010, there were just 614 hybrid vehicles sold in the state; by the end of 2019, there were

[56] U.S. Census Bureau, "American Community Survey 5-Year Population Estimates."
[57] NOACA estimates using US EPA's MOtor Vehicle Emissions Simulator, version 2014a (MOVES2014a).
[58] Federal Highway Administration (FHWA), "Average Fuel Efficiency of U.S. Light Duty Vehicles," https://www.bts.gov/content/average-fuel-efficiency-us-light-duty-vehicles (accessed April 8, 2021).
[59] US EPA, *2019 Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975* (Washington, DC: US EPA, 2020); https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100YVFS.pdf (accessed April 8, 2021).

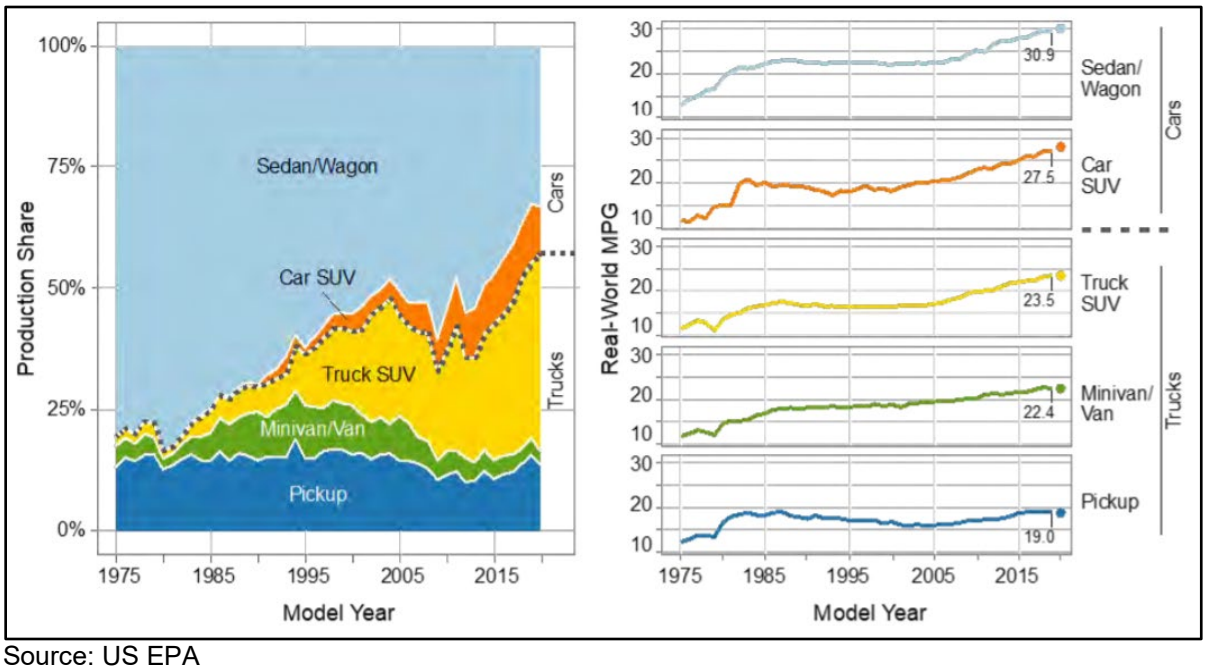
105,670 alternative fuel vehicles on Ohio's roads, of which 10,880 (10.3%) were fully electric vehicles (EVs) and 7,843 (7.7%) were plug-in hybrid electric vehicles (PHEVs) (see Figure 8-12).[60] Nationally, the market share of hybrids, PHEVs, and EVs increased to 3.6% in 2019, higher than the 2.2% share in Ohio. While the fuel economy of new passenger vehicles in the U.S. increased by an average of 1.5% per year from 2010-2014, that fell to just 0.7% per year from 2015-2019 (see Figure 8-13).[61] This reduction was largely due to consumers' shift away from passenger cars to larger, less fuel-efficient crossovers, sport utility vehicles (SUVs), and light-duty trucks. Whereas cars made up 67% of vehicles produced in MY2009, this share fell to 32.7% in MY2019.

Figure 8-12. Alternative Fuel Vehicle Sales in Ohio, 2010-2019[62]



[60] Alliance of Automobile Manufacturers, *Advanced Technology Vehicle Sales Dashboard*, (Washington, DC: Auto Alliance, 2020); https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/ (accessed April 8, 2021).
[61] US EPA, *2019 Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975* (Washington, DC: US EPA, 2020); https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100YVFS.pdf (accessed April 8, 2021).
[62] Alliance for Automotive Innovation, "Advanced Technology Vehicle Sales Dashboard," https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/ (accessed April 8, 2021).

Figure 8-13. Vehicle Production Share and Real-World Fuel Economy in the US, 1975-2019[63]

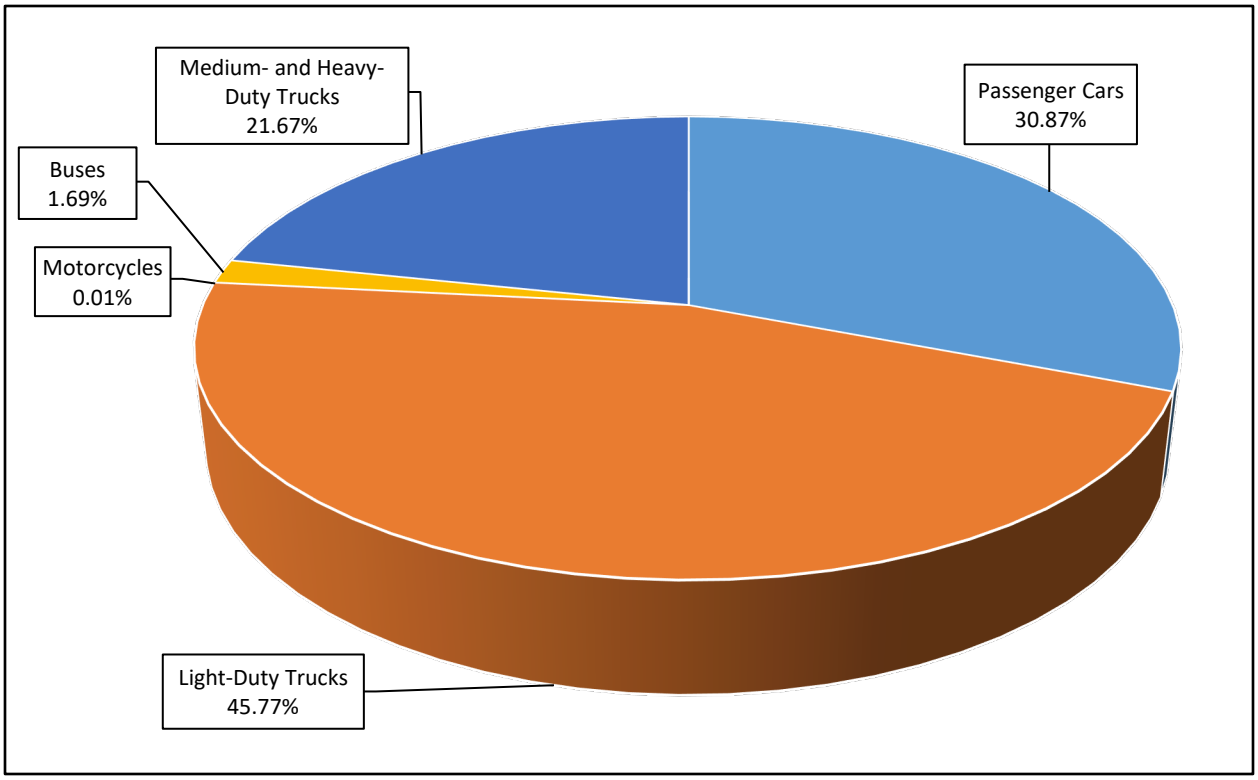


Source: US EPA

Within Northeast Ohio, light-duty vehicles, which include passenger cars and light-duty trucks, such as sport utility vehicles (SUVs), account for the vast majority of transportation sector GHGs (76.6%) and the largest share of vehicles (93.3%). While medium- and heavy-duty trucks make up just 3.6% of total vehicles, they generate 21.7% of total GHGs. Combined, motorcycles and buses account for 1.7% of total on-road GHG emissions.

[63] US EPA, *2019 Automotive Trends Report,* https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010U68.pdf (accessed April 8, 2021).

Figure 8-14. Share of GHG Emissions by Vehicle Type in Northeast Ohio (2019)



Due largely to these improvements in fuel economy, both for light-duty and heavy-duty vehicles, GHG emissions from on-road transportation in the NOACA region are expected to decline significantly by 2050. While VMT in the five-county area is set to increase through 2050, GHG emissions are projected to fall, as illustrated in Figure 8-14.

Greenhouse Gas Emissions by Future Transportation Infrastructure Investment Scenario

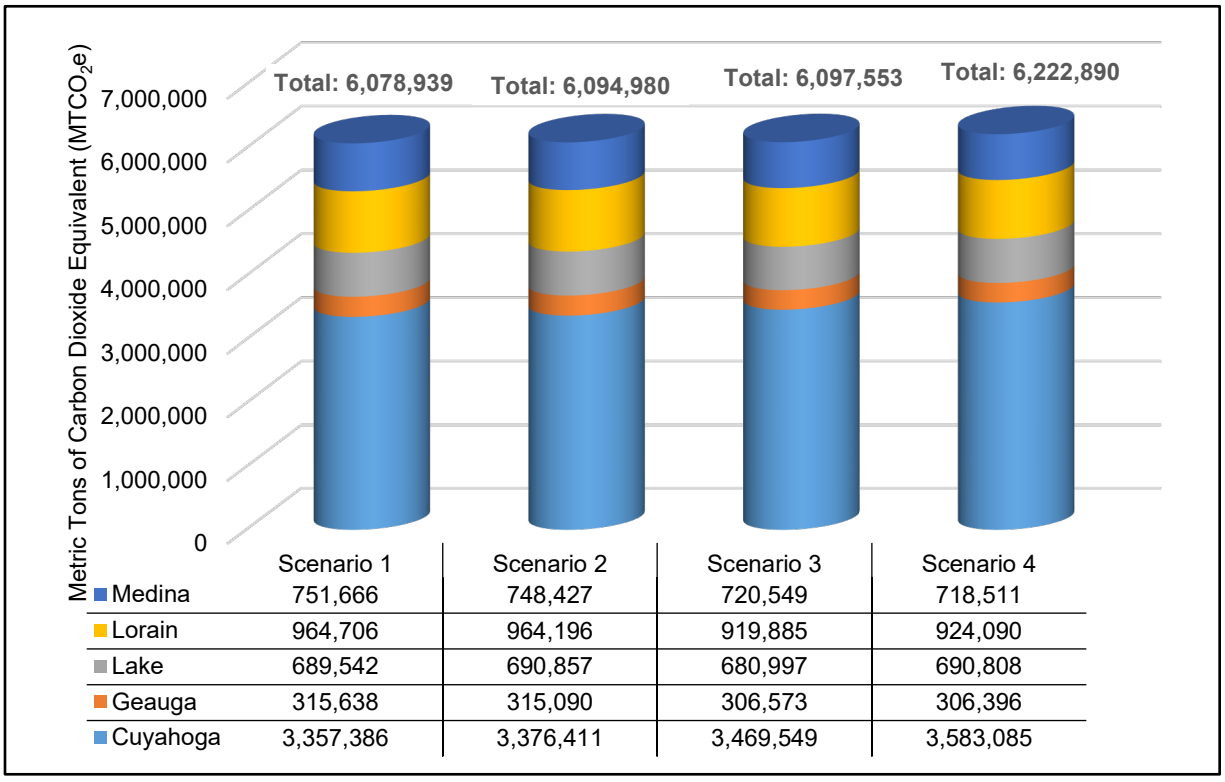
In Scenario 1 (MAINTAIN), emissions fall 30.2%, relative to the 2019 baseline (see Figure 8-15). The greatest decrease occurs in Cuyahoga County (32.6%), while the other counties experience smaller decreases (25.6-29.4%). This result reflects the fact that households will continue to expand outward, reducing Cuyahoga County's share of the region's population. In this scenario, fewer people live within walking distance of transit or within walking and biking distance of their worksite, which slightly increases the share of commuters who drive alone to work. As such, VMT increases by 7.6%, from a low of 4.2% in Cuyahoga County to a high of 13.1% in Medina County. While passenger vehicle fuel economy improves by nearly 80% to 38.2 MPG, the increase in VMT and the lack of improvement in fuel economy for other vehicle classes offsets more than half of this benefit. Scenario 2 (CAR), which is similar to MAINTAIN but with a more fully developed highway system, has the largest increase in VMT (7.8%) and the smallest decrease in GHG emissions (30%).

Scenarios 3 (TRANSIT) and 4 (TOTAL) envision population growth in the region, which drives up VMT and GHGs emissions. TRANSIT, which incorporates a more robust regional transit system and a better mix between jobs and housing development in the region, sees VMT

increase by a slightly larger margin (8.5%), while GHG emissions fall by 30%. TOTAL, which further improves the jobs-housing mix in the region, sees a comparable VMT increase of 8.5%, but it shows the smallest reduction in GHG emissions (28.6%). Ultimately, while population growth does increase emissions somewhat (0.3-2.4%), these differences are small and represent annual emission reduction rates far lower than observed annual variations.

These scenarios do not account for the impacts of significant vehicle electrification, which would tend to reduce emissions further. Currently, the average fully electric passenger vehicle in Northeast Ohio emits 53.6% less GHGs per mile than the average passenger vehicle with an internal combustion engine.[64] Nevertheless, while improving fuel economy and electrifying the vehicle fleet are essential for reducing GHG emissions, they are not sufficient, on their own, to meet the region's climate goals or to prevent the most serious impacts of climate change on the region. Even if Northeast Ohio were to require all new passenger vehicles to be EVs in 2030, that would still fall well short of reaching carbon neutrality for transportation by 2050. To achieve this, the region will need to take additional steps to cut VMT significantly.

Figure 1-15. GHG Emissions for Northeast Ohio by *eNEO2050* Scenario



	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Medina	751,666	748,427	720,549	718,511
Lorain	964,706	964,196	919,885	924,090
Lake	689,542	690,857	680,997	690,808
Geauga	315,638	315,090	306,573	306,396
Cuyahoga	3,357,386	3,376,411	3,469,549	3,583,085

Climate Change Impacts on Water Resources

One of the most anticipated and worrisome impacts of climate change in Northeast Ohio may be its influence on precipitation. Since 1950, annual precipitation has increased by 19.1% (7.1 inches), with the greatest increases occurring during the fall (28.2%) and summer (25.3%)

[64] Union of Concerned Scientists, "How Clean Is Your Electric Vehicle," https://evtool.ucsusa.org/ (accessed April 8, 2021).

months.[65] Much of this change has been due to an increase in the frequency and intensity of extreme precipitation events. Northeast Ohio has experienced 53 days with at least 2 inches of precipitation since 1950.[66]

These types of extreme events can overwhelm the ability of the natural and built environment to absorb additional moisture, particularly in areas with greater imperviousness. This, in turn, can cause flash flooding and combined sewer overflow (CSO) events, which dump pollutants and raw sewage into waterways. Therefore, climatic changes are taking a toll on the health of Lake Erie, which is the region's most important natural resource. Many manufacturers locate in the region because they need easy access to abundant fresh water. Tourism for lake-based recreation brings people from around the world; the Lake Erie Shores and Islands Visitor Center conducted an economic impact analysis showing that in 2018, 11 million people visited the lake and generated $1.4 billion for local economies.[67] This was statewide, but the NOACA region certainly captured an important share of that since it has the largest population center on Lake Erie and other tourist attractions in and around Cleveland, as well as wineries in Lake County and five major rivers. Shippers move tens of millions of tons of freight in and out of ports in Cuyahoga, Lake, and Lorain each year.[68] These are some of the largest economic sectors in the region.

Climate change poses several risks, however. Higher winter temperatures have halved ice cover on the lake from 1973-2010. Increases in surface water temperatures and extreme rainfall will increase the frequency and intensity of harmful algal blooms (HABs), which have plagued Lake Erie each summer since 2002. In 2014, a severe HAB off the Toledo shoreline deprived 500,000 people of clean drinking water for three days.[69] The lake may also see increasing fluctuations in water levels that threaten coastal communities and damage property.[70] Businesses that need fresh water for operations will most likely be negatively impacted, presenting challenges for attraction, retention and expansion. Likewise, population growth will be inhibited if people perceive drinking water and recreation as unsafe. All of this will weaken economic development and quality of life in the region.

Extreme rainfall disproportionately affects minority communities, as Black and Latino neighborhoods experience more severe flooding.[71] And the disparate impact of flooding does

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[65] Great Lakes Integrated Sciences and Assessments (GLISA), "Northeastern Ohio," http://glisa.msu.edu/division/oh03 (accessed November 15, 2020).
[66] This represents the 99.9th percentile of precipitation events.
[67] Ohio Lake Erie Commission, *Lake Erie Protection and Restoration Plan, 2020* (Columbus, OH; Ohio Lake Erie Commission, 2020), 24; https://lakeerie.ohio.gov/wps/wcm/connect/gov/fa97a536-ad44-41ae-a117-5f48b7c7ce9d/LEPR2020_Final.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE.Z18_M1HGGIK0N0JO00QO9DDDDM3000-fa97a536-ad44-41ae-a117-5f48b7c7ce9d-nqF.QeX (accessed April 8, 2021).
[68] Northeast Ohio Areawide Coordinating Agency (NOACA), *NOACA Multimodal Regional Freight Plan* (Cleveland: NOACA, 2017), 26; https://www.noaca.org/home/showpublisheddocument?id=21293 (accessed April 8, 2021).
[69] Laura Johnston, "2017 Harmful Algal Bloom Blossoms across Lake Erie, as Toledo Mayor Wants Water Designated 'Impaired,'" *Cleveland.com*, Sept. 27, 2017; https://www.cleveland.com/metro/2017/09/2017_harmful_algal_bloom_bloss.html (accessed April 8, 2021).
[70] Ibid.
[71] Kevin T. Smiley, "Social inequalities in flooding inside and outside of floodplains during Hurricane Harvey," *Environmental Research Letters* 15 (2020), 0940b3.

not stop with the disaster itself. As the number of disasters in a county increases, the racial wealth gap tends to widen significantly.[72]

Moreover, climate change may heighten traditional winter- and springtime freeze-thaw cycles, which places additional strain on pavement. The costs of maintaining, repairing, and replacing pavement in the Midwest is projected to increase by $1.5 billion through 2050 and more than $3 billion by 2100 without efforts to curb GHG emissions globally.[73] Elevated flood risks already affect the region's transportation systems, which causes road and bridge damage and shipping delays that hurt businesses. Heat waves may cause buckling or other damage to roads, bridges, and (particularly) railroads that can result in slower shipping times or even closures.[74]

Expansion of the regional roadway network to increase capacity for vehicles, as proposed by Scenario 2 (CAR), will raise the future costs associated with the effects of climate change. Increased stormwater runoff, laden with nutrients and metals, will impact local streams and rivers. All proposed scenarios will contribute to degradation of regional water quality as the transportation system is largely built-out, even in areas where capacity far exceeds demand. Scenarios 3 (TRANSIT) and 4 (TOTAL) discuss concentrating future development within target areas, which may benefit regional water conditions if areas are conserved near high-quality streams and wetlands. Preserving the health of waterways may create greater climate resiliency for the region and will contribute to a higher quality of life for communities.

Climate Change Opportunities

While it will require significant investments and policy changes to mitigate the harms of environmental degradation and climate change in Northeast Ohio, this effort presents a clear opportunity for the region. As Chapter 5 discussed, manufacturing is the largest sector of the Greater Cleveland economy by gross domestic product (GDP) and second largest by employment. Accordingly, the region is well suited to provide the technologies necessary to advance a clean economy.

Ohio currently leads the country in wind turbine component manufacturing, with more than 60 factories.[75] Companies like Lincoln Electric, Parker Hannifin, and Swiger Coil Systems play key roles throughout the wind power supply chain. The nonprofit LEEDCo, a public-private partnership, has received $40 million from the U.S. Department of Energy to plan and implement the first freshwater, off-shore wind project in North America on Lake Erie. Construction is slated to begin in 2022 and has the potential to cement Northeast Ohio further as a national and even global leader in the development of this industry.[76] The region also has a foothold in other clean energy sectors, including solar energy manufacturing and installation. Solar technicians trained at one of the region's community colleges can work for local firms, such as YellowLite, to install First Solar arrays manufactured in Toledo on custom racks

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[72] Junia Howell and James R. Elliott, "As Disaster Costs Rise, So Does Inequality," *Socius: Sociological Research for a Dynamic World* (2018).
[73] US EPA, "Climate Action Benefits: Roads," *Climate Change in the U.S.—Benefits of Global Action* (Washington, DC: US EPA, 2015); https://www.epa.gov/cira/climate-action-benefits-roads (accessed April 8, 2021).
[74] Ibid.
[75] Greg Alvarez, "Fact Check: Setting the record straight on President Trump's recent wind comments," *The Power Line*, Dec. 23, 2019, https://cleanpower.org/blog/fact-check-setting-record-straight-president-trumps-recent-wind-comments/ (accessed April 8, 2021).
[76] Lake Erie Energy Development Corporation, "Icebreaker wind: The first offshore wind project in the Great Lakes," http://www.leedco.org/ (accessed February 14, 2021).

produced by Talon Products. Northeast Ohio companies also play leading roles in manufacturing LED lights (General Electric, TCP Lighting) and electric vehicle components and charging infrastructure (Eaton Corp.). Initiatives to remediate lead and weatherize the region's aging housing stock will create good jobs and help mitigate the disproportionate burden that people of color pay in utility costs and health impacts.[77]

Lake Erie presents the region with a potential competitive advantage in a changing climate. The Cleveland Water Alliance is working to capitalize on this vital resource. The organization formed in 2014 to "build upon Ohio and the Great Lakes assets and resources to create a clean water innovation ecosystem that harnesses technology, spurs the economy, enhances education, and drives research."[78] This is similar to the Water Council, a Milwaukee, Wisconsin nonprofit.[79] The Brookings Institution analyzed their water technology cluster in 2018, finding that it included 175 firms with $10.5 billion in revenues and more than 20,000 employees; these firms are capitalizing on the global market for water technologies that was estimated to be more than $600 billion in 2016.[80] As climate change stresses water resources while the global population simultaneously grows, the demand for clean water, and the technology to ensure it, will only increase.[81]

Agriculture is another critical industry in Northeast Ohio where mitigating climate change and other pollution is also good for business. The USDA notes that "farming practices such as conservation tillage, organic production, improved cropping systems, land restoration, land use change and irrigation and water management, are ways that farmers can address climate change. Good management practices have multiple benefits that may also enhance profitability, improve farm energy efficiency and boost air and soil quality."[82] In other words, the methods that reduce climate impacts also reduce input costs or increase outputs for farmers, so it makes economic and environmental sense. Additionally, transportation of crops and processed goods contributes to climate change, so it is important to reduce the distance food travels in order to reduce emissions. Chapter 5 showed that food and beverage production is a rapidly growing employment sector, so the region is well-suited to capitalize on a more local food system.

Health care is the region's largest sector by employment and continues to grow, so how this sector responds to climate change is critically important. If climate change exacerbates public health, this would increase health-care spending and therefore GDP, but the costs on the region would be substantial. Rather, businesses in the health-care sector can respond to climate change by reducing their contribution to global warming and ensuring people affected by it can

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[77] Constantine E. Kontokosta, Vincent J. Reina, and Bartosz Bonczak, "Energy cost burdens for low-income and minority households: Evidence from energy benchmarking and audit data in five US cities," *Journal of the American Planning Association* 86, no. 1 (2020), 89-105.
[78] Cleveland Water Alliance, "Our Mission," 2021, https://clevelandwateralliance.org/about-us) (accessed Feb. 14, 2021).
[79] The Water Council, "At the center of global freshwater innovation," 2021, https://thewatercouncil.com/about-us/ (accessed Feb. 14, 2021).
[80] Brad McDearman, "Rethinking Cluster Initiatives. Case Study: Milwaukee Water Technology," Brookings Metropolitan Policy Program at Brookings, July 2018; https://www.brookings.edu/wp-content/uploads/2018/07/201807_Brookings-Metro_Rethinking-Clusters-Initiatives_Milwaukee-Water-Technology.pdf (accessed April 8, 2021).
[81] United Nations, "Water and Climate Change," *UN Water*, 2021 https://www.unwater.org/water-facts/climate-change/ (accessed Feb. 14, 2021).
[82] Jeff Schahczenski and Holly Hill, *Agriculture, Climate Change and Carbon Sequestration* (ATTRA—National Sustainable Agriculture Information Service, 2009); https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_002437.pdf) (accessed April 8, 2021).

access care. The Cleveland Clinic has committed to carbon neutrality in its operations, and partners with local groups to plant trees to improve air quality.[83] Health-care providers should also consider their siting locations and design, so that people can access them by low- or zero-carbon transportation such as transit, walking, and cycling, and so that low-income residents most likely to be affected by climate change can access care if and when needed. Organizations such as Ohio Clinicians for Climate Action and Healthcare without Harm are dedicated to tackling climate change and pollution in order to enhance health.

The most severe impacts of climate change, including increased wildfire risk, sea level rise, persistent drought conditions, and dramatic shifts in rainfall patterns, will likely occur outside Northeast Ohio. If that displaces residents of places that are more susceptible to these threats than Greater Cleveland, then some of those people may relocate to the region, which is expected to be relatively safe from these harms.[84] One study predicts that Greater Cleveland will see thousands of new residents by 2100 if sea level rises six feet.[85] Given that the region has been losing population for decades, this would represent a significant shift, and planners should be prepared to accommodate them through redevelopment of areas that currently have underused infrastructure due to population loss.[86] It is important to note that even if these severe impacts occur, they may not result in population shifts that result in more residents in the region. It is nonetheless worth considering for this long-range plan that stretches out to 2050, and it shows the importance of preparing underused infrastructure for revitalization. Policies to promote infill development, better use existing infrastructure, and expand housing diversity will enhance regional quality of life.

Where Will We Go?

Future Development Scenarios

Looking forward to 2050, there are a number of different possible paths for the NOACA region to realize its future. The following four scenarios serve as predictions for what could be, based on levels and types of transportation investment. There will be particular focus on worker accessibility to jobs and equity. The scenarios—MAINTAIN, CAR, TRANSIT and TOTAL—are discussed in relation to impacts on air quality, water quality, and climate resilience in the region. Chapter 9 provides a more detailed presentation of the scenarios, their components, and performance measures used for scenario comparison and selection.

Scenario 1: MAINTAIN—State of Good Repair

Scenario 1 focuses on maintenance of the existing transportation system, with no expansion of roads, bridges, highways, or public transit. The scenario assumes no variation from the current

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[83] The Cleveland Clinic Foundation, “Climate Resilience”, https://my.clevelandclinic.org/about/community/sustainability/sustainability-global-citizenship/environment/climate-resilience (accessed Feb. 14, 2021).

[84] Al Shaw, Abrahm Lustgarten, and Jeremy W. Goldsmith, “New Climate Maps Show a Transformed United States,” *ProPublica* and *New York Times*, Sept. 15, 2020; https://projects.propublica.org/climate-migration/ (accessed April 8, 2021).

[85] Caleb Robinson, Bistra Dilkina, Juan Moreno-Cruz, “Modeling migration patterns in the USA under sea level rise,” PLOS ONE 15, no. 1 (Jan. 22, 2020), e0227436; https://doi.org/10.1371/journal.pone.0227436 (accessed April 8, 2021).

[86] Daniel C. Vock, “Climate Migrants Are on the Move,” *American Planning Association*, Winter 2021; https://www.planning.org/planning/2021/winter/climate-migrants-are-on-the-move/. (accessed April 8, 2021).

population and employment forecasts for the region, which reflect recent trends (slight decrease in population, slight increase in employment).

Under Scenario 1, the continued outward movement of the workforce in Northeast Ohio will exacerbate the existing jobs-housing disconnect in the region. This form of job sprawl makes it difficult for many employers to recruit an adequate workforce, and it exacerbates existing racial disparities by making it nearly impossible for many low-income minority workers to access those jobs without a private automobile.

One of the major drivers of mode shift—traffic congestion—is not a serious problem in most of Northeast Ohio, which may make it more difficult to increase the share of alternative modes. In Scenario 1, the improved roads and highways may increase the region's SOV rate. In turn, this induced demand may neuter any congestion reduction benefit; travel delays will increase by 5%.

Scenario 1 maintains the existing system and the persistent pattern of outward expansion of imperviousness into exurban and rural subwatersheds. These headwater streams and creeks may suffer the most from development, particularly without best practices such as those outlined in *Clean Water 2020.* Much of the work by local, grassroots watershed planning organizations is at risk, along with the health of Lake Erie.

Scenario 2: Captivating Auto Region (CAR)-Single—Occupancy Vehicles

In Scenario 2, road capacity expansion is the priority. This includes new and improved infrastructure (roads, highways, bridges, and interchanges), shorter travel times through traffic signal timing optimization, reduction of highway bottlenecks, ramp metering, and reduced commutes to job hubs. Like Scenario 1 (MAINTAIN), CAR assumes no change to the projected population (slight decrease) and employment (slight increase) totals by the year 2050.

Under Scenario 2, the continued outward movement of the workforce in Northeast Ohio, facilitated by the expansion of the regional highway network, will exacerbate the existing jobs-housing disconnect in the region even more than in Scenario 1. This form of job sprawl makes it difficult for many employers to recruit an adequate workforce, and it exacerbates existing racial disparities by making it nearly impossible for many low-income workers and people of color to access those jobs without a private automobile.

In Scenario 2, the additional highway lane miles makes driving to work more attractive, slightly increasing the region's SOV rate. In turn, this induced demand eliminates any congestion reduction benefit and travel delays increase by 8.4%.

Scenario 2 focuses on car travel throughout the region and exacerbates the spread of imperviousness through active widening of roads and highways and the addition of new highway interchanges. Scenario 2 would likely hasten degradation of headwater streams in exurban and rural areas that experience significant development, but also potentially increase the downstream impacts in more developed areas.

Scenario 3: TRANsportation System with Improved Transit (TRANSIT)—Multimodal Transportation System

Scenario 3, TRANSIT, is essentially the opposite of CAR (Scenario 2). TRANSIT expands all transit agencies in the region through implementation of the improved 2017 Visionary Rail

Network and increased bus service to Environmental Justice Areas.[87] TRANSIT also includes connections between transit stops and job hubs with autonomous shuttles and new pedestrian and bike routes. In Scenario 3, the projected 2050 population and employment is based on the same NOACA forecasts used in the MAINTAIN and CAR scenarios, plus additional increases as described below.

Scenarios 3 and 4 involve significant enhancements to the regional transit network, which should help foster mode shift and bolster transit in the region. In Scenario 3, transit mode share nearly doubles to 9.7%. In 2017, the average transit trip in the region emitted approximately 9% less CO_2 than the average car trip.[88] According to one estimate, doubling per capita subsidies to transit could reduce GHG emissions from transportation by 18%.[89]

Scenario 3 helps mitigate sprawl and focuses a greater share of the residential population near regional job hubs. This shift will bolster transportation demand management (TDM) policies, as employees are vastly more likely to use alternative modes if they live near their workplaces. Scenario 3 helps create the conditions to reduce the region's SOV rate, which is far higher than the national average.

On the other hand, Scenario 3 includes enhancements to the transit system without associated expansions of the road network. This leads to a 38.5% increase in congestion. This considerable increase in delay within the region may help to further promote mode shift, as the cost of driving increase, but it also increases mobile emissions impacts, which exacerbates poor air quality in the region and all of its negative consequences.

Scenarios 3 focuses on increased residential density and economic growth in target areas. NOACA will need to take a holistic approach that includes multimodal transportation infrastructure, access to transit, and pollution mitigation features to address the region's air and water resource and environmental justice challenges.

Scenario 4: Transportation with Optimal Technology and Access for All (TOTAL)—Advanced Multimodal Transportation

The fourth scenario, TOTAL, incorporates all projects in the CAR (save highway interchanges) and TRANSIT scenarios. Additionally, the TOTAL scenario includes technological advances in the form of electric vehicle (EV) charging stations; autonomous vehicle lanes; and the futuristic Hyperloop system and stations. The projected 2050 population and employment in TOTAL is based on the same NOACA forecasts used in the other scenarios, plus additional increases as described below.

Although Scenario 4 experiences increased costs due to both congestion and emissions, the increases are lower than the other four scenarios. The wholesale changes in the transportation system (both expanded transit service and arterial/highway network) create better connections between jobs and housing. Nearly 250,000 more jobs become accessible within a 30-minute commute. Total annual transit trips in the region increase by 70 million, nearly two-thirds higher than the 42 million increase projected in Scenario 3.

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[87] NOACA, *AIM Forward 2040* (Cleveland: NOACA, June 2017); https://www.dropbox.com/s/1pvfvhx8xszgdlo/AIM%20Forward%202040.pdf?dl=0 (accessed March 16, 2021).
[88] NOACA estimates using US EPA's MOVES2014a model.
[89] Sungwon Lee and Bumsoo Lee, "The influence of urban form on GHG emissions in the U.S. household sector," *Energy Policy* 68 (2014), 534-549.

From a water quality standpoint, the expansion of the road network increases the spread of imperviousness, but that is tempered somewhat but the concentration of employment and population growth within the vicinity of major regional job hubs. More of the additional growth will take place within the developed footprint of the region, which will curb greenfield disturbance in exurban and rural areas.

Performance Measures and Targets

Although Chapter 9 will present a much more detailed discussion and analysis of the four future scenarios mentioned above, this section details performance measures to assess progress toward a cleaner environment and a more climate-resilient region. The performance measures are variables used to assess the scenarios comparatively against each other. There are two important values associated with each performance measure: the baseline and the target. The baseline is the value of the performance measure in the current state (2020). The target is the value of the performance measure in the future state (2050). One of the four future scenarios will be the preferred scenario and its performance measures will be the target values NOACA will use to assess the region's progress from the current state to the preferred future state. Table 8-29 illustrates the performance measures and targets focused on air quality, water quality, and climate resilience.

The outputs are presented in a specific way to help the reader digest the information clearly and concisely with the following guidelines:

1. The baseline represents current conditions (2020 conditions). The outputs reflect how the performance measure will change from the baseline to the target year (2050) under each of the four scenarios.
2. The "-" and "+" (minus and plus) signs shown as outputs for each performance measure under each scenario indicate the direction of change. A "-" (minus) sign indicates a decrease from the baseline and a "+" (plus) sign indicates an increase from the baseline. There are two sizes for each sign; they represent the magnitude of change (smaller signs indicate slight change; larger signs indicate more substantial change).
3. The colors of the signs and numbers for each output are also important. Red color indicates a negative impact on the region, while green indicates a positive impact on the region. While many people commonly associate "-" signs with a negative impact and "+" signs with a positive impact, that is not always the case. It is possible to have a red "+" sign, meaning the value of that performance measure will increase under a scenario, but that increase will have a negative impact on the region.
4. Most of the performance measures in Table 8-32 are qualitative. To help the reader interpret the differences across scenarios, consider the performance measure, "future population and employment in communities with peak population in 1970."
    a. MAINTAIN: Maintenance of the status quo will likely yield continued slow decline of population in those communities whose population peaked in 1970, the same year the region's population peaked. These communities make up the region's peak population development footprint; after 1970, all growth essentially came at the expense of older, urban core neighborhoods that experienced decline, disinvestment, abandonment, and demolition.
    b. CAR: Prioritization of arterial and highway infrastructure expansion will likely yield a substantial decline in the population and employment of the 1970 development footprint.

c. TRANSIT: Investment in expansion of transit lines and stations instead of road/highway capacity will restore some of the population and employment within the 1970 development footprint.
d. TOTAL: Investment in both transit and road capacity expansion will restore some of the population and employment within the 1970 development footprint.

Table 8-29. Performance Measures and Targets (Air Quality, Water Quality, and Climate Resilience)

Performance Measure	Scenario 1 MAINTAIN	Scenario 2 CAR	Scenario 3 TRANSIT	Scenario 4 TOTAL	2020 Baseline
Regional Population	- (42,806)	- (42,806)	+ 100,406	+ 200,892	2,026,866
Regional Employment	+ 55,850	+ 55,850	+ 66,254	+ 132,950	1,421,195
Annual Emissions Cost in 2050$ (Per Capita)	+ 49	+ 41	+ 53	+ 33	551
Bike Lanes, Sidewalks and Bike/Walk Paths	SAME	SAME	+	+	Current bike infrastructure (lane miles of shared/separated service) and walk infrastructure (sidewalks, paths, crosswalks) in major regional job hubs
Ecologically Sensitive and Agriculturally Productive Lands	-	-	SAME	-	Current acreage of ecologically sensitive and agriculturally productive lands in Northeast Ohio
Future Population and Employment in Communities with Peak Population in 1970	-	-	+	+	Current estimate of total population and employment for all communities whose population peak occurred on or before 1970 (another option is to consider median age of single-family homes (1970 or earlier)
Cleaned Brownfields (formerly developed, polluted sites)	-	-	+	-	Current number and acreage of brownfields
Attain National Air Quality Standards (*need to check against Ali's new emission cost numbers from most recent model run*)	-	-	-	-	Moderate Nonattainment for Ground-Level Ozone
Greenhouse Gas Emissions	+	+	+	+	Current greenhouse gas emissions for region
Flood Threat to Major Regional Job Hubs	+	+	SAME	+	current % major job hub areas within or proximal to designated floodplains or flood hazard zones

Principal Considerations for Transportation in the Context of Environment and Health

Given NOACA's role as the regional environmental planning agency for Northeast Ohio, it can play a major role in enhancing the region's water and air quality as well as in advancing the region's resilience to climate change. Overall, NOACAs efforts in these areas can improve

equity and quality of life across the region. NOACA's continued investment in multimodal transportation infrastructure will be vital for reducing GHG emissions, improving public health, expanding transportation choice and access, and reducing racial and economic inequities.

To achieve the desired equitable future for Northeast Ohio, principal considerations must be contemplated in response to the anticipated challenges during the coming decades.

1. Populations can be disproportionately affected by impairments to water and air quality and the impacts of climate change.
2. Development of action plans to reduce greenhouse gas emissions substantially support of state, regional, and local emissions reduction goals.
3. Substantial reduction of greenhouse gas emissions will reduce the impacts of climate change on the region.
4. Awareness of the region's air quality challenges and the linkages with air quality, transportation, land use, and public health will allow individuals to make informed transportation decisions.
5. Air quality planning integrated into proposed economic strategies can promote compact growth patterns, carbon neutral travel choices, and tree canopy and open space protection.
6. Transportation network and land-use patterns significantly influence water quality conditions and watershed planning efforts.
7. Regional collaboration through data sharing reduces redundancy, identifies information gaps, and develops more effective programs.
8. Decisions on the expansion/extension of wastewater services and transportation access made in accordance with one another that take into account the development implications of expanding infrastructure into undeveloped land mediates negative outcomes .

Implementation Action Items

Looking forward to 2050, NOACA should implement the following actions to move the region toward a more equitable future:

1. Collaborate with NOACA members, community partners, and stakeholders to define a regional carbon reduction goal and priority actions to achieve it by 2050.
2. Establish a Climate Resilience working group to advance programs and projects aimed at mitigating impacts of future conditions on natural resources, transportation infrastructure, and disproportionately impacted areas.
3. Provide technical assistance to NOACA membership on development of local Climate Action Plans/Climate Adaptation Plans.
4. Address the region's resilience to climate impacts by identifying the adaptive capacity through a comprehensive assessment of vulnerability to natural hazards directly impacting and impacted by transportation, water and air quality and related comprehensive planning.
5. Continue to monitor, evaluate, and publish air quality conditions (e.g., daily Air Quality Index (AQI), annual Air Quality Trends Report).
6. Support public policies that provide greater transportation choice, reduce mobile emissions, benefit public health, create economic opportunity, and enhance the quality of life in Northeast Ohio.
7. Maintain and regularly update Water Quality Management Plans, including the Areawide 208 Plan to address regional water quality and water infrastructure needs.
8. Promote strategies outside NOACA to change transportation and infrastructure policy to recognize funding needs for clean air and water quality enhancement projects.

9. Continue to promote mode shift from private automobiles to active transportation through NOACA's Transportation for Livable Communities Initiative (TLCI), its ACTIVATE Plan for bicycle and pedestrian planning, and technical assistance to local communities.
10. Continue to increase employer participation in the Gohio Commute platform, Ohio's premier trip planning, logging, and matching platform (enables individuals to find information on how to get from point A to point B via every available travel mode, and it provides them with transparent information on the true costs and benefits of each travel mode).
11. Continue to host the Commuter Choice Awards, which recognize employers throughout the region who do the most to promote TDM and alternative commuting.
12. Modify or enhance NOACA's use of the FPA boundaries to facilitate more long-term and comprehensive planning in the region.