3 CLIMATE & ENVIRONMENT

Finding Meaning

Existing Conditions

Climate Context

Climate change is the greatest environmental challenge of the 21st century. It poses a serious threat to Northwest Indiana's economy, quality of life, and natural resources. Addressing this challenge is essential to creating a healthier, safer, and more equitable world. Climate scientists expect that with current trends in fossil fuel use, Americans will see more intense storms, flooding, extreme heat events, and droughts in the future. If not addressed, these impacts will impair our communities, residents, environment, and economy. Northwest Indiana has an unparalleled opportunity to make changes to mitigate climate change while also creating jobs and improving our quality of life. Action is required at all levels, and local governments have a unique role to play in building low-carbon communities.

NIRPC is joining an increasing number of regional governments committed to addressing climate change at both regional and local levels. NIRPC recognizes the risks that climate change poses to Northwest Indiana residents. It is critical to address the impacts of a changing climate, such as flooding and heat waves, and to adapt systems and infrastructure accordingly. Ultimately, local action is necessary to reduce Northwest Indiana's contribution toward the problem of climate change and adapt to its current and future effects.

Climate Action Northwest Indiana (CAN) will consist of three volumes making up the Northwestern Indiana Regional Climate Action Framework and the multi-stakeholder effort to encourage long term action, engagement, and implementation of climate actions. The three volumes of the Framework will include the Northwest Indiana Regional Greenhouse Gas Inventory, the Northwest Indiana Regional Climate Action Planning Framework, and a NWI Regional Climate Resilience Plan. These regional documents will be utilized to guide and provide technical support for local government planning and action around carbon emission reduction and climate resiliency planning.

NWI 2050+ summarizes current predictions of climate change and risks to our region and provides a brief description of all major NWI GHG sources in our 2017 Baseline Inventory. A general forecast of future emissions in 2030 and 2050 with a business-as-usual scenario is developed. Greater detail is provided on transportation and mobile sources and their interdependence with land use, the sectors most relevant to *NWI 2050+* as the region's Metropolitan Transportation Plan. The remaining source sectors will be presented in greater detail in the completed NWI Regional Climate Action Planning Framework.

What is Climate Change?

Climate change is the result of the accumulation of greenhouse gases (GHG), such as carbon dioxide (CO2) and methane (CH4) in the atmosphere derived, primarily, from burning fossil fuels and land use changes. Although the greenhouse effect is natural and keeps the Earth warm, human activity has caused increased accumulation of GHG in the atmosphere, resulting in climatic changes.

The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report confirms that human activities have unequivocally caused an increase in carbon emissions[1]. Between 2011 and 2021 concentrations of the three most significant greenhouse gases, atmospheric carbon dioxide, methane, and nitrous oxide have increased 6.2%, 3%, and 3.2% respectively[2]. World-wide, there is high confidence that if these concentrations continue to increase at current rates, the average global temperature will increase 34.7 °F between 2030 and 2052. In some parts of the globe, the average temperature increase will double or even triple.

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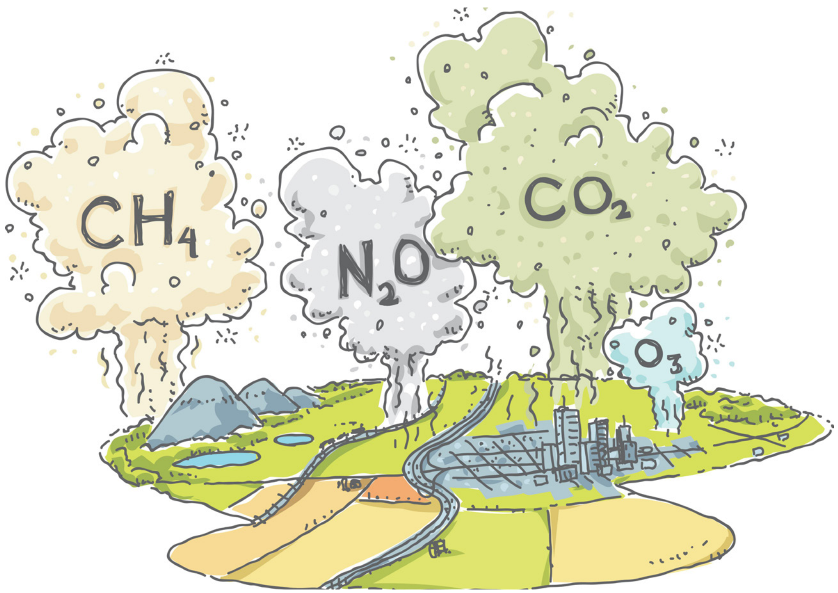
1 IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

2 Climate Change Indicators: Atmospheric Concentrations of Greenhouse Gases | US EPA



Greenhouse Gas	GWP Factor	# Tons of CO2e per ton of individual GHG
Carbon Dioxide (CO2)	1	1
Methane (CH4)	25	25
Nitrous Oxide (N20)	298	298

Table 3-1: Global warming potential of major greenhouse gases

Carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) are the three greenhouse gases most emitted from human activity. They are not all created equal in terms of their climate change effect, the amount of time they remain in the atmosphere, their sources, and their reduction strategies there are vast differences. To simplify the discussion and provide a common denominator, methane and nitrous oxide each have global warming potential factors expressed in terms of CO2 equivalents (CO2e). Table 3-1 compares the CO2e for these three most common compounds. Using this table, you can calculate a single CO2e value for an emission source based on its emissions of any combination of the CO2, CH4, and N2O.

GHG also include four classifications of fluorinated hydrocarbons that can contribute thousands of CO2e per unit, however these are not typically included in community inventories here because they are typically only released in measurable quantities by manufacturing facilities You can find more information about fluorinated hydrocarbon emissions on EPA's Facility Level Information on Greenhouse gases Tool (FLIGHT).

The energy production, industrial, and transportation sectors have dominated these emission increases. With the current trajectory of population growth, urbanization, and reliance on personal vehicles; global transportation emissions are expected to double by 2050. Given the critical impacts of climate change on humanity, the time to act to reduce GHG emissions and our carbon footprint is now.

With more than 80% of Americans living in urban areas, local governments can play a powerful role in addressing climate change. The design of cities—how we use our land, how we design our buildings, how we get around—greatly impacts the amount of energy we use and the volume of GHG emissions we produce. Within the next 20 years, we expect another 1.5 billion residents in the world's cities. It is critical that regions like Northwest Indiana demonstrate that it is possible to dramatically reduce GHG emissions while creating more vibrant and prosperous places to live, work and play.

How will Climate Change impact Northwest Indiana?

The Purdue Indiana Climate Change Impacts Assessment predicts that average Indiana temperatures will increase 5 - 6°F by 2050 [1]. Since 2020, the average warmest month temperature has been 78.4°F, and the average coolest month temperature has been 15.1 °F. By 2050 these averages will be more likely to be 84.4°F in summer and 21.1°F in winter. What does this mean for the region's already unpredictable weather? A doubling or tripling of the number of extreme high heat events (Table 3-2) and a 30-70% increase in the number of extreme rain or snow events (Table 3-3).

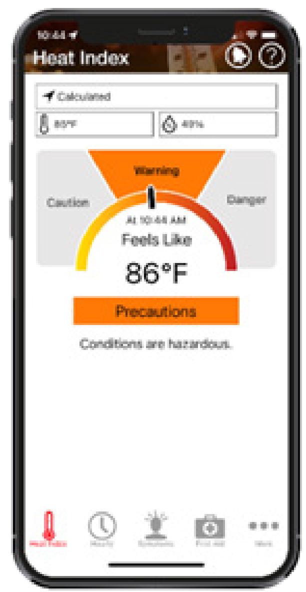


Figure 3-1: NIOSH-OSHA Heat Safety App

1 Indiana's Past & Future Climate: A Report from the Indiana Climate Change Impacts Assessment – Indiana Climate Change Impacts Assessment (purdue.edu

What do these changes mean on the ground? Extreme heat events can cause increased emergency room visits and even deaths due to dehydration and heat stroke, especially for vulnerable populations such as children and the elderly. They can contribute to increased air conditioning costs in public facilities, or lost learning days in schools without central air and increase the risks of fire. Extreme precipitation events can increase the risk of catastrophic flooding as well as the frequency of nuisance flooding leading to road closures, residential losses, and infrastructure failures.

Climate Equity in Northwest Indiana

Government action alone is not enough to address climate change; everyone must be a part of the solution. Currently, however, the benefits and burdens of climate impacts and actions to mitigate them are not equitably shared. Communities of color and low-income populations have historically been underserved by programs and investments and underrepresented in decision making on climate policy. Lack of low-carbon, safe, transportation options, inefficient housing, vulnerability to flooding and extreme heat, and lack of access to healthy food are examples of disparities experienced by some communities. If not addressed, these inequities could result in inequitable benefits from climate actions as well as inequitable burdens of the impacts of climate change. These inequities primarily result from ongoing institutional bias and historical practices that have resulted in the inequitable distribution of resources and access to opportunities.

Average Number of Extreme Heat Events per Year in Northwest Indiana				
Timeframe	High Heat Days (High > 90 °F	High Heat Nights (Low > 68 °F)	High Heat Days and Nights	Total Days with Extreme Heat Events
Current	8	6- 8	5-7	19 -23
2050s - Medium Emissions Scenario	21-22	10-12	24- 27	56-60
2050s - High Emissions Scenario	24-26	11-13	34-37	70-73

Table 3-2: Current and forecasted average number of Extreme Heat Events per year

(> 2 inches rain per day or > 20 inches snow)	
Timeframe	Number of Extreme Precipitation Events
Current	10 - 13
2050s - Medium Emissions Scenario	12 - 16
2050s - High Emissions Scenario	13 - 17

Table 3-3: Current and forecasted average number of Extreme Precipitation Events per year

Culvert washout at Walker Brook in Becket, Massachusetts

Climate change is likely to amplify the impacts of these existing inequities, and if intentional action is not taken, frontline communities such as lower income, communities of color, unhoused, outdoor workers, the very young, and older residents will disproportionately bear the burdens of climate change impacts. In addition, the many economic and health benefits of carbon reduction investments may not be shared equitably across the region, especially among people of color and low-income communities.

All communities need the ability to shape their own present and future. Equity is both the means to healthy communities and an end that benefits us all. Equity should be a major concern for addressing climate change. Vulnerable populations, such as the elderly or chronically ill, low-income individuals, and people of color are more at risk of experiencing the impacts of climate change. These communities already experience institutional and systematic disadvantages that result in less access to resources, capital, and services. Climate change can exacerbate these gaps. By targeting programs and making changes to services or infrastructure before extreme events happen, we can mitigate the most devastating impacts to already vulnerable populations.

Climate equity ensures the just distribution of the benefits of climate protection efforts and alleviates unequal burdens created by climate change. This requires intentional policies and projects that simultaneously address the effects of and the systems that perpetuate climate change and inequity. By targeting programs and investments and making changes to services or infrastructure before extreme events happen, we can mitigate the most devastating impacts to already vulnerable populations.

Baseline Greenhouse Gas Emissions in Northwest Indiana

In 2021, NIRPC, working with Earth Charter Indiana, the Indiana University Environmental Resiliency Institute, and six climate fellows, created the first regional GHG Emissions Inventory in Indiana. The inventory was completed using the Global Protocol for Community-Scale Green House Gas Emission Inventories (GPC), as assembled within ClearPath, an online tool of the Local Governments for Sustainability (ICLEI). In addition to the three-county inventory produced for the region, local community inventories were developed for 13 different municipalities to use as a baseline for a regional Climate Action Planning Framework. Because the cities of Gary and Michigan City had previously completed inventories for 2017, that year was chosen the regional inventory baseline to align all efforts.

Overall GHG emissions in Lake, Porter, and LaPorte counties in the base year of 2017 were estimated to be 54.5 million metric tons (Figure 3-2). Not surprisingly in an economy built on heavy industry, industrial energy and industrial process emissions totaled 43.3 million metric tons, 80% of Northwest Indiana's entire carbon footprint. Transportation and mobile sources were the next largest source category at 4.8 million metric tons per year, representing 15.6% of the annual baseline. Residential and commercial energy use generated 5.5% and 4.8% of the emissions respectively. Overall, solid waste management, and water and wastewater treatment totaled less than 1% of the region's baseline GHG emissions.

At the regional scale, the top five source sectors generate 99.4% of regional GHG emissions. The top two source sectors, industrial energy use and industrial process and fugitive emissions, producing 79.6% of the regional climate impact, are largely out of regional or local government influence. Transportation and mobile sources, residential energy use and commercial energy use are the most regionally significant source categories with the most potential to be influenced by regional strategies and local government actions and will receive the greatest focus. Solid waste management and water and wastewater management are relatively small sources regionally, but at the local level their contribution can be more significant, and local governments can have significant influence.

The mixed group of agriculture, forests, and other land use, referred to as AFOLU, will also be covered in some detail. Forests, non-forest tree canopy, and conversion of forest to other land use types can both generate and remove carbon from the atmosphere. These factors are calculated as a net change overtime in a free online ICLEI mapping tool, which reports the difference between carbon absorbed by trees and that emitted by loss of trees or conversion of forests as results as a net flux of CO2 over time. This net flux is then grouped with emissions from livestock manure management. AFOLU includes factors that can both generate carbon emissions or absorb them. As a result, the Global Protocol used for the inventory reports it as a net change over time rather than an annual emission. Northwest Indiana's AFOLU between 2011-2016 had a net result of reducing CO2e by 40.

At first glance, the heavy slant of the regional baseline inventory toward industrial energy and process emissions might lead local governments and residents to believe that efforts to reduce emissions from other sources are insignificant. However, the opposite is in fact true. The largest industrial employers in Northwest Indiana operate within "hard to abate" sectors. "Hard to abate" sectors are those energy intensive industries that produce basic materials such as steel, petrochemicals, aluminum, cement, and fertilizers[1]. A look at the region's Lake Michigan shoreline clearly shows that Northwest Indiana's economy is built on an interdependent foundation of those energy-intensive, hard to abate industries.

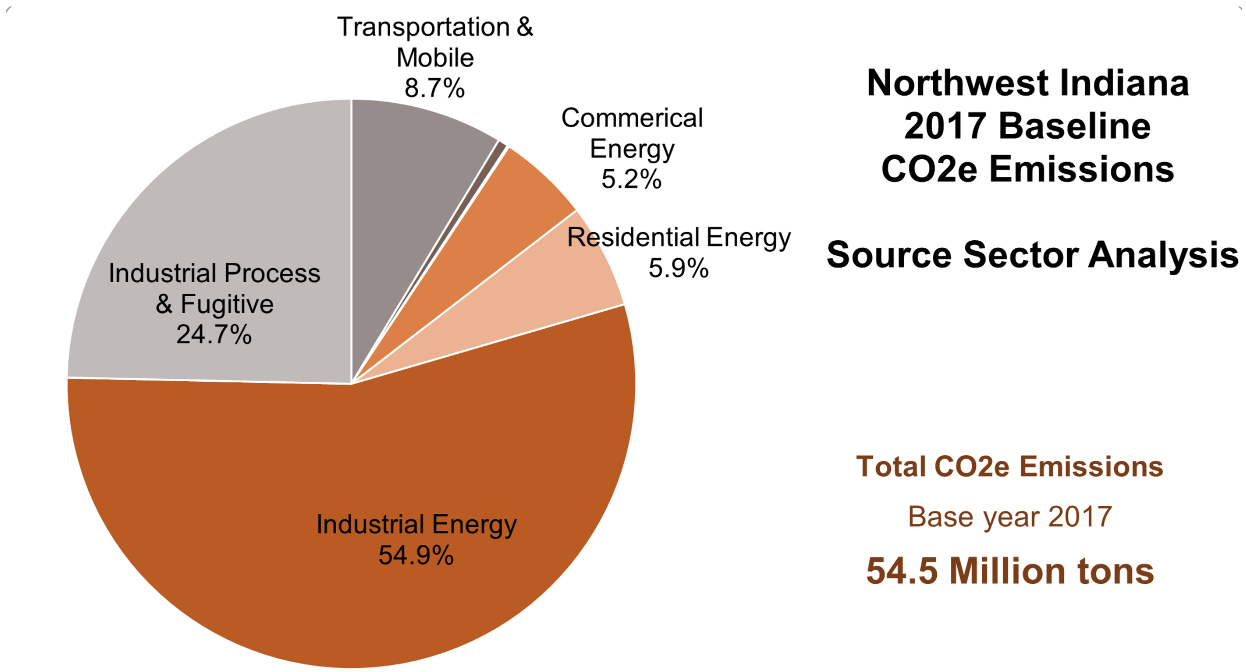


Figure 3-2: Northwest Indiana 2017 Greenhouse Gas Emissions by Source Sector

Many of the technological innovations needed to reduce emissions or remove and permanently sequester carbon from their energy sources or waste streams are still in research and development mode, not ready for full scale implementation.

1 Unlocking the "Hard to Abate" Sectors | World Resources Institute (wri.org)

In addition to the technical hurdles to decarbonization these industries face, operations are heavily regulated at the federal and state level. The economics of the commodities they produce are influenced by global scale economic factors and international trade agreements. Some discussion of research and pilot future control strategies will be discussed in the NWI Regional Climate Action Framework. Realistically, regional planning and local government action have very little ability to impact GHG emissions from these sectors. The technical reality of Northwest Indiana's "hard to abate" industries means that NIRPC, local governments, businesses and residents work even harder to reduce emissions from sectors we can influence with simple changes that are often the economically smart thing to do anyway.

Another important part of the Greenhouse Gas (GHG) equation is the quantity of carbon, nitrogen, and methane absorbed by forests and trees. NIRPC used the Land Emissions and Removals Navigator (LEARN) interactive mapping tool to estimate removals by various land uses on a per acre basis, as well as emissions from deforestation per acre to provide the net impact of trees on the regions carbon footprint.

NWI 2050+ will first provide a brief overview of top 4 non-transportation source categories of Greenhouse Gas emissions in the region. The Transportation and Mobile Sources group will then be addressed in a more substantial way. Finally, we will discuss the impacts of land use changes, forest and tree canopy loss on our regional climate footprint.

For complete information regarding the emissions inventory and forecast, including methodology and supporting data, please reference the NIRPC 2017 Regional Emissions Inventory Report located at www.nirpc.org/climate/.

Industrial Energy Use

Energy usage at Northwest Indiana industrial facilities is by far the largest source of greenhouse gas emissions in the region. As shown in Figure 3-1, Industrial Energy usage generated close to 55% of the NWI GHG emissions in 2017 Emissions from electricity use were built from NIPSCO and Kankakee Valley Rural Electric Membership Corporation (KVREMC) data for industrial customers. Emissions from natural gas usage were calculated from NIPSCO natural gas usage data for industrial customers. Lastly fuel use and emission data reported to US EPA by large facilities was retrieved from the US EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT) and incorporated into ClearPath's Combustion Emissions from Stationary Sources calculator. Fuels used in the "Other Fuel Combustion" section of Figure 3-3 include blast furnace and coke oven gas, residual fuel oil, distillate fuel oil, bituminous coal, propane, used oil, and other biomass gas, some of which would be waste products if not recycled for internal energy generation

Emission reductions from this source category are already forecast due to NIPSCO's conversion from coal fired electricity generation to natural gas and renewables. Many corporations also have publicly available energy efficiency and greenhouse gas emission reduction goals and strategies.

Potential for Hydrogen Fuel use in NWI Industries

Expanding production and uses of Hydrogen Fuel is an important strategy the Department of Energy is pursuing toward "Enabling A Low-Carbon Economy". Potential new uses for hydrogen include: replacing coke and natural gas as a reducing agent in iron and steel production, de-carbonization of cement, fertilizer, and petrochemical industries, long-haul and heavy-duty trucks, trains, ships, and on-road passenger transport, and energy storage. In 2020 Cleveland-Cliffs, owner of fully-integrated steel mills in both Burns Harbor and Indiana Harbor opened the Great Lakes region first direct reduction iron plant in Toledo. The facility utilizes Hydrogen and Carbon Monoxide gases to reduce iron ore to hot-briquetted iron, with much fewer carbon emissions than traditional coke processing.

Carbon Capture and Storage (CCS)
CCS is a critical strategy in development for addressing carbon dioxide (CO_2) emissions from "hard to abate" industries.
Investments continue to grow in research and development of new or improving technologies and infrastructure to:

- remove CO_2 from industrial emissions before it can reach the atmosphere,
- transport compressed liquid CO_2 to safe long-term storage sites,
- identify locations with the right geology and infrastructure to safely inject, store, and monitor CO_2 thousands of feet below active or potential drinking water sources.

The bp Whiting Refinery, NiSource, and Purdue University NW are all part of Midwest Alliance for Clean Hydrogen (MachH2) which has recently submitted a full application for $1.5 Billion to build a Midwest Regional Clean Hydrogen Hub with Northwest Indiana in its center. Removing the carbon dioxide from natural gas results in production of hydrogen gas, a clean fuel with no greenhouse gas impact.
Indiana has many geologic formations with potential to be ideal for long term liquid carbon storage. In 2022 the state passed HEA 1209, which enables land owners to capture the value of the carbon storage capacity of their property. Northwest Indiana has the bp Whiting Refinery which is preparing to invest in CO_{2e} capture technology.

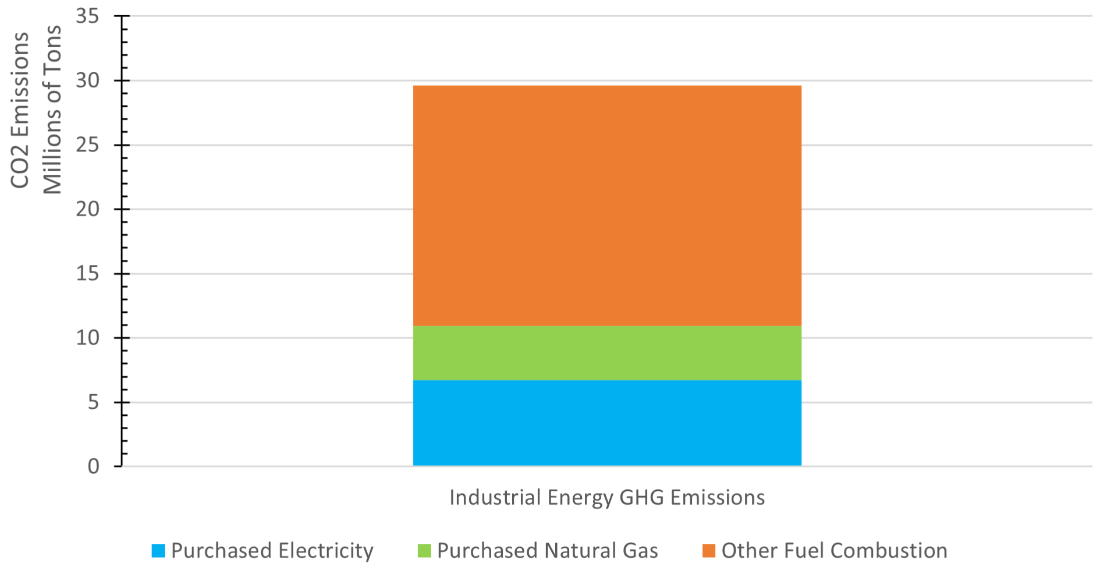


Figure 3-3: 2017 baseline greenhouse gas emissions from industrial energy

Industrial Process and Fugitive Emissions

Industrial Process and Fugitive Emissions are the second largest source of GHG emissions in northwest Indiana. Process Emissions are those that originate from a manufacturing process unrelated to the energy used to do it. They can be generated by chemical processes involved in manufacturing, by chemicals used for refrigeration, or by petroleum products used for lubricants. These are separately inventoried because the Industrial Process emissions would occur regardless of how little carbon emission the energy input generates.

A good example for understanding industrial process versus industrial energy GHG emissions can be found in the process of producing cement from limestone. Cement, the powdery binder that holds gravel and sand together to form concrete, is made by baking limestone at very high temperatures in enormous kilns which converts it to lime and clinker, important ingredients in cement. The GHG emissions from generating the energy used to heat these kilns is in our inventory under Industrial Energy Use. The CO_2 released in the chemical reactions occurring as the heated limestone converts to lime and then to clinker is captured in the inventory as an Industrial Process emission.

Fugitive Emissions are also included in this category. In the context of climate protocol, these are emissions from the handling, storage, and movement of fossil fuels. Examples in NWI might include emissions from natural gas pipeline leakage; coal storage piles; and processing, storing and transporting gasoline. Fugitive Emissions are also part of the information industries must report to EPA and appear in FLIGHT.

Altogether, this category produced almost 25%, or 319,000 tons or of CO_{2e} equivalent generated in Northwest Indiana during our baseline year.

Residential Energy GHG Baseline Emissions

The residential energy portion of the greenhouse gas emissions inventory is derived primarily from electricity and natural gas usage of NIPSCO residential customers aggregated by zip code. KVREMC residential customer data aggregated energy use, as well as estimates of propane, wood, and other heating fuels used based on information in the US Census Bureau's 2017 American Community Survey. In 2017, residential energy use was responsible for 3.2 million tons of GHG emissions, almost 6% of the region's total. While residential energy is a small source of emissions compared to the industrial categories at the regional scale, in many local communities it is relatively more significant. Local climate action plans encouraged through the NWI Regional Climate Action Framework will include policy tools available to local governments to reduce them through encouraging energy conservation. Regionally, residential energy GHG emissions will benefit from NIPSCO's ongoing investments to reduce the carbon intensity of their energy production. Increasing extreme heat events could easily lead to an increase in electricity use for air conditioning during summer months.

Household energy costs can be an equity issue. While in most of Northwest Indiana average energy burden as a percentage of income is between 2% and 3%, 19 census tracts in Northwest Indiana have been identified by Climate and Economic Justice Screening Tool as energy cost disadvantaged. Energy cost disadvantaged is defined as being in the 90th percentile nationally of energy cost as a percent of household income and being in the 65th percentile for low income. Increasing home energy efficiency in pursuit of GHG emissions reduction can be an investment in not only strictly efficiency but also neighborhood equity.

Commercial Energy GHG Baseline Emissions

Commercial energy GHG emissions were inventoried in the same manner as residential energy, by aggregating NIPSCO and KVREMC commercial customer electricity and natural gas data. This source category generated 2.85 million tons of carbon dioxide equivalents in 2017, 5.2% of the regional total. Similar to the residential energy source, this category will be thoroughly addressed in the NWI Regional Climate Action Framework. The Framework will include tools governments can use to address these sources at the local level within their individual climate action plans.

Customers classified as commercial by the utilities may also include a variety of public facility types that are not traditionally thought of as "commercial". Examples include NICTD's South Shore Commuter Rail, local drinking water utilities, and wastewater treatment facilities. Strategies to address these institutional sources will be presented in Transportation or in Water and Wastewater Treatment. Although these facility types are further discussed in Transportation or Water and Wastewater source categories for purposes of local climate action planning, for the regional inventory they are captured under commercial energy to reduce any risk of double counting emissions across categories.

Transportation and Mobile Sources GHG Emissions

Nationally, the transportation sector represents about 29% of total U.S. greenhouse gas emissions each year. According to the results of the ClearPath activity based emission models, transportation and mobile sources generated 3.8 million metric tons of carbon dioxide equivalent in 2017, or 16% of Northwest Indiana's GHG emissions.

These emissions can be further broken down by generating activity and fuel source. Table 3-3 details mobile source carbon dioxide equivalents by category. Of the six major categories, commuter rail, aviation, and marinas together contribute less than 1% of the mobile source emissions.

These emissions can be further broken down by generating activity and fuel source. Table 3-4 and Figure 3-4 details mobile source carbon dioxide equivalents by source category. On-road emissions are further broken down into gasoline and diesel fueled vehicles because emissions from each type of fuel can be significantly different. Of the six major categories, commuter rail, aviation, and marinas together contribute less than 1% of the mobile source emissions at the regional scale and will not receive further discussion here. For individual cities or towns, they may be more significant and receive additional attention.

Public Transit GHG Emissions for the various bus services within the region are captured here within the On-Road Gas and On-Road Diesel emissions show in Table and Figure 3-4. Emissions from the South Shore Commuter Rail are included within the Commercial Electricity source category discussed above. All together, Public Transit generated approximately 22 thousand metric tons of CO_{2e} in 2017, or approximately 0.4% of all transportation emissions in the region. Public Transit emissions ranged from 1.1 to 4.1 CO_{2e} tons per thousand revenue miles and between <1 and 13 tons per thousand passengers depending on fuel type, transit type, and other factors. This diversity will require emission strategies to be determined on a operator by operator basis.

Mobile Source Type	2017 CO2e Emissions (Metric Tons)
On-Road Vehicles- Gas	3,309,951
On-Road Vehicles-Diesel	645,591
Non-Road Mobile (Construction and landscaping equipment)	551,952
Freight Rail	211,977
Commuter Rail	17,114
Aviation	10,008
Marinas	4,219

Table 3-4: Greenhouse Gas emissions from mobile source types

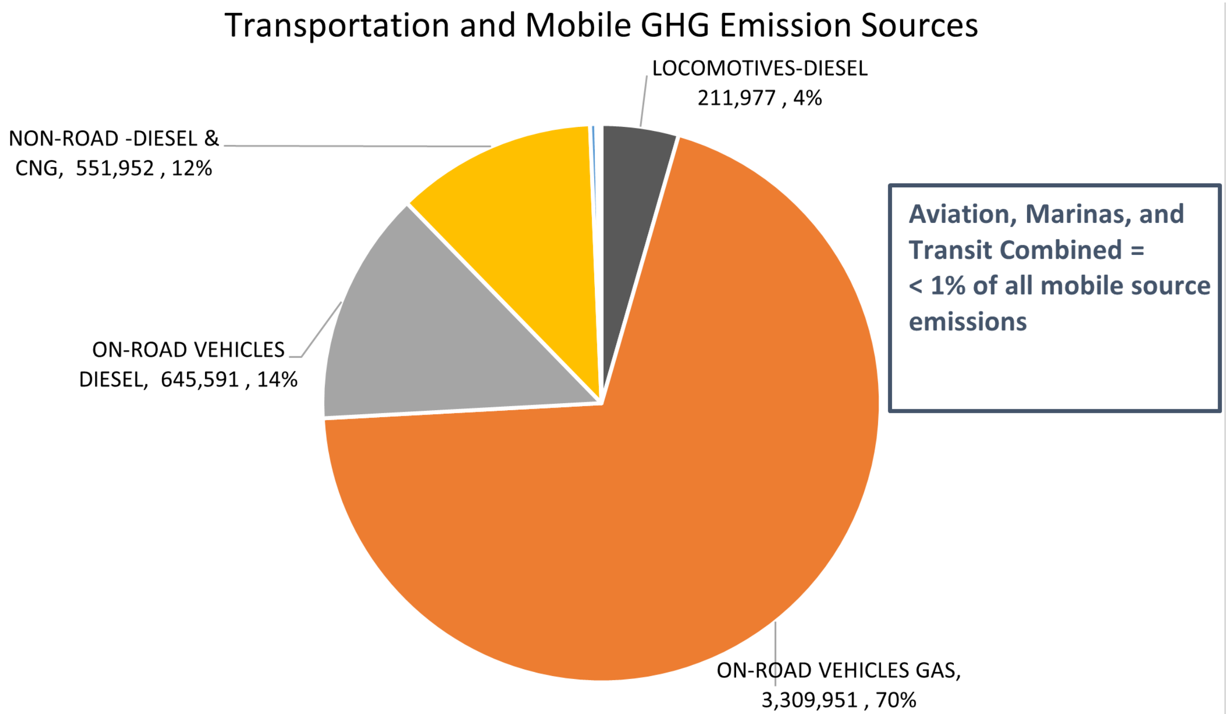


Figure 3-4: Relative contribution of significant mobile sources in Northwest Indiana

On-Road Gasoline Fueled Vehicle Emissions

On-Road Gasoline Fueled Vehicle GHG Emissions are essentially from passenger cars and trucks driven by residents and visitors throughout Northwest Indiana. This category is truly one in which every driver in the region contributes to the problem and can make a difference in the solution. In 2017, gasoline fueled vehicle emissions were by far the largest source of GHG in the transportation category, contributing 3.3 millions of tons carbon dioxide equivalents. This represents 6% of the region's total carbon footprint, but 70% of NWI's transportation and mobile source category. It averages 4.2 tons per year of GHG per person per year, which is the same weight as a fully grown hippopotamus.

On-Road gasoline fueled vehicle emissions were calculated within the ClearPath inventory module using vehicle miles traveled developed for *NWI 2050* Air Quality Conformity demonstration. 2017 vehicle registrations for the three counties were obtained from the Bureau of Motor Vehicles. ClearPath applies vehicle type percentages to annual vehicle miles traveled to arrive at annual emission totals for major greenhouse gases, which are reported here in carbon dioxide equivalents (CO_2e). Table 3-6 shows the values entered into ClearPath for factors driving the GHG emissions inventory for this source are Annual Vehicle Miles Traveled and light duty vehicle fleet mix. For purposes of this inventory, all VMT were considered to be In-Boundary Scope 1 Emissions. In future years, NIRPC will generate vehicle GHG emission inventories using the EPA MOVES model, which should result in more accurate division of emissions into Scopes 1 and 3.

Annual Vehicle Miles Traveled	Annual Energy Used MMBTU	Emissions Per Capita (MT CO2e)	Emissions per Mile (MT CO2e)	Percent Motorcycles	Percent Passenger Vehicles	Percent Light Trucks
8,716,745,286	46,683,966	4.33	380	3.58%	82.71%	9.40%

Table 3-5: 2017 Baseline Input Conditions for Gasoline Fueled Vehicle GHG

Mitigating GHG emissions from this source category will require NWI to make changes in everything from each community's built environment, to each family's vehicle purchases, to each individual's daily traveling decisions. Driving less, sharing rides with neighbors, co-workers, or transit, and driving low or no emission vehicles are the keys to impacting this source of climate changing pollution.

On-Road Diesel Fueled Vehicle Emissions

Heavy duty diesel vehicles make up 4.3% of the annual vehicle miles traveled in Northwestern Indiana, but in 2017 generated 14% of the Greenhouse Gas emissions from the transportation and mobile source sector, over 645,000 tons. Transportation in general, and trucking in particular is an important growth sector in the region due to our transportation reliant industrial sector and location within a 24 hour drive of 80% of the US population. Truck transportation and warehousing is a growing economic sector in the region. Between 2010 and 2019, employment in transportation and warehousing grew by 46.4%.

On-Road transport makes up one third of freight movement in NWI by tonnage and more than half by economic value. In 2017 trucks carried 69 million tons of freight in the region. A detailed breakdown of the commodities trucked in the region is presented in Table 4-12 of the Freight Chapter. This table shows that activity in this emission category is closely tied to activity in the industrial facilities directly responsible for 75% of the region's GHG emissions.

While a significant segment of the heavy duty truck traffic in the region serves our companies and employers, the confluence of four Interstates (I-65, I-80, I-90, and I-94) meeting in our region ensures that there is also a major segment without local origins or destinations.
In addition to heavy duty trucks, on-road diesel vehicle emissions also includes a diverse assortment of other vehicles often used in the public sector such as school buses, larger transit buses, garbage trucks, and street sweepers.

Several recommendations in the Freight section of this plan would also have significant potential to reduce GHG emissions from this sector by reducing the carbon intensity and energy efficiency of the trucking industry in Northwest Indiana.

- Investments in additional truck parking and truck parking information systems can reduce the average hour per day truck drivers spend looking for parking, exacerbating congestion and wasting fuel.
- Expanding investments in the designated Alternate Fuel Corridors to ensure growing capacity for trucks fueled with Compressed Natural Gas, Propane, and ultimately Hydrogen fuel.

Rail Sources

Apart from direct heavy industry production, Northwest Indiana also sees heavy emissions from freight rail, which operates in high volumes in the region. The average freight train car carries 4,082 tons of material, and doing so requires heavy emissions from its diesel engines. The most realistic pathway to reducing carbon emissions in the region is to increase locomotive fuel economy. Fully 4,693,594 tons of Northwest Indiana's annual carbon dioxide emissions come from the freight rail sector. Here again, the size of operations and energy demands inherent to the industry make decarbonization a difficult milestone to reach. But that is not to say that freight rail isn't improving in efficiency, or that plans don't exist to fully decarbonize. Since 1990, fuel economy in the industry has improved by more than 40%, and there are incremental efficiency improvements year over year (Figure 3-5).

The nature of freight rail in Northwest Indiana makes it the most difficult emission source to quantify and to distinguish between in-boundary and out-of-boundary scope. Indiana Department of Transportation (INDOT) data shows approximately 850 miles of active freight rail in Northwest Indiana, in addition to multiple switching yards, side rails, and multi-modal terminals[1]. Multiple eastern rail companies converge on Chicago around the southern tip of Lake Michigan, creating a highly congested rail pinch point in Northwest Indiana.

1 Indiana Department of Transportation. 2006. Rail System of Indiana

For the purposes of this document, aggregate emissions estimates, forecasting, and discussion for the rail sources are separated into Class I Passenger, Class I Freight, and Class II Railroads. The South Shore Line Commuter Rail system is discussed under Public Transit. Class I Railroads are defined by the Interstate Commerce Commission and governed by the Surface Transportation Board. The only Class I Passenger Rail source is Amtrak. Class I Railroads are currently defined as those with over $943.9 million in annual revenue. Class I Railroads with track miles in Northwestern Indiana include Amtrak, Norfolk Southern (NS), Canadian National (CN), and CSX Transportation (CSXT). Together these three rail companies own 628 miles of linear track in the region, 71% of the total.

The other rail carriers operating in Northwest Indiana are designated Class III or short-line railroads or they are switching and terminal railroads. These include Chicago, South Shore, and South Bend (CSSB) Railroad, Chicago, Ft. Wayne and Eastern Railroad (CFER), Gary Railway (GRW), and Indiana Harbor Belt (IHB). Together these rail companies own almost 200 linear miles of track, a figure which doesn't fully account for multi-line tracks at switching yards and industrial facilities throughout the region. NIRPC was unable to find GHG emissions data or fuel usage data for any of these specific rail carriers. However, the CFER is one of over one hundred owned by the Genesee and Wyoming Railroad (GWRR), which does provide an annual Sustainability Report. For purposes of developing emissions estimates, the GWRR data was applied to all local railways.

Although the linear miles of track are fairly constant over time, the rail industry structure and corporate ownership of different rail operators change somewhat frequently. NIRPC was able to obtain corporate reports with GHG emissions and/or diesel fuel usage for Canadian National, Genesee & Wyoming (owners of CFE among many other short haul regional railroads), Anacostia Rail Holdings Company (owner of CSSB), and CSX. The Genesee and Wyoming GHG emission profile was applied to all listed Class III Railroads.

Rail Class	NWI Miles	% of Miles	NWI CO2e (Metric Tons)	% of Rail CO2e
Class I Passenger	20.4	2%	29	**<1%**
Class I Freight	628.1	71%	146,000	**69%**
Class III Freight	198.8	23%	66,000	**31%**

Table 3-6: Miles of rail and relative GHG emission in Northwest Indiana by Class 1. (Rail miles may not include rail leased from other carriers.)

Within the context of community climate action planning, freight railroads are a source of emissions that local governments have little to no control over. However, all the Class I Railroads, as well as the Genesee and Wyoming (corporate owner of CFE) do include GHG emissions, and emission reduction trends or goals in their 2017 sustainability or responsibility reporting. For example, CSX reported in 2017 that they had reduced GHG emission intensity by 5.1% and energy intensity by 4.7% between 2011 and 2017. NIRPC will build achievement of corporate carbon intensity goals into future emission reduction scenarios.

There is recognition among freight rail corporations that GHG reductions are critical over the coming decades. For example, Canadian Pacific, a Class 1 rail network operating in Northwest Indiana, released a Climate Strategy plan in 2021, establishing science-based targets for its Scope 1, 2, and 3 emissions. Using fuel-saving technologies like Trip Optimizer and its Locomotive Modernization program, Canadian Pacific plans to update its locomotive fleet and targets a 38.3% reduction in locomotive GHG emissions by 2030 (from a 2019 emissions baseline). Other class 1 rail networks like CSX and Union Pacific have sustainability plans of their own targeting similar fuel efficiency reductions. Figure 3-4 shows that while business as measured in Gross Ton Miles (GTM) has increated almost 400% over the past 30 years, the amount of GHG emitted per GTM has decreased by 30%. NIRPC will incorporate future reductions in rail carbon intensity commitments in future climate planning scenarios.

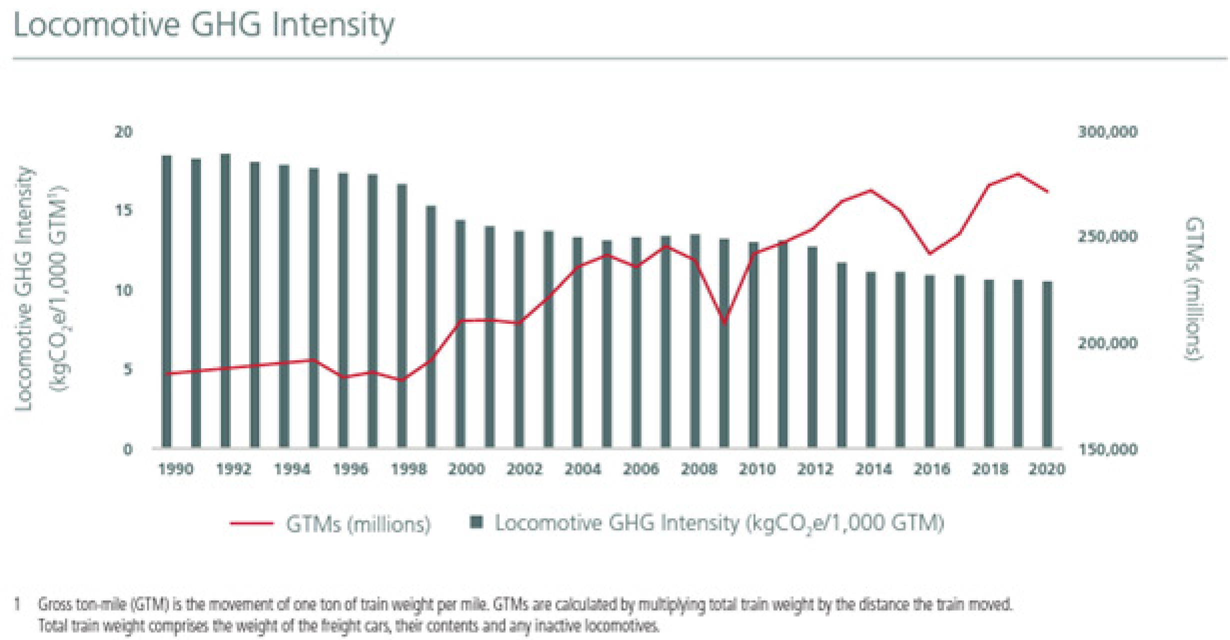
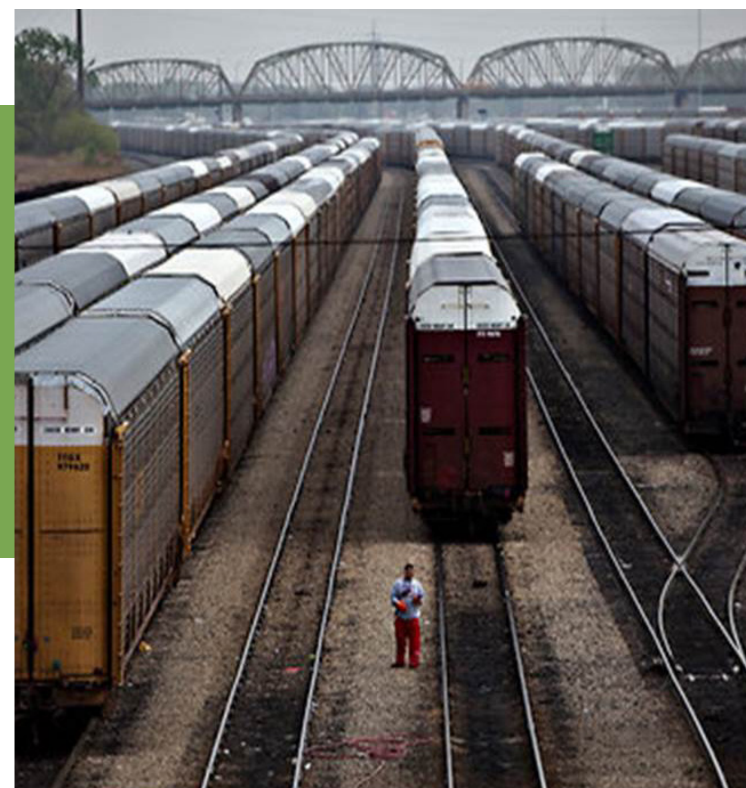


Figure 3-5: Locomotive greenhouse gas intensity

Indiana Harbor Belt Retrofit Project wins VW Settlement Funding

IHB VW Settlement Emission Reduction Project

With the support of NIRPC's Green Fleet Partner Drive Clean Indiana, one regional Class III Railroad was awarded close to half a million dollars in VW Settlement funds for a project to retrofit 33 locomotives in Northwest Indiana with Auxiliary Power Units (APUs).The locomotives, ranging 45 to 57 years old typically idle their 1500-3000 horsepower engines on average 3,500 hours per year to keep the engines from freezing. The VW funds will retrofit the locomotives with APUs that can run air conditioning, heat, electric power, lights, other onboard equipment, and prevent frozen engines with a mere 28 horsepower instead of the entire engine during those idling hours. The project will reduce IHBs diesel fuel usage by 543,800 gallons per year eliminate 6,189 tons of CO2e emissions



Ultimately, freight rail will have to move away from diesel locomotives to achieve full decarbonization, requiring new technologies for locomotive engines that can match the carrying capacity of diesel. There is currently no technology that can match diesel locomotives in this category, but there are several long-term pathways to achieve this goal. Hydrogen fuel cell engines are in the early stages of deployment in several small commuter scale scenarios. The San Bernadino County Transportation Authority in California plans to open a hydrogen rail line in the County by 2024, and the Alstom Coradia LINT model has several passenger locomotives operating in Germany. The main challenge to hydrogen fuel is that it provides significantly less energy by volume than diesel, and so its application in hauling typical freight payloads is currently limited. There is also the climate change concern that most hydrogen is captured and processed as a byproduct to natural gas drilling operations, making their effect on emissions reduced greatly reduced. The Department of Energy has called for further investigations into hydrogen locomotive reliability, as well as fueling infrastructure needs before it will be ready for further innovation and commercialization into the freight rail sector.

Another decarbonized method for freight rail would include full electrification of all Class 1 freight rail lines. While there are no serious proposals for such a transformation at this time, advocacy groups like Solutionary Rail are pushing lawmakers to invest in rail electrification projects. Solutionary Rail sees this as an opportunity to not only address freight rail emissions, but also to reduce freight trucking emissions by moving them to expanded electric rail lines. More information about this pathway can be found at solutionaryrail.org.

Stakeholder and Public Involvement and Input

In 2023, NIRPC worked with diverse partners and stakeholders to develop the Northwest Indiana Climate Action (CAN) Planning Framework for Northwest Indiana. CAN Work Group members represented local government, multi-jurisdictional organizations, non-profit organizations, universities, industry employees, with Northwest Indiana residents also participating. The Work Group met remotely on seven occasions between May 2022 and March 2023. Work Group meetings generally lasted for two hours and consisted of presentation of relevant information and process in developing the framework, as well as interactive discussions and feedback.

Purpose Driven Planning

Purpose, Scope, and Goals of the Climate Action Framework

Purpose

The purpose of the Northwest Indiana Climate Action Framework is to suggest common-sense approaches and cutting-edge policies that our local governments are uniquely positioned to implement – actions that can reduce energy use and waste, create local jobs, improve air quality, preserve our local landscape and cultural history, reduce risk to people and property; and in many other ways, benefit Northwest Indiana for years to come. The Framework lays the groundwork for Northwest Indiana communities to work together to achieve regional climate and sustainability goals. The Framework coordinates local efforts to achieve a regional goal of 63.4% reduction in 2017 GHG emissions levels by 2030 and a carbon neutral region by 2050. These targets are based upon the One City One Planet Challenge (OPCC) Methodology. This method was recommended by ICLEI, because it is the most compatible with those in usage with other local governments around the country. OPCC essentially takes the global target of 50% emission reduction by 2030 and adjusts by prescribed factors related to the country's level of economic development. This places all US cities on an even footing, yet at the global scale acknowledges US role in the cumulative carbon emissions of the past century.

In addition to addressing carbon mitigation concerns, the Climate Action Framework highlights vulnerabilities to climate hazards and opens a dialogue for how local communities can further investigate local risks, respond to them and increase resilience. An adaptation framework is provided to develop and implement actions to reduce the risk of climate impacts to Northwest Indiana's resources and infrastructure, while also increasing the social and economic resilience of the system. Reduction of risk is a far more complex undertaking than reducing emissions, as these challenges are interconnected with inequitable systems of economy, healthcare, education, transit, and others. Ultimately, no one strategy will undo these challenges, but the implementation of multi-faceted strategies can set Northwest Indiana on the right path.

Equity and inclusion concepts and components are interwoven throughout the Framework. Creating a resilient community means addressing the social inequities that cause disparities in health outcomes, income, educational attainment and more. Local communities should consider disproportionate and inequitable impacts of climate change as well as mitigation strategies, sharing both the burdens and benefits of mitigation measures on all residents. Diverse groups should be engaged in local planning for climate action and adaptation.

Scope

The Northwest Indiana Climate Action Framework covers objectives and strategies for reducing GHG emissions resulting from local government and community-wide activities in Northwest Indiana. It identifies major sources of community emissions and sets forth achievable objectives and strategies in these focus areas meant to achieve greenhouse gas reductions. While the larger Framework will cover additional sources and sectors (process and fugitive, transportation and mobile, industrial energy, residential energy, commercial energy, solid waste), this document focuses on transportation and mobile sources and their interdependence with land use, the sectors most relevant to *NWI 2050+*.

Goals

The NWI Regional Climate Action Planning Framework recommends a regional goal of 63.4% reduction in 2017 GHG emissions levels by 2030 and a carbon neutral region by 2050. The Framework outlines regional strategies to achieve these goal, and recommends local strategies for community climate action that would cumulatively help the region to achieve these goals. Net Zero means that the amount of GHG emissions generated from region sources is equal to the amount of GHG removed by region forests and carbon capture technology.

Northwest Indiana's GHG Reduction Target

NIRPC has set targets to reduce regional community emissions to 63.7 percent below 2017 levels by 2030. The combination of measures Northwest Indiana stakeholders have already implemented, and actions presented through this Climate Action Framework are designed to achieve the 2030 targets. Reductions in 2030 rely on the best information currently available pertaining to population forecasts, future changes to building codes, and vehicle fuel efficiency standards among other information. Table 3-5 translates these percentages into tons of reduction needed from the 2017 baseline.

Northwest Indiana's targets are based on the One Planet City Challenge method, which are more aggressive than those suggested by regional or state agencies or proposed in federal legislation. Almost all sources recommend a global reduction of 80% by 2050. Selecting Net Zero as the regional target is aspirational and highly dependent on the scale of advancement and investment in industrial process emission reduction and carbon capture.

Future Greenhouse Gas Emissions – Forecasting Business as Usual

In order to plan for future emission reductions needed to meet Scientifically Based Targets, NIRPC completed an emissions forecast based on projections of current data and expected future trends. The emissions forecast is a "Business as Usual" forecast, a scenario estimating future emissions levels if no further local action (i.e. projects within the Climate Action Framework) were to take place. For this forecast, planning assumptions for population growth and vehicle miles traveled were aligned with the land use, housing, and travel demand portions of *NWI 2050+*. Sources used for growth planning assumptions in different source sectors are shown in Table 3-7.

GHG Emission Source	Growth Factor Proxy	Planning Assumption Source
Residential Energy	Population Growth	*NWI 2050+* Planning Assumptions
On-Road Vehicle	Vehicle Miles Traveled	*NWI 2050+* Travel Demand Model
Commercial Energy	Commercial Employment Growth	*NWI IGNITE the Region*
Industrial Energy	Industrial Employment Growth	*NWI IGNITE the Region*
Industrial Process & Fugitive	Industrial Employment Growth	*NWI IGNITE the Region*
Freight Rail	Industrial Employment Growth	*NWI IGNITE the Region*
Aviation	Commercial Employment Growth	*NWI IGNITE the Region*
Forest and Land Use Change	Forest and Tree Canopy Change	LEARN Report 2011-2016

Table 3-7: Sources for growth planning assumptions

The "Business as Usual" forecast methodology does allow for incorporating future projects that are already underway. In Northwest Indiana, our "Business as Usual", or BAU, Forecast includes changes resulting from the Northern Indiana Commuter Transportation District (NICTD) Double Track and Westlake Corridor Projects. It also includes future renewable energy commitments by NIPSCO (Northern Indiana Public Service Company), which provides power to all of Northwest Indiana. It does not include voluntary GHG emission or carbon intensity reduction goals by private industry. These are incorporated into one of the GHG planning scenarios.

Carbon intensity is a term often used in the private sector to measure their greenhouse gas contributions and reduction efforts. Carbon intensity is the amount of carbon dioxide or carbon dioxide equivalents emitted per unit for some type of work or product generated depending on the industry. This method provides a way to distinguish between annual GHG emission fluctuations caused by business cycles or external market forces versus GHG Changes attributed to improvements in processes or energy efficiency. For example, in electricity generation, carbon intensity is the amount of CO_2e released to produce one kWh of electricity. In the steel industry, it might be measured as the quantity CO_2e emitted per ton of steel. In the rail industry, as shown in Figure 3-5, it is expressed units of amount of CO_2e emitted per ton of freight delivered one track mile or Gross Ton Miles.

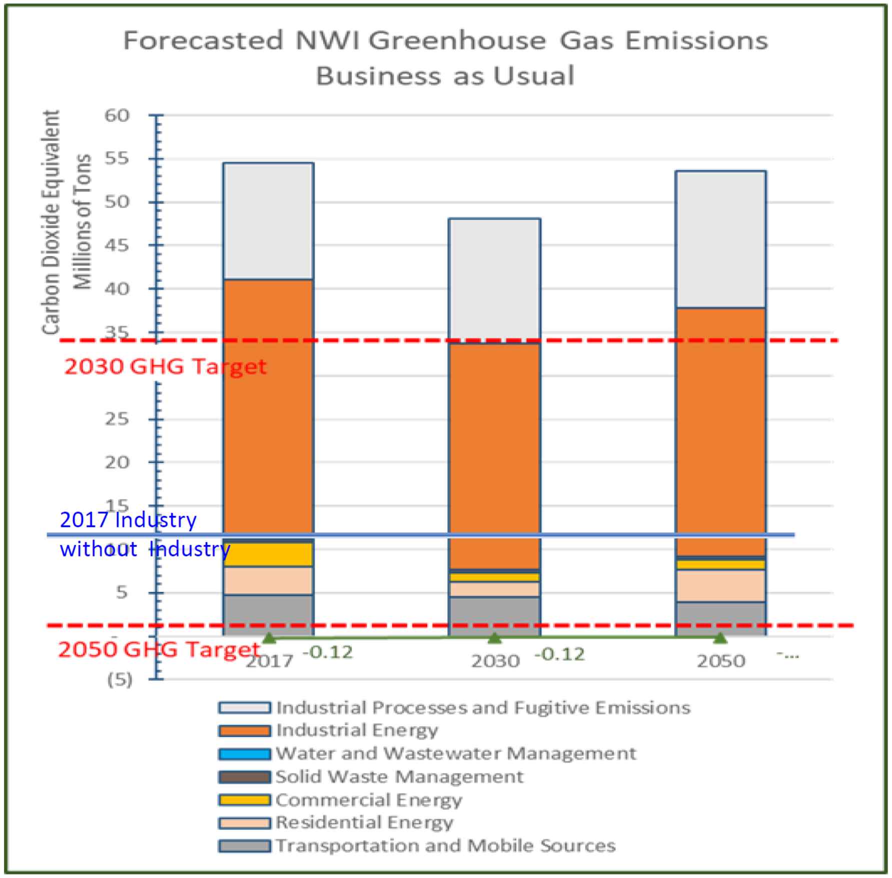
As discussed later in this section, the BAU forecast indicates that committed transitions to renewable energy by the Northern Indiana Public Services Company (NIPSCO) will decrease GHG emissions over the coming decade in the Residential, Commercial, and Industrial Energy Use Emissions, even without additional actions. It is essential to note that these reductions will not be enough on their own to meet regional reduction targets, and further action should be taken to put Northwest Indiana on the path to carbon neutrality by 2050.

Year	Baseline GHG Emission (Metric Tons)	NWI GHG Emissions with Business as Usual Forecast.	NET GHG Reductions from Forests and Trees (2011-2016)	Northwest Indiana Net GHG Emissions Estimates (Tons CO2e)	Annual GHG Reduction Required to Achieve Goals
2017	54,600,000		-123,000	54,000,000	
2030 *(63.4% less than 2017)*		48,000,000	- 119,000	49,000,000	14,900,000
2050 *(Net zero)*		53,600,000	-113,000	58,000,000	58,000,000

Table 3-8: Greenhouse Gas Reduction Targets and Business as Usual Emission Forecasts

1 NIRPC annualized net carbon emissions (reductions) from land use and forest cover changes over the period of 2011 to 2016 as calculated in the ICLEI LEARN Tool for the NWI 3 county area.

Figure 3-6 shows forecasted emissions in 2030 and 2050 compared to the 2017 baseline. The benefits of NIPSCO's decarbonization efforts are clear in 2030, as GHG from residential, commercial, and industrial electricity use all show substantial declines. By 2050, we see that with no other action taken, predicted population, vehicle miles traveled, and economic growth combined with current rates of tree and forest loss cause emissions to rebound and rise above 2017 levels. For the Business as Usual forecast, NIRPC held deforestation, reforestation, and tree canopy loss rates consistent with that between the 2011-2016 as calculated in the ICLEI LEARN Tool. During that period the region lost forest at a rate of 0.29% per year. Reforestation occurred at a rate of 0.14% per year for a net annual deforestation rate of 0.15% For the same period trees outside forests decreased by 0.5% annually.



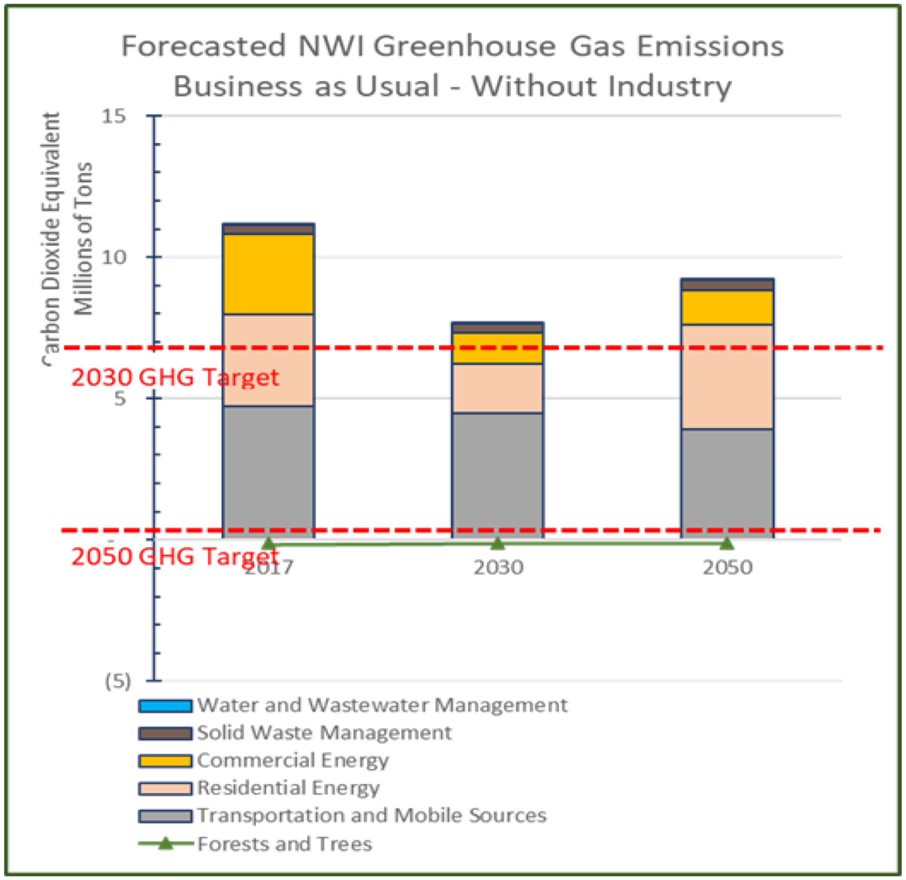


Figure 3-6: Comparison of NWI greenhouse gas emissions baseline, 2030, and 2050 forecasts with and without industrial emissions. Business as Usual

Planned Projects included in the “Business as Usual” Forecast

Future Commitments to GHG reductions in Northwest Indiana

Apart from the reduction strategies outlined in this plan, emissions reduction efforts have already begun in Northwest Indiana. Where possible, reduction effects of these plans have been incorporated NIRPC’s “Business as Usual Forecast”. Three projects specifically incorporated into emission forecasts are briefly described below. By 2030, these projects bring all but the Industrial Process and Fugitive Emissions sector within reach of the regional target.

NIPSCO Coal-Free By 2026-2028

NIPSCO has made significant efforts in decarbonization of their energy generation and committed to continued investment in renewable energy in their regulatory filings with the Indiana Utility Regulatory Commission. GHG emission reductions in their electricity generation sector by elimination of coal are incorporated into the BAU Forecast. Figure 3-7 and 3-8 shows the impact of NIPSCO investments in reducing the carbon intensity of their electricity generation on the Residential, Commercial, and Purchased Industrial Energy GHG Emissions.

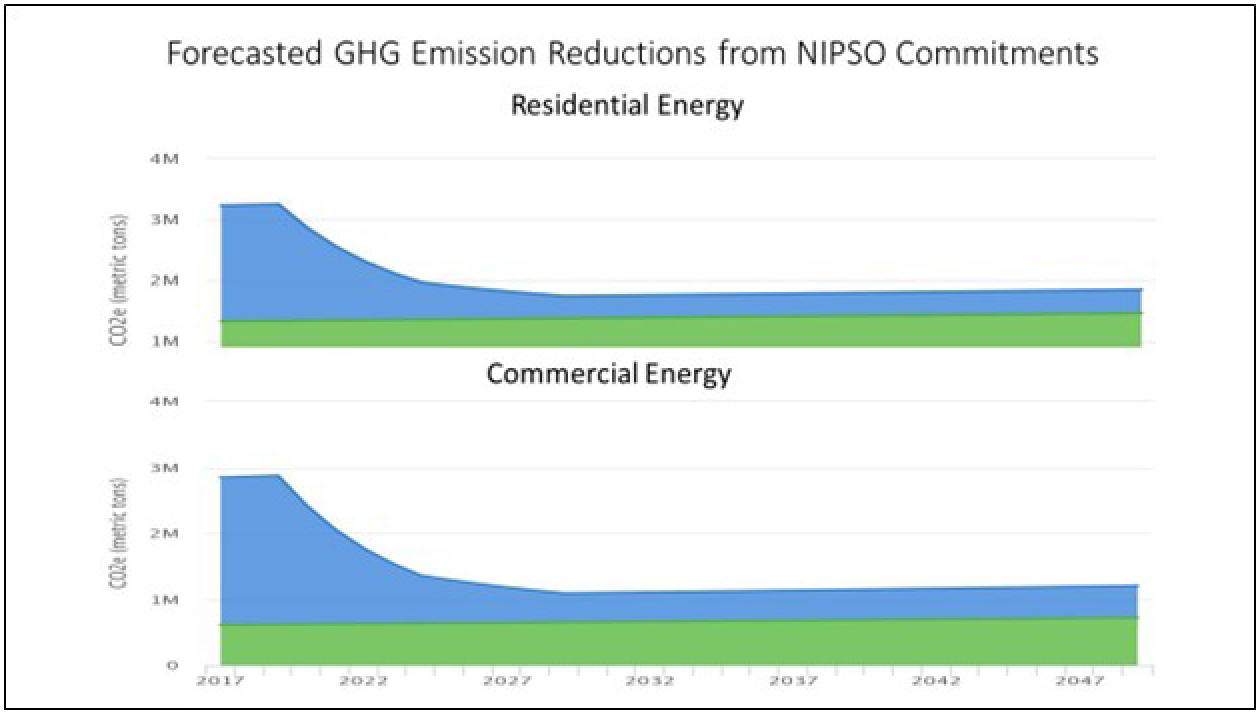


Figure 3-7: Forecasted greenhouse gas emission reductions from NIPSCO commitments

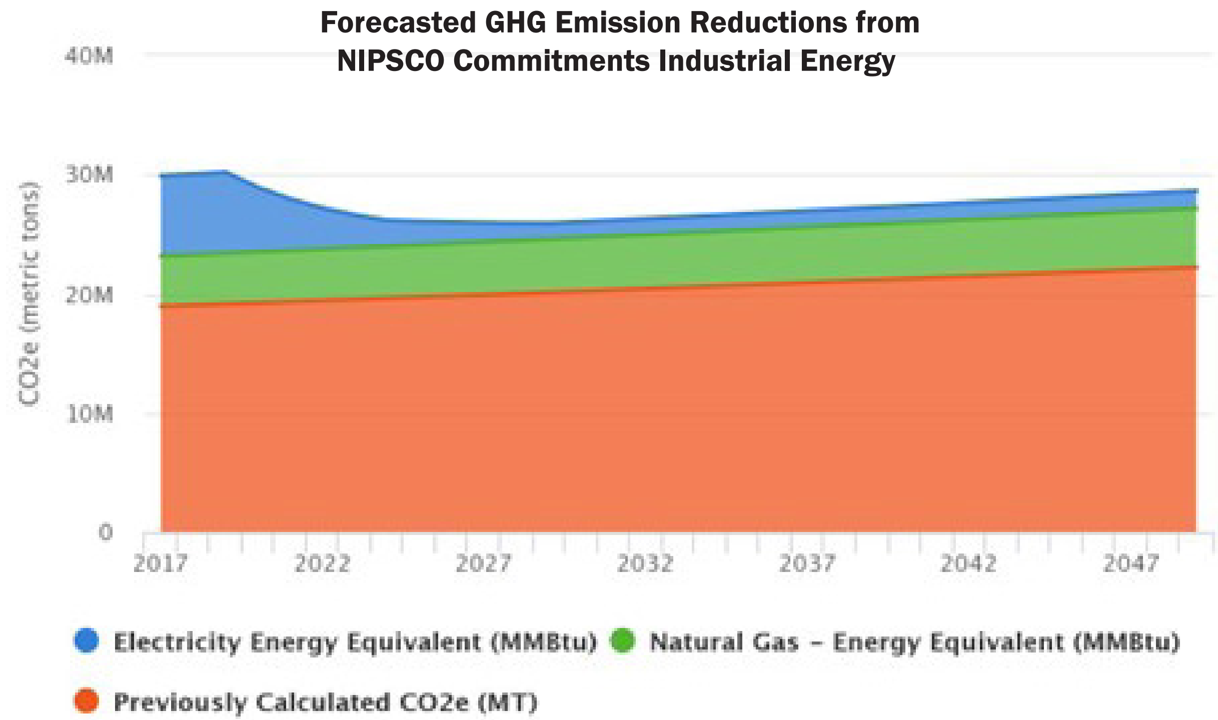
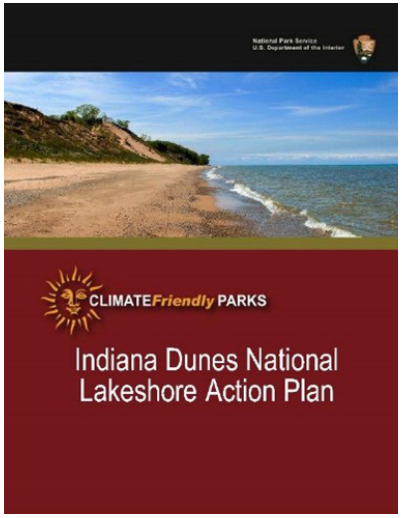


Figure 3-8: Forecasted greenhouse gas emission reductions from NIPSCO commitments

Industrial Energy Use Emissions from electricity also benefit from NIPSCO's decarbonization commitments. However, the "Business as Usual" picture is made more complicated by the significant portion of emissions from facilities off-grid individual fossil fuel combustion emissions occurring at many facilities. GHG baseline emissions for large facilities in this sector are required to be reported to US EPA in a proscribed format which can be found online in the EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT) .

Forecasting of Business as Usual On-Road Vehicle Emissions utilized planning assumptions developed for NWI 2050+ and annual VMT growth predictions in the new 2022 Travel Demand model. It also included default assumptions from US EPA CO_{2e} per mile or Carbon Intensity for vehicles will decrease by 1.8% annually based on changes in federal CAFE standards. Despite this reduction in emissions pervehicle, the 4 % annual VMT growth rate predicted in NIRPC's Travel Demand Model surpasses anticipated energy efficiency improvements for vehicles. If Northwest Indiana continues with Business as Usual, this source category will increase from 70 % of the Transportation emissions in 2017, to 74% in 2030, and 77% in 2050.

Plans and Projects considered into future GHG reduction scenarios, but not Business as Usual Forecasts



Indiana Dunes National Lakeshore Action Plan
Indiana Dunes National Park's 15,000 acres and 15 miles of shoreline represents the best Northwest Indiana has to offer. Like so many of our nation's natural monuments, climate change presents an existential threat to the long-term health and stability of the parkland. As part of the Climate Friendly Parks initiative by the National Parks Service, the Indiana Dunes National Park created the Lakeshore Action Plan, joining a network of parks putting climate friendly behavior at the forefront of sustainability planning. This comprehensive plan conducted an emissions inventory in and near the park, set reduction targets, and recommended strategies for promoting the long-term sustainability of the park. The plan aims to reduce vehicular and waste related emissions in the park and provide robust educational programming to staff and visitors on sustainable park practices.

Voluntary Corporate Sustainability or Climate Initiatives that are publicly available
Many international or publicly traded companies have made public commitments to carbon emission reduction, energy efficiency, and other sustainability measures. Typically, these commitments are made at the corporate level and reported on annually with other mandatory business reports. It is not always possible to determine from published documents how these corporate goals and plans will specifically impact Northwestern Indiana facilities or business activities. Nevertheless, because many of these corporations are large contributors to Industrial Energy, Industrial Process and Fugitive, and Freight Rail Emissions, which together account for 84% of the regions GHG emission baseline.

Strategies

Table 3-9 identifies the focus areas within the Northwest Indiana Climate Action Framework, the number of strategies within each focus area, and the contribution of each focus area toward the GHG reduction goal. Each focus area has a dedicated section within the framework where specific actions (both new and those already employed) are described.

While Northwest Indiana's local governments cannot address climate change by themselves, government policies and practices can dramatically reduce greenhouse gas emissions from a range of sources and help prepare Northwest Indiana for the anticipated impacts of climate change. In addition, NIRPC will assist residents and businesses in their endeavors to reduce emissions through programs explained in the framework. By working together, Northwest Indiana can not only do its part toward achieving a stable climate, we can also reap the benefits of healthier air, lower costs for utilities and services, improved transportation and accessibility, a more vibrant local economy, and many other positive side effects of reducing our carbon footprint.

Focus Area	Description	Number of Distinct Strategies	Percentage of Total Reduction at 2020
Transportation	Policies and programs to reduce transportation related GHG emissions	16	11%
Commercial Buildings	Policies and programs to reduce commercial and municipal sector GHG emissions, also interfacing with key utility efforts	15	22%
Residential Buildings	Policies and programs to reduce residential sector GHG emissions, also interfacing with utility efforts	11	19%
Waste, Composting and Recycling	Policies and programs to reduce waste generation and landfill emissions, promote recycling	[X]	15%
Water and Wastewater Management	Policies and programs to reduce water demands and corresponding wastewater treatment needs	[X]	12%
Land Use	Policies and programs to sequester carbon and improve climate resilience	[X]	[X]

Table 3-9: Northwest Indiana Climate Action Plan Summary Table – Emission Reduction Focus Areas

Emissions Reduction Focus Areas

NIRPC has prioritized emission source categories for regional climate action planning using two primary metrics (see Figure 3-9):

- Relative Regional Contribution to climate change as measured by GHG Emissions
- Ability of regional planning and/or local government to influence GHG Emissions.

Regional Emission Reduction Strategies are prioritized by three factors:

- Cost Effectiveness
- Time-Scale for meaningful change
- Co-Benefits align NIRPC's Critical Paths to 2050.

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At the local municipal or county level source categories and priorities may stack up differently. NIRPC will provide climate action plan templates and technical support to cities and towns interested in pursuing local Climate Action Plans.

The following emission reduction focus areas are explored in the Northwest Indiana Climate Action Frameworks: Transportation; Commercial Buildings; Residential Buildings; Water and Wastewater Management; Waste, Composting, and Recycling; and Land Use. In each focus area, a series of objectives with supporting strategies are explored. An "Objective" is a goal, end result, or target that supports a focus area, and a "Strategy" is a means of realizing the objective. Each focus area draws on the actions of both the local government and Northwest Indiana residents and businesses, although some areas may be largely one or the other.

GHG emissions in general are a function of the amount of an activity and the amount of fossil fuel required to accomplish it. For example the emissions from vehicles is the product of the number of vehicles, annual miles traveled, fuel type and fuel quantity. Strategies to reduce vehicle miles traveled may focus on reducing the number of vehicles through encouraging car pooling or public transit. Encouraging walking and biking by building safer streets for all users can reduce vehicle miles traveled. Planning or retrofitting 15 minute cities with necessary services, amenities, and destinations within a 15 minutes bike or walk can also reduce driving. Transitioning to low emission fueled vehicles, biofuels, and electric vehicles reduces the GHG emissions from vehicle miles traveled. This is an important distinction to make when the emitting activity is otherwise beneficial.

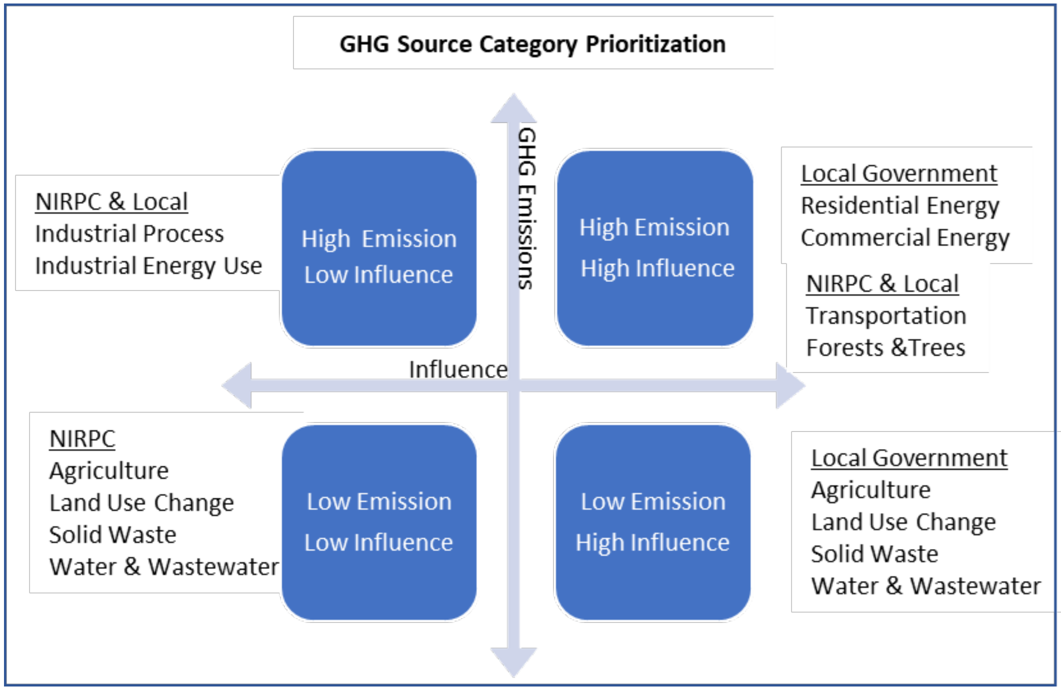


Figure 3-9: Greenhouse gas source category prioritization

Government Operations & Community Objectives & Strategies

Government operations strategies are specific to the internal operations of Northwest Indiana. They apply to buildings Northwest Indiana owns or leases, vehicles used to provide services such as police and fire, lighting of roadways, etc. Community strategies require involvement and participation from citizens. Each strategy is noted as one or both.

Emissions Reduction Potential

Calculating expected emissions reductions for each objective requires making assumptions about degree of implementation, technology, and individual behavioral changes several years into the future. The uncertainty associated with these assumptions makes it difficult to assign exact reduction totals to each objective or strategy. To address this uncertainty and provide a simple but useful reference for reduction potential, a series of symbols and percentage ranges has been devised to represent the emission reductions associated with each objective and its strategies:

Symbol	GHG Reduction
	Small Impact Range
	Medium Impact Range
	Large Impact Range

Specific implementation assumptions and GHG reduction estimates are listed in the Appendix.

Evaluation of Strategies and their Benefits

In addition to measuring the GHG reduction potential, each strategy is also evaluated for other benefits such as public health, equity and justice, jobs and prosperity, and environmental conversation. The symbols below will indicate which co-benefits a measure will generate.

This Climate Action Framework includes a combination of existing policies and programs as well as new ideas based on best practices from around the country. Whether a strategy is new or existing is noted in the strategy heading.

Symbol	Co-Benefit
	High potential to support jobs and prosperity
	High potential to advance equity
	High potential to improve local environmental quality
	High potential to improve health

Co-Benefits of Climate Protection Measures

Climate co-benefits are beneficial outcomes from action that are not directly related to climate change mitigation. Such co-benefits include cleaner air, the creation of green jobs, improved public health from active travel, and can support biodiversity due to the expansion of green space. Planning climate action that also delivers co-benefits can enable locales to bolster support from key stakeholders, mobilize scarce resources across governmental departments, and maximize opportunities to address multiple social, environmental, and economic challenges.

Co-benefits are not always well documented in GHG emission reduction initiatives. This underestimates their positive impact. The outcome of economic assessments can differ significantly once these co-benefits are factored in. The payoffs of particular projects change once these co-benefits are taken into account, which raises new financing possibilities. Choosing between different mitigation strategies needs to consider not only the economic costs of implementation and the impact on GHG emissions reduction but also the value of these co-benefits.

Actions to reduce GHG emissions present an opportunity to improve Northwest Indiana communities in a number of ways. Accounting for up to 70% of global emissions and home to 55% of the global population, all localities in our region are at the forefront of this challenge and have a vital role to play in meeting global targets. By taking actions to cut emissions and reduce vulnerabilities, Northwest Indiana can realize multiple co-benefits from climate action measures.

With increasing energy prices and insecurities, transitioning away from fossil fuels can save our region money and ensure energy security and resilience. Many actions proposed in this plan make economic sense and can yield a return on investment by reducing direct and indirect costs. Emerging green sectors can create in-demand, high-paying jobs to strengthen our communities. Investments can also improve public health and quality of life in the region.

Saving Money

Climate mitigation policy can be considered as part of larger strategy for low carbon development, where co-benefits play an important role in the motivation for action! In fact, in some cases, policies may seek the co-benefits as the primary target (for example, reducing pollution or tapping into new forms of energy to reduce costs) while climate change mitigation becomes a collateral effect.

Climate action that reduces greenhouse gas emission does have the potential for significant cost savings. Many of the measures in this plan "pay for themselves" quickly by reducing direct costs, such as fuel or energy used as well as indirect costs, such as maintenance, a "right-sized" vehicle fleet is, for example, less expensive to purchase and to fuel, while also being less costly to maintain.

Encouraging energy efficiency, public transit use, building improvements, and other measures will result in lower energy and water bills for residents and business owners. Acting now will save on the runaway costs of climate change, especially in the longer term. Examples of such costs range from infrastructure damage of extreme storms and pest control to industry losses; particularly for industries that rely on climate, such as winter sports. The costs of not acting to tackle climate change are much higher than the costs of taking action in every sector. The Global Commission on the Economy and climate concluded that transition to a low-carbon sustainable growth path could deliver a direct economic windfall of $26 trillion and create over 65 million new jobs by 2030 compared with business-as-usual. Measures that help people adapt to these impacts also incur costs, but evidence shows that the future benefits of action overwhelmingly outweigh the future costs of inaction. For instance, for every $1 spent on protecting communities from flooding, around $9 in property damages and wider impacts can be avoided.

Creating Jobs

Switching to renewable energy is imperative but also a major opportunity. The new economic model required to address climate change will also drive rapid technological innovation and create jobs in new industries.

The solar industry estimates that it created more than 15,000 jobs in 2007 and 2008, and the wind industry boasts of having created more than 35,000 new direct and indirect jobs in 2008. Similarly, new green sectors such as sustainable tourism, green construction, and urban agriculture can provide new job opportunities. These climate protection measures can spur business and job growth during the design, manufacture, installation, and maintenance of energy efficient technologies and other green sectors. This presents a particular opportunity to reinvest in the local economy and generate green jobs within Northwest Indiana.

Enhancing Resource Security

A key strategic side benefit of climate change mitigation activities is enhanced energy security through reduction in total demand. This will put less strain on the energy system as a whole as we transition to clean renewable energy. Similarly, demand shifts can help improve water and food security.

Many of the actions identified here to mitigate GHG emissions will also help Northwest Indiana's government, businesses, and residents adapt to a changing climate. For example, extreme and prolonged heat waves can put considerable strain on the reliability of energy delivery in peak periods, possibly leading to service disruption during times when cooling is most needed. With increasing efficiency across Northwest Indiana, service disruptions will be less likely, and Northwest Indiana will be able to better cope with those situations. Similarly, climate strategies can secure food and water sources and prevent damage and service disruptions to these systems from drought, flooding, and fire.

Improving Public Health

Health co-benefits have attracted much attention as they are obvious and significant. The overall costs of air pollution, which can largely be attributed to the use of fossil fuels, is huge. The cost of these co-benefits, which can be locally captured, should be taken into account when assessing the impact of initiatives.

Health benefits related to transportation include reducing vehicle emissions. Overall, the cost of climate change mitigation is lowered by the benefits obtained from reducing air pollution. Short-lived climate pollutants, such as those found in vehicle emissions, have strong warming effects but they are also a major component of air pollution. Addressing this source of pollution contributes to both climate change mitigation and improved health outcomes.

Mitigation activities engender a greater degree of choice for Northwest Indiana residents. Increasing the feasibility and attractiveness of biking or walking improves health by both reducing air pollution and encouraging active lifestyles   More transit options combined with transit-oriented development practices make for more vibrant, livable communities. This creates more connected and resilient neighborhoods. Health matters.

Climate equity is included in the overall Climate Action Plan vision and objectives. Each of the strategies in this plan were evaluated on whether they help increase climate equity and/or reduce disparities. Some actions were called out explicitly in the strategies. The strategies that do address community health, safety and livability; access, prosperity and inclusive engagement are marked with a symbol.

Transportation & Development

Broadly speaking, the use of fossil fuels for transportation is the single largest contributor to GHG emissions and climate change. Emissions from transportation and land use are a common sight to nearly everyone in Northwest Indiana. Transportation accounts for 40% of Northwest Indiana's total GHG emissions. Besides emitting greenhouse gases, transportation fossil fuels also produce a host of criteria air pollutants when combusted, reducing local air quality, and affecting our health. This chapter focuses on programs and policies to reduce emissions from transportation and includes design-oriented approaches as well as expansion of alternate modes such as walking, biking, or public transportation to and from the most common destinations in Northwest Indiana.

Electric Vehicles and Electric Vehicle Infrastructure

Dramatic increases in electric vehicle (EV) adoption are a critical component of our transportation decarbonization forecast. Drive Clean Indiana, in conjunction with Purdue University, developed a forecast for personal EV adoption rate scenarios for the state of Indiana[1]. The forecast indicates a moderate "business as usual" case with an EV adoption rate of 6% by 2050.

Year	Electric (EV)	Plug-In Hybrid Electric (PHEV)	Hybrid Electric (HEV)	Gas	Diesel	TOTAL Vehicles (Millions)
2016	0.023%	0.042%	0.963%	85.79%	2.77%	5.65
2017	0.033%	0.055%	1.035%	84.59%	2.80%	5.78
2018	0.058%	0.070%	1.097%	83.65%	2.88%	5.84
2019	0.086%	0.080%	1.167%	82.82%	2.98%	5.90
2020	0.117%	0.089%	1.260%	82.28%	3.07%	5.98
2021	0.172%	0.124%	1.461%	85.30%	2.51%	6.04

Table 3-10: Comparison of electric and hybrid vehicle registrations with gas and diesel Indiana statewide light duty vehicle fleet

Looking at statewide vehicle registrations, increasing the current EV adoption rate to 6% by 2050 requires 35 times more EVs that were registered in 2021, or approximately 12,000 more each year (Table 3-10).

An optimistic case with an adoption rate of 95% of the registered vehicles in Indiana by 2050. Under the more optimistic scenario, the net present value of cumulative net benefits statewide could exceed $32.2 billion by 2050. The study notes that the latter scenario of adoption rates is not likely unless aggressive policy action is taken at the state and local levels.

1 [Konstantinou, T., Chen, D., Flaris, K., Kang, K., Koo, D. D., Sinton, J., Gkritza, K., & Labi, S. (2022).] A strategic assess¬ment of needs and opportunities for the wider adoption of electric vehicles in Indiana (Joint Transporta-tion Re¬search Program Publication No. FHWA/IN/JTRP-2022/12). West Lafayette, IN: Purdue University.

Electric Vehicle Charging Infrastructure

While most EV charging takes place at home, growth in EV adoption increases with increases in public charging infrastructure[1]. There is a positive correlation between the availability of public DC Fast Charging (Level 3) stations and EV adoption rates. Municipal and regional actors can expedite EV adoption and meet this target by investing in EV charging infrastructure and structuring municipal code to encourage private actors to build EV charging infrastructure.

Figure 3-10 shows a map of currently active and eight near future public Level II or Level III electric vehicle charging stations with Level II or Level III Charging Stations. The eight new stations on the map are part of a larger Indiana Utility Group Fast Charging Station Plan being implemented as part of IDEM's VW Settlement Funding Program by 2024. An additional five stations are planned at major interstate intersections as part of Indiana's National Electric Vehicle Infrastructure Plan.

1 Update on electric vehicle adoption across U.S. cities

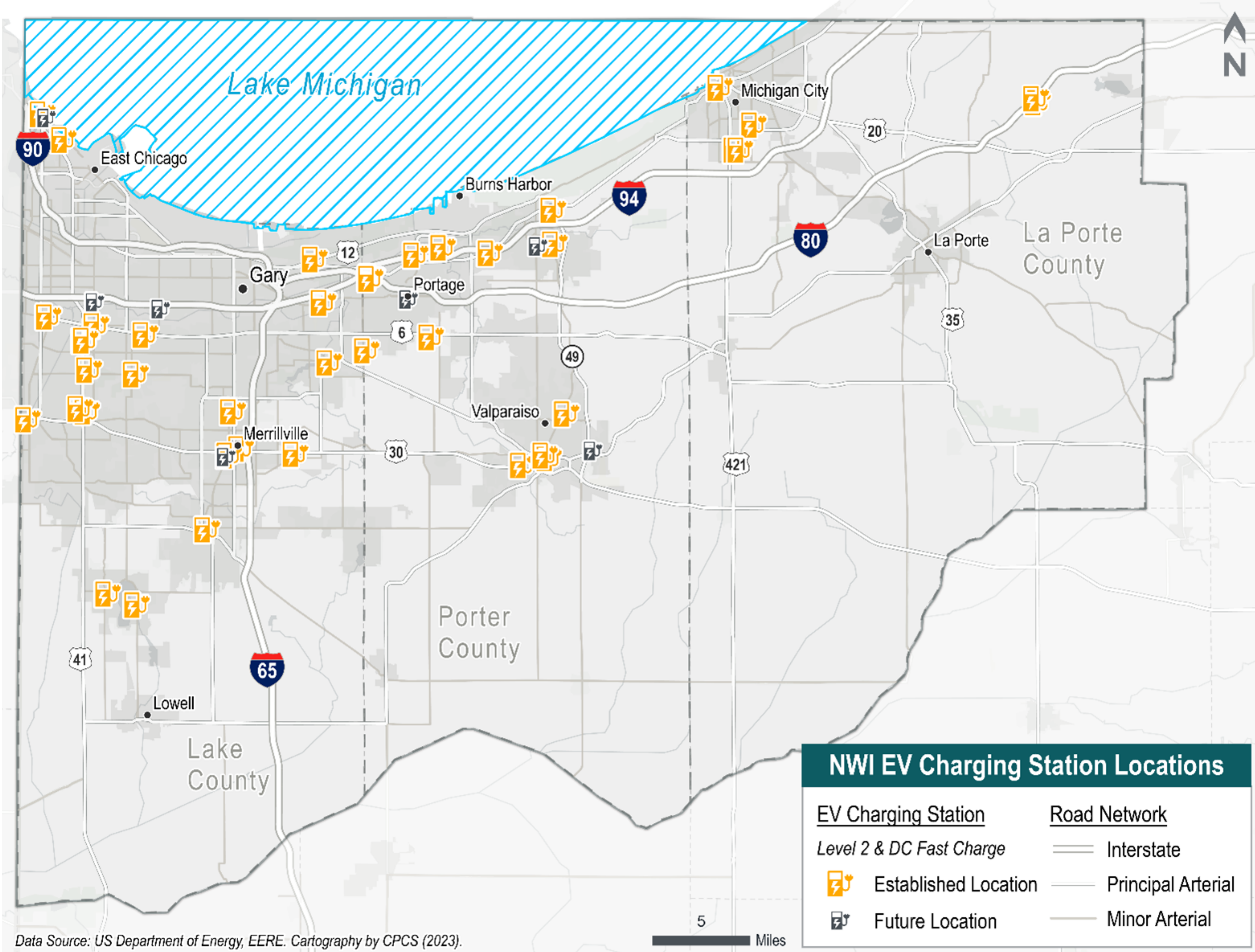
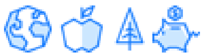
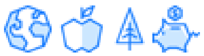
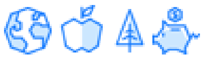


Figure 3-10: currently active and future public Level II or Level III electric vehicle charging stations

Objective	Supporting Strategies	Reduction Potential	Co-Benefits
T&D 1 – Adapt development processes to accelerate investment in EV charging infrastructure	T&D-1A, T&D-1B, T&D-1C, T&D-1D		
T&D 2 – Collaborate to enhance regional transit and expand capacity	T&D-2A, T&D-2B, T&D-2C		
T&D 3 – Prioritize transit-oriented and transit-supportive development and curtail sprawl	T&D-3A		
T&D 4 - Promote compact community development and walkable communities	T&D-4A, T&D-4B, T&D-4C, T&D-4D, T&D-4E, T&D-4F, T&D-4G		
T&D 5 - Increase bike infrastructure	T&D-5A, T&D-5B, T&D-5C		

Objective T&D 1 – EV Promotion
Adapt development processes to accelerate investment in EV charging infrastructure

Strategy Number	Strategy	Benefits	Local Government Role	Examples
T&D-1A	Establish EV-ready code		1. Lead – Install electric vehicle charging stations at public buildings and facilities 2. Encourage – Offer grant funding to offset the cost of purchasing and installing electric vehicle charging stations, especially in equity zones 3. Enact - Amend building code to require EV-ready or EV-capable parking in new residential and commercial buildings	1. San Francisco 2. Irving TX 3. San Francisco 4. Columbus 5. Spokane 6. Atlanta 7. Denver
T&D-1B	EV Promotion - Lead		1. Lead – Purchase EVs for municipal fleets 2. Lead – Establish EV adoption goal for community	1. San Francisco 2. Columbus
T&D-1C	EV Promotion – Encourage		Encourage – offer grant funding to offset the cost of purchasing and installing electric vehicles charging stations, especially in equity zones Encourage – Offer funding to transportation service providers to purchase EVs Encourage – Educate consumers about the benefits of EVs Encourage – Waive fees for EV charging stations	Spokane
T&D-1D	Green Vehicle Purchasing		Lead – replace municipal vehicle fleet with electric vehicle alternatives	1. Minneapolis 2. Columbus

Additional Resources:

A Strategic Assessment of Needs and Opportunities for the Wider Adoption of Electric Vehicles in Indiana - https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3345&context=jtrp
https://metroenergy.org/wp-content/uploads/2016/08/ehp-appendix-o.pdf

Update on electric vehicle adoption across U.S. cities - https://theicct.org/sites/default/files/publications/EV-cities-update-aug2020.pdf
DOE – EV benefits and considerations - https://afdc.energy.gov/fuels/electricity_benefits.html
EPA - EV Myths - https://www.epa.gov/greenvehicles/electric-vehicle-myths

EPA Federal Fleets - https://www.epa.gov/greenvehicles
Climate Mayors Electric Vehicle Purchasing Collaborative - https://driveevfleets.org/

Objective T&D 2 – Expand Regional Transit		
Collaborate to enhance regional transit and expand capacity		

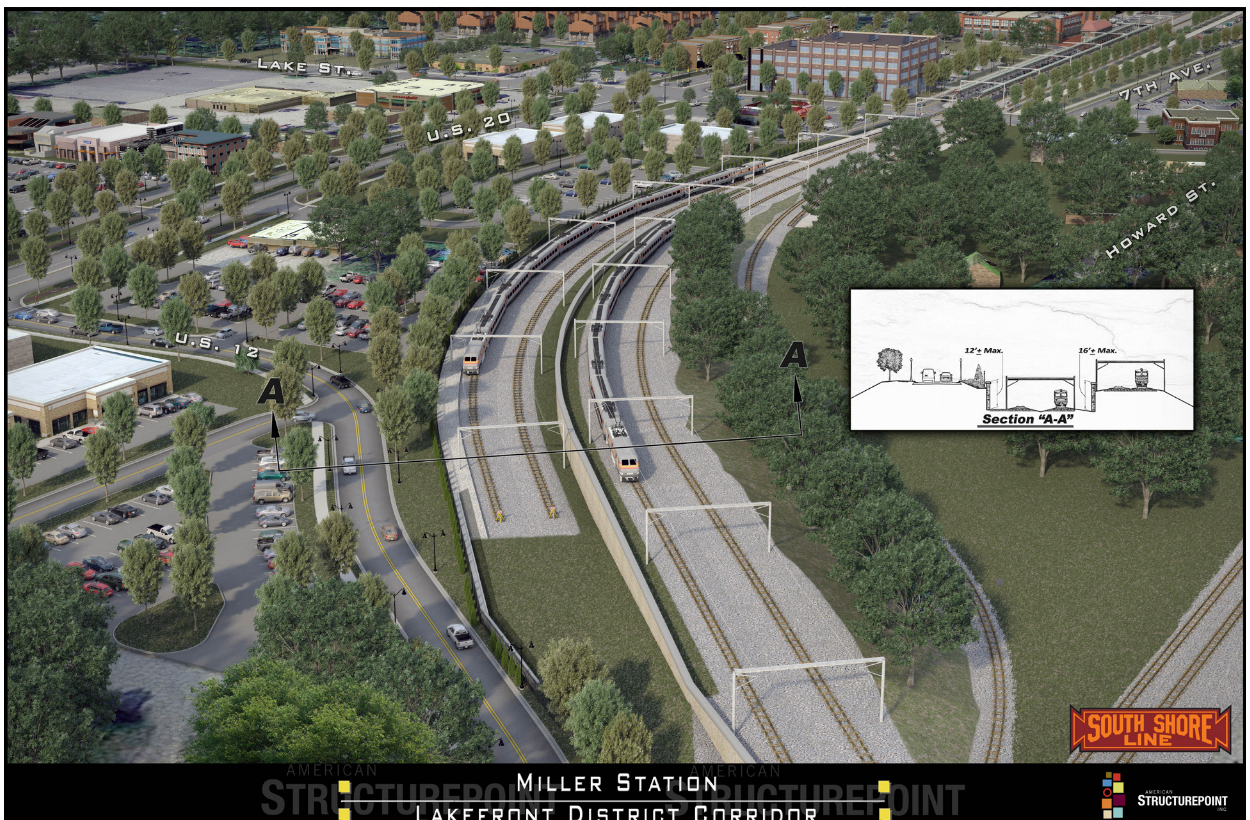
Strategy Number	Strategy	Benefits	Local Government Role	Examples
T&D-2A	Commuter Incentives		1. Encourage – offer vanpool lease agreements 2. Encourage – Encourage local businesses to adopt commuter incentives for employees	1. Austin, TX 2. Kansas City
T&D-2B	Increase Transit Coverage Area		Lead - Collaborate with transit agencies, regional and state partners and other municipalities to fund targeted expansions to transit service and implement policies and programs to increase transit ridership	Double Track West Lake Corridor
T&D-2C	Bus Rapid Transit Service		Lead – Collaborate with NIRPC, state, and municipal partners to stablish a regional fixed route mass transit system	Indianapolis, IN

Additional information on policies and strategies to expand and improve access to transit in Northwest Indiana is presented in NWI 2050+ Chapter 7: Transit

Objective T&D 3 – Prioritize Transit-Oriented Development		
Increase Jobs within transit service areas of fixed-route transit from 86,922 to 117,500 by 2035 and 160,000 by 2050 (region-wide. Source: NIRPC On To 2040 Goals)		

Strategy Number	Strategy	Benefits	Local Government Role	Examples
T&D-3A	Transit—Oriented Development		1. Lead - Position municipal development projects and services in transit-served locations instead of areas not served by transit 2. Enact - Incorporate Transit-Oriented Development (TOD) provisions into local zoning codes for development near transit stops	1. Puget Sound Regional Council 2. Chicago 3. Kansas City

In depth analysis and additional information on Northwestern Indiana strategies and investments in Transit Oriented Development are presented in NWI 2050+ Chapter 5: Land Use.



Objective T&D 4 – Promote Compact development and Walkable Communities		
Promote Compact Community Development and Walkable Communities		

Strategy Number	Strategy	Benefits	Local Government Role	Examples
T&D-4A	Accessory Dwelling Units		1. Enact – allow all types of accessory dwelling units	Minneapolis
T&D-4B	Reduce Minimum on-site parking requirements		1. Lead – Study parking challenges and establish plans to address them 2. Encourage – Allow property owners to lease parking credits in public parking garages 3. Enact – Eliminate minimum on-site parking requirements	1. Overland Park, KS 2. Pasadena, CA 3. Sandpoint, ID
T&D-4C	Prioritize Infill Development		1. Lead – Designate upzone urbanizing locations 2. Lead – Establish infill plan guidelines	1. Minneapolis 2. Kansas City
T&D-4D	Update Zoning to Promote Walkability		1. Enact – integrate walkability enhancements into maintenance and infrastructure projects 2. Encourage – Complete an assessment of current community walkability and recommendations to enhance walkability.	1. Overland Park, KS 2. Amery, WI
T&D-4E	Complete Streets		Enact – review and adopt Complete Streets policies	1. Hennepin County, MN 2. Lewiston, ME
T&D-4F	Sidewalks		1. Lead – Initiate a sidewalk repair program 2. Enact - Implement development regulations that require sidewalks in new private developments or in significant rebuild projects	1. Ann Arbor, MI 2. Richardson, TX
T&D-4G	Walk-Friendly Community Designation		Lead - Earn the Walk Friendly Community designation. Once earned, look for ways to achieve the next level of designation for their community	Somerville, Mass
T&D-5G	Implement a NIRPC Creating Livable Communities Grant Project		Lead – Apply for and Implement a CLC Capital Projects Grant targeted at public pedestrian features like sidewalks, bike lanes, bike racks, crosswalks, and benches	1. Gary 2. Michigan City

In depth analysis and additional information on Northwestern Indiana strategies and investments in Transit Oriented Development are presented in NWI 2050+ Chapter 5: Land Use.

Objective T&D 5 – Increase Bike Infrastructure		
Reduce Vehicle Miles Traveled by Increasing Bike Infrastructure and building a Regional Cycling Network		

Strategy Number	Strategy	Benefits	Local Government Role	Examples
T&D-5A	Bicycle-friendly community designation		Encourage – Encourage community and business designations	Arlington, VA
T&D-5B	Safe Routes to School		1. Lead - Incorporate Safe Routes to School engineering guidelines in municipal projects 2. Enact - Implement development regulations that require sidewalks in new private developments	1. Phoenix, AZ 2. Overland Park, KS
T&D-5C	Creating Cycling Networks		1. Encourage – Provide grants for bike parking in business districts or neighborhoods 2. Enact – Implement development requirement that minimum bicycle parking be provided in new private development projects	1. Cambridge, MA 2. Portland, OR

Land Use and Natural Areas

Land use patterns and decisions are inherently tied to GHG emissions as well as climate resiliency. Sprawling development can lead to increased vehicle travel as well as impacts to natural areas. Trees and natural areas can sequester carbon while also providing valuable co-benefits, such as flood control, improved air quality, and recreational opportunities. Natural areas are a net sink for carbon, for example Northwest Indiana's forests and trees cover approximately 20.3% of the land area. Together that area removes 133,000 tons of carbon per year from the atmosphere. The conversion of natural areas to developed land uses eliminates this carbon sequestration and often increases GHG emissions. For example, between 2011 and 2016 conversion of forest to other land uses generated 36,108 t CO2e annually between 2011 and 2016. Every acre of new urban trees planted removes approximately one ton of carbon from the per year.

Actions can be taken at the local and regional level to reduce transportation emissions and mitigate emissions through sequestration. This chapter focuses on programs and policies to reduce emissions from transportation, including design-oriented approaches as well as expansion of alternate modes such as walking, biking, or public transportation. Additionally, this chapter covers practices to mitigate or reduce GHG emissions by preserving and expanding natural areas and incorporating green infrastructure into our communities.

Critical Natural Resources in Northwest Indiana

Northwest Indiana is unique in its juxtaposition of industrial and developed areas alongside nationally and globally significant natural areas. Major natural assets include the Lake Michigan shoreline and associated ecosystems, the Valparaiso moraine forest, wetlands, and the region's abundant rivers, streams, and wetlands. The unique geography of the region also makes it incredibly biodiverse and home to many rare, threatened, and endangered species. Protection of these natural assets can help to make Northwest Indiana more resilient and vibrant by maintaining the valuable ecosystem services they provide, such as flood control, heat abatement, air quality improvement, beautification, and tourism.

Threats to Natural Areas

Despite conservation efforts, Northwest Indiana's incredible natural resources face constant and emerging threats. Development pressures often push development away from the urban core and into previously undeveloped areas, encroaching upon natural areas and farmland. Local and regional planning decisions have a significant impact on development patterns, and sound decisions can protect sensitive natural resources from sprawling or irresponsible development.

Climate change presents an unprecedented threat to our communities and natural resources. Climatic changes will significantly disrupt temperature and precipitation patterns. The changes will affect our quality of life and economy by increasing extreme heat events and flooding. Native plant and animal species have evolved under and require specific climatic conditions. A changing climate can stress these species- by altering the conditions of their natural habitats. Habitat fragmentation can limit the ability of species to migrate to adapt to climate changes. Additionally, new pests, diseases, and invasive species can enter our region as the climate warms.

Lake Michigan shoreline, Indiana Dunes, and associated ecosystems

Lake Michigan was formed as a result of glaciers retreating thousands of years ago. As the glaciers retreated, bands of glacial materials were deposited, forming our Indiana dunes, as well as older, inland dunes and interdunal swales. Indiana dunes ecosystems are A dynamic system, the Lake Michigan shoreline and dunes are continuously changing. The Indiana Dunes cross several ecological transition zones, resulting in many habitat types and incredible biodiversity. The dunes region is home to oak savannas, swamps, bogs, marshes, prairies, rivers, and forests. Though much of Indiana's shoreline and associated dunes were lost to development, thousands of acres are protected in the Indiana Dunes National and State Parks as well as properties owned and managed by non-profit organizations and local government agencies. Remnants of the globally-rare "dune and swale" ecosystem remain in the region.

Waterways

In addition to being home to Lake Michigan, Northwest Indiana has incredible inland lakes and rivers. From the highly industrialized Grand Calumet River to scenic stretches of the East Branch of the Little Calumet River to the Kankakee River which marks the region's southern border, Northwest Indiana's waterways each have unique characteristics, assets, and challenges. Major waterways include the Kankakee River, The Grand Calumet River, Trail Creek, and the Little Calumet River and its tributaries, including Deep River and Salt Creek. These waterways, as well as inland lakes, should be buffered and protected from development to preserve water quality and protect communities from flooding and erosion.

Wetlands

Northwest Indiana is home to nationally significant wetlands from the Great Marsh in the north to the Grand Kankakee Marsh in the South. The Great Marsh once paralleled the Lake Michigan shoreline from Gary to Michigan City. Largely drained and developed in the early 1900s, remnants of the marsh remain protected in the Indiana Dunes National Park and other properties owned and managed by the Indiana Department of Natural Resources and non-profit land trusts. The southern part of the three-county region was historically home to the Grand Kankakee Marsh Protecting Northwest Indiana's waterways, from small headwater streams to large downstream rivers helps to protect our region from hazards such as flooding and erosion while also keeping our aquatic resources clean for drinking, recreation, and more. Once called "the Everglades of the North", the Kankakee River wetlands once drew waterfowl hunters from across the country. While less than 10% of the original Marsh remains today largely due to draining for agricultural and other land uses, important natural and cultural remnants remain, and conservation partners continue work to restore this natural treasure. Protecting wetlands and their function in the landscape is an important strategy for climate resiliency.

High Priority Conservation Areas

Conservation action planning provides a globally recognized framework for engaging in conservation work to benefit people and the environment. Partners and stakeholders have worked together to develop conservation action plans (CAPs) for high priority areas in the Calumet region of Northwest Indiana and Southeast Chicagoland. Conservation partners, including conservation organizations, land managers, planning organizations and other stakeholders contributed to the development of the fundamental aspects of each CAP, including: a conservation vision, geographic scope, focus area map, conservation targets, human well-being targets, conservation threats and conservation strategies.

Conservation action plans have been developed for the following geographies in Northwest Indiana: West Branch of the Little Calumet River, Hoosier Prairie, Moraine, Ambler Flatwoods, Heart of Calumet, Ecosystems of the Indiana Dunes, the East Branch of the Little Calumet River, Hobart Marsh, and Deep River in Northwest Indiana. Conservation partners, including NIRPC, continue to work together to strategically advance work toward the shared conservation goals detailed in the plans. The map in Figure 3-11 provides a high-level overview of these areas and how tributaries of the historic Calumet River connect them through the urban landscape.

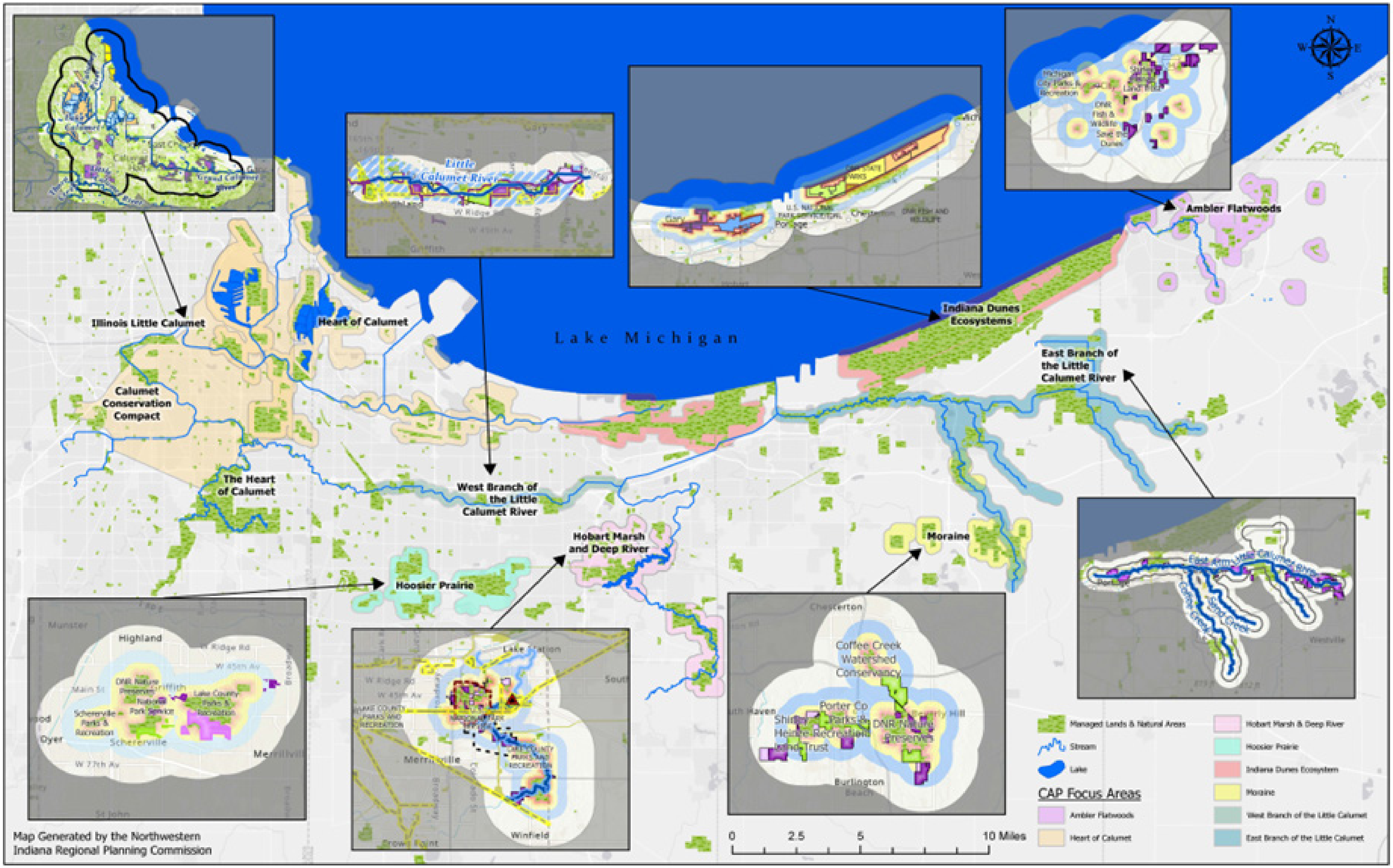


Figure 3-11: Consensus Based Map of High Priority Conservation Areas in the Calumet basin of Northwestern Indiana and Northeastern Illinois

Plans to Increase Resilience in Northwest Indiana

Northwest Indiana can take actions to prepare for and adapt to the impacts of climate change. Several plans have been developed to ensure Northwest Indiana's resilience.

LMCP Coastal Resilience Needs Assessment

In 2022, NIRPC worked with the IDNR Lake Michigan Coastal Program to develop the Coastal Watershed Hazards Resiliency Needs Assessment. The self-assessment is intended to help local government staff and decision-makers of Indiana coastal watershed communities evaluate potential impacts of natural hazards and consider planning and mitigation actions to increase resilience. Resilience, in the context of the self-assessment, is the ability to respond to, withstand, and adapt to the impacts of natural hazards. A summary of assessment results will be finalized in 2023 and will assist the Indiana Lake Michigan Coastal Program in identifying, developing, and delivering the technical resources needed by coastal watershed communities to reduce or prevent natural hazard risks.

Climate Friendly Parks: Indiana Dunes National Lakeshore Action Plan

As part of the Climate Friendly Parks initiative by the National Parks Service, the Indiana Dunes National Park created the Lakeshore Action Plan, joining a network of parks putting climate friendly behavior at the forefront of sustainability planning. This comprehensive plan conducted an emissions inventory in and near the park, set reduction targets, and recommended strategies for promoting the long-term sustainability of the park. The plan aims to reduce vehicular and waste related emissions in the park and provide robust educational programming to staff and visitors on sustainable park practices.

IDNR Wetland In-Lieu Fee Program

The Indiana Department of Natural Resources (DNR) instituted an in-lieu fee program for mitigation of impacts to aquatic resources. Advance credits are purchased by permittees in lieu of performing mitigation themselves. The legal obligation to provide compensatory mitigation is then transferred to the sponsor of Indiana DNR. The program allows IDNR to complete and maintain higher quality mitigation projects.

Watershed Management Plans

A watershed management plan is a strategy and work plan for achieving water resource goals. It includes the analyses, actions, participants, and resources related to development and implementation of the plan. The primary purpose of a watershed management plan is to guide watershed coordinators, resource managers, policy makers, and community organizations to restore and protect the quality of lakes, rivers, streams, and wetlands in a given watershed. The plan is intended to be a practical tool with specific recommendations on practices to improve and sustain water quality. These are also "living documents", meaning that as conditions change over time in a watershed, the plan must be reexamined and revised to reflect goals that have been achieved or not met.

In Northwest Indiana, watershed management plans exist for Coffee Creek, Deep River- Portage Burns Waterway, Dunes Creek, the East Branch of the Little Calumet River, Galena River, Salt Creek, Trail Creek, the West Branch of the Calumet River. Additionally, NIRPC developed a region-wide watershed framework. The critical areas and recommendations in these watershed management plans should be consulted in local land use planning and decision-making.

Invasive Species Management

An invasive species is a species that does not naturally occur in a specific area and whose introduction does or is likely to cause economic harm, environmental harm, or harm to human health. In late 2017, Southern Indiana Cooperative Invasives Management (SICIM) and the USDA Natural Resources Conservation Service (NRCS) entered into a contribution agreement for the purpose of developing local Cooperative Invasive Species Management Areas (CISMAs) (hyperlink to https://www.sicim.info/) throughout Indiana. Both SICIM and the NRCS have been working for many years to combat invasive plants and raise public awareness of the devastation being caused by these non-native pests, and both have come to the realization that we will not begin to make much headway until the problem is addressed at the local level by local people using local resources. As of 2023, Porter and LaPorte counties have a joint CISMA, and Lake County is in the process of organizing a CISMA.

NIRPC Green Infrastructure Policy and Guidance

Green infrastructure utilizes vegetation, soil, and engineered systems to mimic natural processes of slowing or storing stormwater. These practices can improve water quality and reduce flooding by intercepting, infiltrating, filtering, and evapotranspiring stormwater. Green infrastructure can provide additional ecological services that traditional gray infrastructure does not, such as improving air quality, reducing the urban heat island effect, providing pollinator habitat, and beautifying communities.

In 2022, NIRPC developed green infrastructure (GI) guidelines to complement NIRPC's Living Streets Policy within roadway public rights-of-way for Lake County, Porter County, and LaPorte County. This policy requires sponsors of local projects selected for funding to scope the feasibility of including functional green infrastructure and complete streets features up to 15% of the project costs. The developed GI guidelines are to be used by applicants to select and plan for appropriately functional GI elements for proposed transportation projects. NIRPC envisions incorporating demonstration of appropriately planned GI technologies into the evaluation criteria for project selection. The goal of the policy is that while Northwest Indiana's highway funds improve the transportation infrastructure, they can also improve the natural and built environment using more ecologically-friendly and sustainable management practices. Integrating GI into projects will provide more resilient stormwater runoff management and additional benefits that improve community quality of life.

Although there are many green infrastructure practices to consider, NIRPC's guidance focuses on some of the best practices to apply in transportation settings including:

- Bio-infiltration
- Flow-Through Planters
- Vegetated Swales
- Urban Street Trees
- Pervious Pavements
- Hydrodynamic Separators

The guidelines identify critical design parameters for GI facilities within transportation settings that focus on reducing stormwater quantity and improving water quality for the Northwest Indiana counties. These guidelines focus on strategies to achieve maximum function based on common site constraints and requirements.

Roadway classification is a primary consideration in determining eligibility for the federal highway dollars that NIRPC allocates to local road projects. Because it is also useful when initially evaluating and selecting GI practices, NIRPC's guidelines are organized by roadway classification. Other considerations for GI selection include location, site constraints, and performance objectives. The guidelines do not address all potential GI available but highlight the most common GI and provide a basic overview of benefits and ecological functions, applications, typical design considerations, and maintenance associated with the GI practice. The guidelines are intended to provide early planning guidance and a tool for planners and designers when considering the inclusion of GI into right-of-way development and retrofit projects. They are not a substitute for appropriate project engineering and design. The guidelines do not supersede regulatory requirements and should always be considered in conjunction with authorities having jurisdiction code requirements.

Transportation Vulnerability Assessment

In 2023 and 2024 NIRPC will be taking a closer look at how and where region communities and infrastructure might be vulnerable to the climate change induced increases in high heat events and extreme precipitation events. The US Federal Highway Administration Vulnerability Assessment and Adaptation Framework provides guidance on the following key steps to follow, some of which have begun through ongoing climate planning efforts.

- ***Articulate Objectives and Define Study Scope***: This process has begun with input from the Climate Action Northwest Indiana working group, local governments and non-profit partners. Initial objectives include: understanding where and to what extent roads, sidewalks, bridges, and culverts are vulnerable to an increase in the frequency and intensity of storms and precipitation, learning how increasing frequency of high heat events might influence regional efforts to normalize active transportation habits in the region, investigating if it is possible to predict whether potential changes in heat/thaw cycles might impact pavement longevity.

- ***Obtain Asset Data***: collecting data from local governments on road flooding complaints and mapping infrastructure and waterway intersections will provide an initial screening for flooding vulnerability. Mapping of heat islands and gaps in street tree canopies will be needed to understand those places with little protection from extreme heat events.

- ***Obtain Climate Data***: Fortunately, the Indiana Climate Impacts Assessment at Purdue University has produced 9 reports detailing how climate change will impact many aspects of the natural and built environment. The statewide Climate Impact Assessment does include the range of future conditions in northern, central, and southern Indiana. It does capture potential climate change impacts on the coastal hazards unique to NWI within the state. Using recent experiences of high and low lake level extremes may provide additional data to bring to this study.

- ***Assess Vulnerability:*** Is the next step needed and will be undertaken during 2023-2024 with procured contractual assistance.

Forests

Trees help to sequester carbon and provide other benefits, such as flood control and cooling. Much of Northwest Indiana was forested prior to development, and large amounts of forested areas remain, from morainal forests to boreal flatwoods. Between 2011 to 2016, the annual net GHG balance of forests and trees was -421,644 t CO2e in Northwest Indiana.

Urban forests refer to the trees in urban areas, such as street trees, trees in parks, and trees on private property. In addition to offsetting GHG emissions, urban forests deliver social, economic, and environmental benefits. These benefits are often needed in urban or underserved communities, which may experience poor air quality and heat island effects. Protecting existing, mature trees is critical to maintaining these valuable ecosystem services, as mature trees provide substantially more benefits and the removal of mature forests itself increases GHG emissions. Investments in urban forests should be equitably distributed throughout Northwest Indiana.

Trees in a community help to reduce air and water pollution, alter heating and cooling costs, and increase real estate values. Urban areas are typically 1-2°C (but as much as 10°C) warmer than rural areas, and this "heat island" effect can be exacerbated by climate change. Urban areas may also be more prone to climate impacts, such as increased flooding. Urban trees can mitigate these impacts by shading communities and absorbing stormwater.

Objective	Supporting Strategies	Benefits	Reduction Potential
LU 1 - Increase Urban Canopy and Urban Green Infrastructure	LU-1A, LU-1B, LU-1C, LU-1D, LU-1E		
LU 2 - Increase Open Spaces and Improve Open Space Management	LU-2A, LU-2B		

LU 1 – Increase Urban Canopy and Urban Green Infrastructure		
Increase Percent Urban Tree Canopy from 17.1% to 23% by 2035 and 30.0% by 2050. (region wide. Source: NIRPC On To 2040 Plan)		

Strategy Number	Strategy	Benefits	Local Government Role	Examples
LU-1A	Protect and increase urban and suburban forests		1. Lead - Complete an assessment of current urban forests and develop a master plan to fund, maintain and improve them through capital improvement programs, public works and parks budgets 2. Enact - Adopt ordinances to require tree preservation, replacement and planting for private development, including enhanced inspection and enforcement capabilities	1. Oxford, MS 2. Cleveland, OH 3. Smyrna, GA 4. New Brunswick, NJ 5. Fayetteville, AK 6. Atlanta, GA
LU-1B	Plan and protect street trees		1. Lead - Ensure city planning master plan incorporates increased street tree plantings, and that tree planting is funded 2. Encourage - Fund a community tree program that provides residents with free street trees and information about their planting and care 3. Enact – Require street trees to be planted in new developments	4. Miami, FL 5. Kansas City, MO 6. Austin, TX 7. Vancouver, WA
LU-1C	Earn recognition for urban forest stewardship with a Tree City USA Growth Award		Lead – Earn a Tree City USA Growth Award	Boulder, CO
LU-1D	Plant shade trees		Encourage – Provide cost-sharing for planting of shade trees	1. Washington, D.C. 2. San Antonion, TX
LU-1E	Harvest and utilize high-value wood products from trees that must be removed		1. Lead - Create an urban wood utilization program for trees cut down by the city 2. Encourage - Create educational materials or programs to make arborists and homeowners aware of alternate options for disposing of harvested wood	1. Davenport, IA 2. Wisconsin Urban Wood

Additional Resources:

Protect and increase urban and suburban forests

Heartland Tree Alliance - https://bridgingthegap.org/heartland-tree-alliance/
US Forest Service, Urban Forests - https://www.fs.usda.gov/ccrc/topics/urban-forests-and-climate-change
Vibrant Cities Lab - https://www.vibrantcitieslab.com/toolkit/plan-the-total-program/
International Society of Arboriculture - https://www.isa-arbor.com/Credentials/Types-of-Credentials/ISA-Certified-Arborist-Municipal-Specialist/Tree-Ordinance-Guidelines

Plant and protect street trees

EPA Heat Island Database - https://www.epa.gov/heatislands/heat-island-community-actions-database
EPA Urban Street Trees - https://www.epa.gov/water-research/urban-street-trees-and-green-infrastructure
22 benefits of urban street trees - https://ucanr.edu/sites/sjcoeh/files/74156.pdf
Univ. or Washington Safe Streets - https://depts.washington.edu/hhwb/Thm_SafeStreets.html
Earn recognition for urban forest stewardship with a Tree City USA Growth Award
Arbor Day Foundation - https://www.arborday.org/programs/treecityusa/

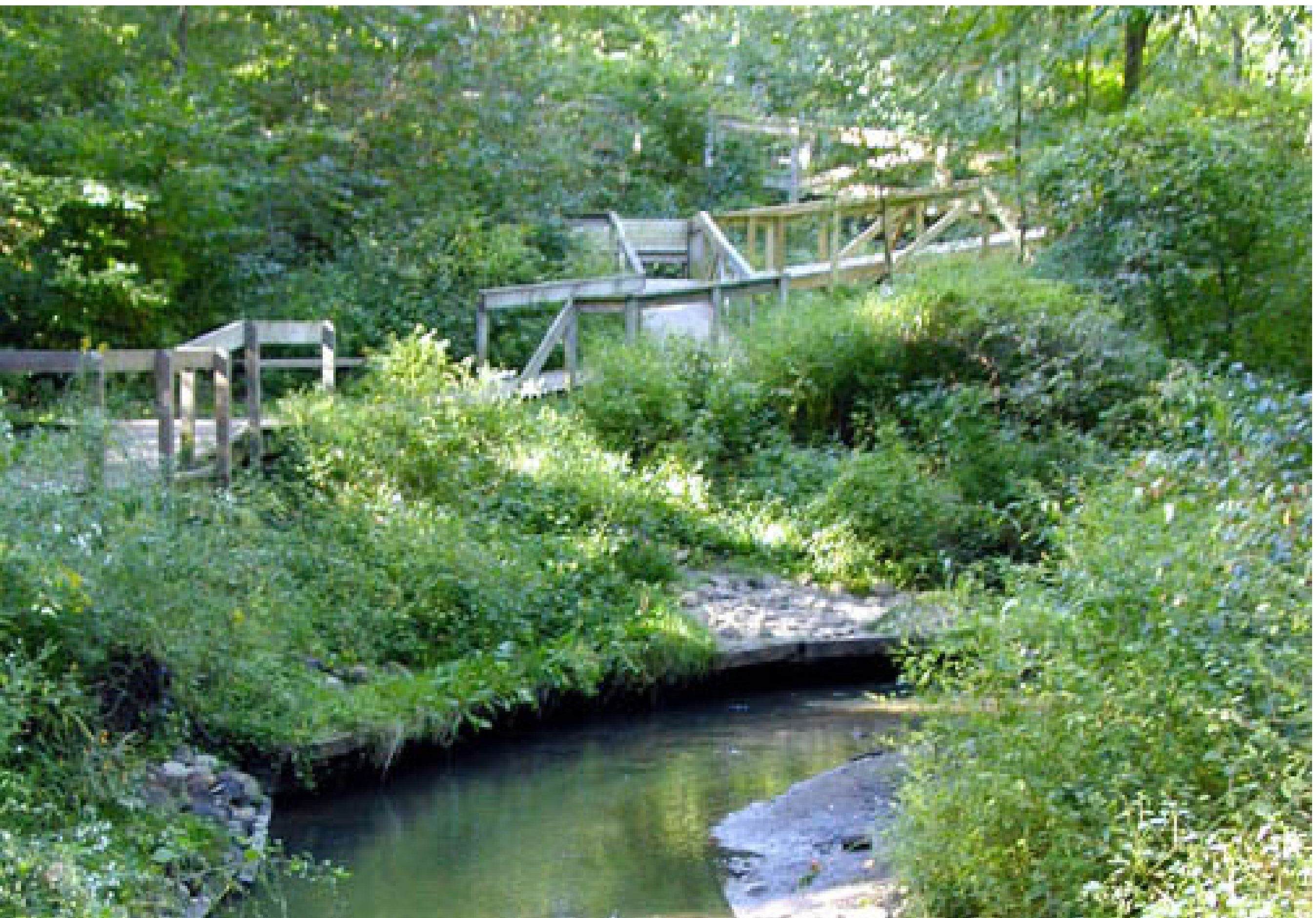
Plant shade trees

DOE Landscaping for Efficiency - https://www.energy.gov/energysaver/energy-efficient-landscaping
Energy Savings from the Tree Shade - https://www.auburn.edu/academic/forestry_wildlife/forest_policy_ctr/documents/energy-savings-ecol-econ.pdf
Harvest and utilize high-value wood products from trees that must be removed
Colorado State Forest Service Urban Wood Utilization - https://csfs.colostate.edu/cowood/

LU 2 – Increase Open Spaces and Improve Open Space Management		
Increase Acres in Manages Lands by USGS from 49,032 acres to 58,000 acres by 2035 to 70,000 acres by 2050 (region wide. Source: NIRPC On To 2040 Plan)		

Strategy Number	Strategy	Benefits	Local Government Role	Examples
LU-2A	Conserve key natural assets and open space, including working lands (agriculture)		1. Lead – Acquire land to be conserved as open space 2. Encourage – Use conservation easements to protect key areas. 3. Enact - Create vegetation protection zones	1. Kansas City 2. Wayland, MI
LU-2B	Fully fund parks and recreation systems		Lead – Provide funding to enhance existing green space and parks	Indianapolis, IN

For more information on land conservation and open space, refer to NWI 2050+ Chapter 5: Land Use



APPENDIX 3A

Inventory Methodology

The first step toward achieving tangible greenhouse gas emissions reductions requires identifying baseline emissions levels, sources, and activities generating emissions in a community. This report presents emissions from the communities of Cedar Lake, Chesterton, East Chicago, Highland, Hobart, Lake Station, La Porte, Merrillville, Munster, Valparaiso, Schererville, Lake County, La Porte County, and Porter County. Subsequently Hammond and Portage were also inventoried. These joined previous inventories completed by the cities of Gary and Michigan City in 2019.

As local governments continue to join the climate protection movement, the need for a standardized approach to quantify GHG emissions has proven essential. This inventory uses the approach and methods provided by the Global Protocol for Community-Scale Emissions (GPC)[1].

Three greenhouse gases are included in this inventory: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Many of the charts in this report represent emissions in “carbon dioxide equivalent” (CO_{2e}) values, calculated using the Global Warming Potentials (GWP) for methane and nitrous oxide from the IPCC 5th Assessment Report.

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO2)	1
Methane (CH4)	28

Community Emissions Protocol (GPC)

The GPC is the official protocol specified by the Global Covenant of Mayors and defines what emissions must be reported and how. In addition, this inventory draws on methods from the U.S. Community Protocol ,which provides more detailed methodology specific to U.S. communities. Inventory calculations were performed using ICLEI’s ClearPath tool.

The community inventories in the GHG emissions inventory include emissions from the following sectors: Stationary Energy, Transportation, Waste, Water & Wastewater, Industrial Processes and Fugitive Emissions. In addition, the net emission or removal of GHG from Agriculture, Forestry, and Other Land Use (AFOLU) changes are calculated.

Carbon dioxide represents the vast majority (99.5%) of the region’s emissions and is produced from burning fossil fuels such as coal, gasoline, diesel, and natural gas. Nitrous oxide emissions were primarily from grid electricity (from fuel combusted to create electricity) and gasoline used for passenger vehicles. Methane accounts for the smallest percentage of region-wide emissions and resulted primarily from grid electricity, gasoline used for passenger vehicles, solid waste generation, flaring of digester gas, and leakage from local natural gas distribution systems.

In Northwest Indiana, forested areas and urban trees sequester enough carbon that the net result from these calculations was 406,347 tons of Carbon Dioxide Equivalents (CO_{2e}) removed from the atmosphere. This is more than the estimated emissions from solid waste management, wastewater and drinking water treatment combined!

1 GHG Protocol for Cities: An Accounting and Reporting Standard for Cities (n.d.) Retrieved from https://ghgprotocol.org/greenhousegas-1protocol-accounting-reporting-standard-cities

Quantifying Greenhouse Gas Emissions

Scopes

Communities contribute to GHG emissions in many ways. The three central categorizations of emissions used in the GPC community inventory are outlined below. By reporting on these three different scopes of emissions, local governments can develop and promote a deeper understanding of GHG emissions associated with their communities. Figure 3A from the GPC GHG Protocol for Cities, depicts the differences and relationships between the scopes.

Scope 1: GHG emissions from sources located within the community boundary.

Scope 2: GHG emissions occurring because of the use of grid-supplied electricity, heat, steam and/or cooling within the community boundary.

Scope 3: All other GHG emissions that occur outside the city boundary because of activities taking place within the community boundary.

By reporting on these three different scopes of emissions, local governments can develop and promote a deeper understanding of GHG emissions associated with their communities. To aggregate community inventories into a region-wide inventory, such as the aggregation of the Lake, Porter, and La Porte County inventories, all scope 1 emissions from each community are totaled. This calculation prevents double counting of emissions between communities.

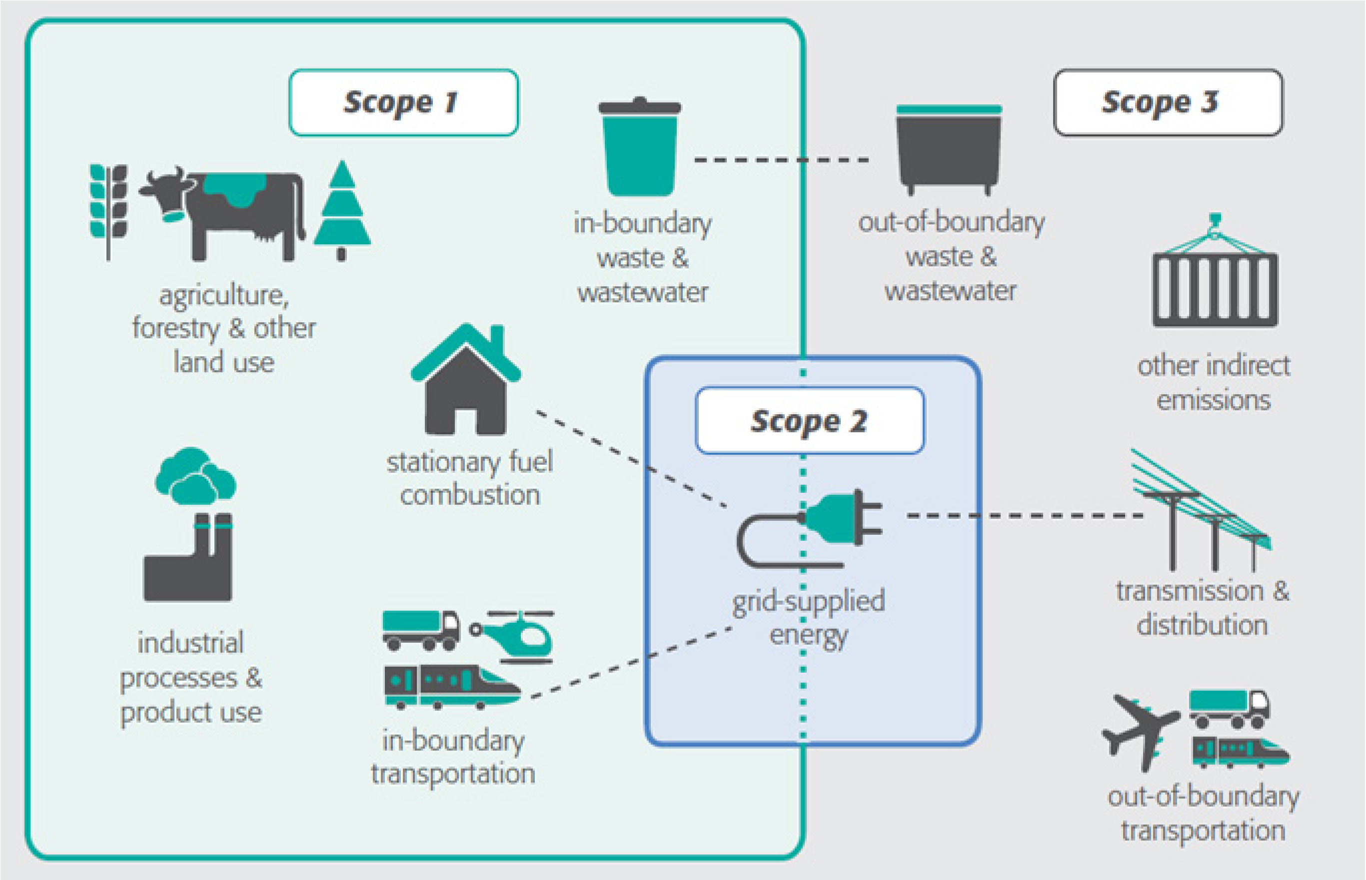


Figure 3A: Community Emissions Protocol Scope Diagram

Base Year

The inventory process requires the selection of a base year with which to compare current emissions. These communities' inventories utilize 2017 as their baseline year because Gary and Michigan City completed their initial GHG emissions inventories in 2017. Using the same year as these other inventories allows for greater comparison of emissions between communities.

Quantification Methods

Greenhouse gas emissions can be quantified in two ways. Measurement-based methodologies refer to the direct measurement of greenhouse gas emissions (from a monitoring system) emitted from a flue of a power plant, wastewater treatment plant, landfill, or industrial facility. Calculationbased

methodologies calculate emissions using activity data and emissions factors. To calculate emissions accordingly, the basic equation below is used:

Activity Data x Emission Factor = Emissions

Most emissions sources in this inventory are quantified using calculation-based methodologies. Activity data refer to the relevant measurement of energy use or other greenhouse gas generated processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Direct measurements were used when necessary, most often for emissions reports from industrial facilities. Please see appendices for more detailed information for emissions activities and factors for each community inventory.

Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data (e.g. lbs CO_2/kWh of electricity). For this inventory, calculations were made using ICLEI's ClearPath tool.

APPENDIX 3B

Summary Report

GHG Inventory for Forests and Trees Outside Forests, 2011 to 2016
Custom uploaded polygon County, N/A

Summary

Forests and trees play a key role in mitigating climate change, yet they are often not included in local greenhouse gas (GHG) inventories or climate action plans. Custom uploaded polygon County, N/A has taken the first step towards understanding how local changes in land use and tree canopy have contributed to the county's net greenhouse gas profile. Unlike other sectors, land use (in this case, forests and trees) not only emit GHGs, they also remove CO_2 from the atmosphere through photosynthesis, and play a critical role in regulating the planet's climate. The information contained in this summary report can be useful when designing climate actions that reduce GHG emissions and/or increase removals of GHGs from the atmosphere.

Key Findings

- Over the period 2011 to 2016, emissions from forests and trees were 40,069 t CO2e per year.
- Over the period 2011 to 2016, the Net GHG balance of forests and trees was -421,644 t CO2e per year.
- Roughly 17% of Custom uploaded polygon County's total land base of 395,942 hectares (978,392 acres) is forest. Manyareas outside of forests are also covered by trees, including an average of nearly 3.3 percent tree canopy on lands outsideof forest areas
- Over the same period, annual CO_2 removals from forests and trees were -461,713 t CO2e per year. (Carbon removals are represented by negative values.)
- Total GHG emissions for Custom uploaded polygon County across all sectors could be reduced if additional forests/trees were added to its land base, and/or if losses of trees were reduced further.

	Removals(t CO2e/yr)	Emissions(t CO2e/yr)
Undisturbed Forest	-347,698	
Forest Disturbances		19,305
Non-Forest to Forest	-6,832	
Forest to Settlement		2,960
Forest to Grassland		2,064
Forest to other non-forest lands		11,779
Trees outside of forests	-107,184	3,961
Harvested Wood Products	0	
TOTAL	-461,713	40,069
Net GHG balance	-421,644	

Table 3B-1: Custom uploaded polygon 'ountyxs GHG fluxes from forests and trees for inventory peri-od 2011 - 2016, all values reported in t CO2e per year

Data Inputs

Data used as inputs into the GHG emission and removal calculations are described below.

Land and Forest Cover

GHG inventories for lands are reported in six "land use" categories which were defined by data on land cover—forest land, grassland, cropland, wetland, settlement and other land (barren, snow, ice). Custom uploaded polygon County's total land base is approximately 395,942 hectares (978,392 acres), with nearly 23.6% Settlement (i.e. developed areas of varying intensity), around 17% forest, 7.6% Grassland (which includes hay/pasture, shrub/scrub and other herbaceous cover), 49.1% cropland, 2.3% wetland and 0.4% other land.

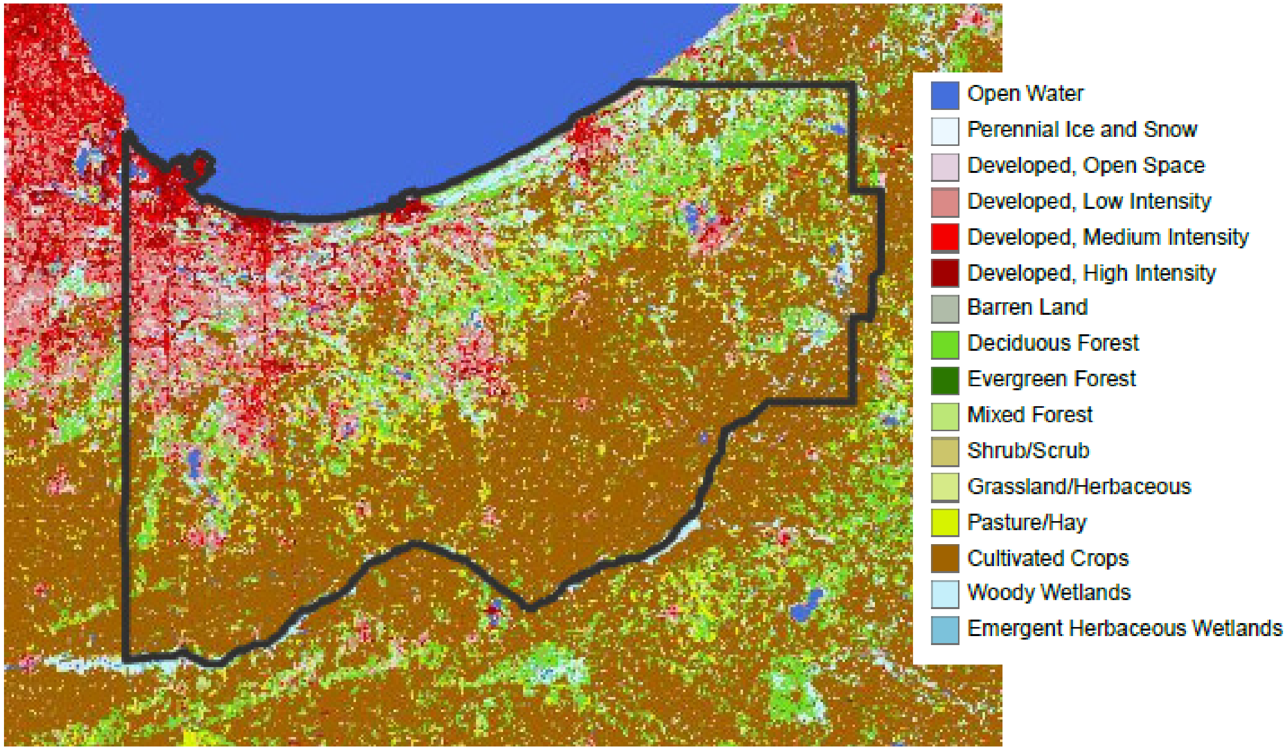


Figure 3B-2: Land cover in custom uploaded polygon from the National Land Cover database, 2016

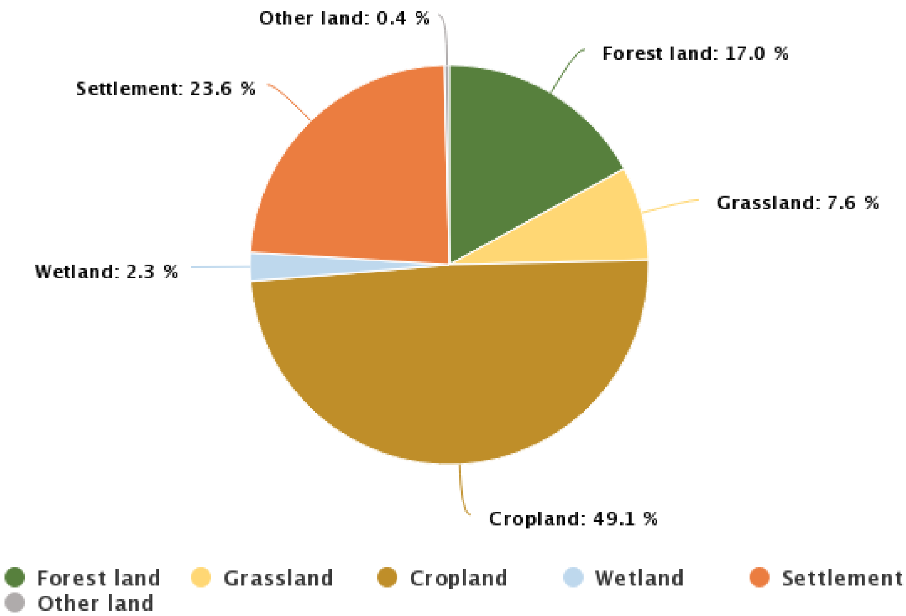


Figure 3B-1: Land cover in custom uploaded polygon from twe National Land Cover database, 2016

Forest Cover Change

Generating GHG estimates requires data not just on areas of land use, but also data on how land use has changed over time. Between 2011 and 2016, the county lost around 959 hectares (2,369 acres) of forest land, largely conversion to wetland. Over the same period, the county gained around 1,157 hectares (2,860 acres) of forest land, largely from Wetland.

Forest Disturbances

Over the inventory period 2011 to 2016, forest disturbance from insects was the most significant in custom uploaded polygon County, affecting 2296.9 hectares (5675.8 acres), followed by harvests, which affected 126 hectares (311.4 acres) and fires, which affected 0 hectares (0.0 acres).

Figure 3B-3: Loss of forest to other land use types between 2011 and 2016 (ha)

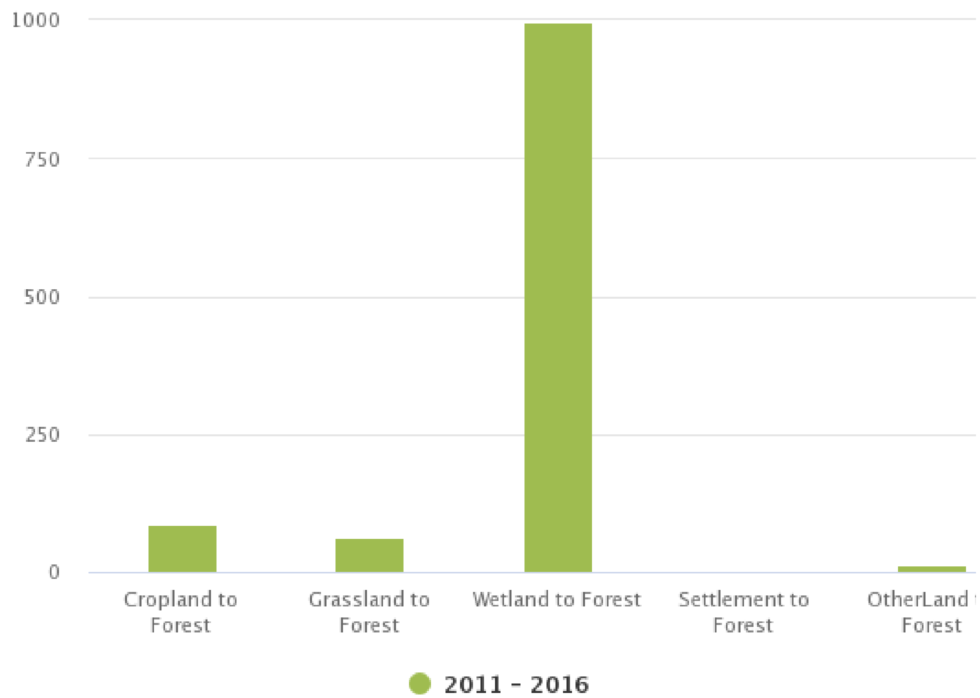


Figure 3B-4: Gain of forest from other land use types between 2011 and 2016 (ha)

Trees Outside Forests

Figure 5 shows tree canopy captured by the NLCD tree canopy data. (Note that some areas with high tree canopy in Figure 3B-5 overlap with the NLCD forest class shown in Figure 3B-2.)

This data is only available for the years 2011 and 2016. Over this time period, Custom uploaded polygon County had an average of 10,659 hectares (26,338 acres) of tree canopy outside forests. Between 2011 and 2016, 11 hectares per year of tree canopy were lost, for a total of 57 hectares (142 acres) of tree canopy loss over the 5 year period. Most of this loss occurred within the Settlement class.

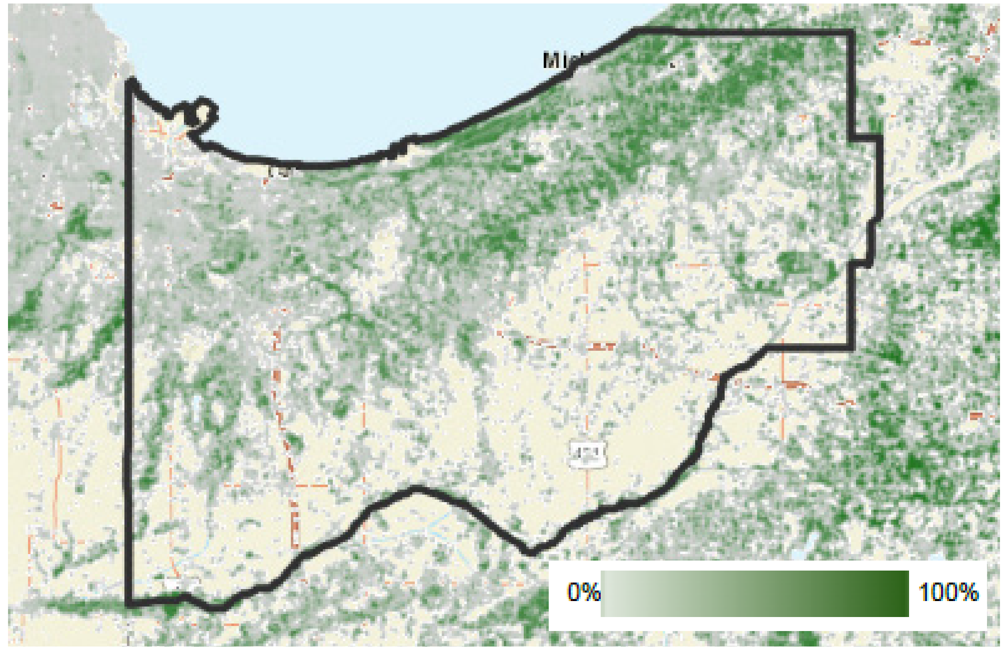


Figure 3B-5: Tree canopy 2016 (Source: National Land Cover Database)

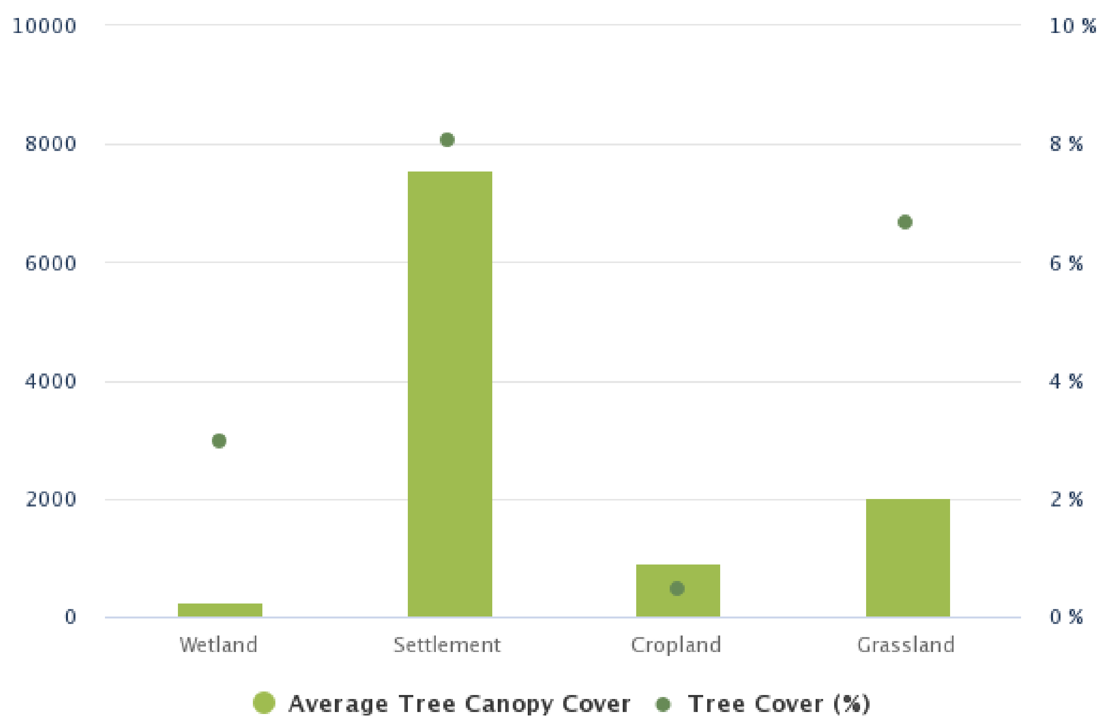


Figure 3B-6: Average tree canopy (in hectares) and % tree canopy in different non-forest land use categories in custom uploaded polygon County for the period 2011-2016.
Note: bars relate to tree canopy area (left vertical-axis, hectares) and dots are the % tree cover per land use category (right-vertical axis). "Other" category not shown due to very low area.

Figure 3B-7: Average area of tree canopy loss in different non-forest land use categories in custom uploaded polygon County over the period 2011 to 2016 (hectares per year). Note: "Other" category not shown due to very low area.

Land Cover Change Matrix

2016: Top 2011: Left	Deciduous Forest	Evergreen Forest	Mixed Forest	Woody Wetlands	Cultivated Crops	Pasture/Hay	Grassland/Herbaceous	Shrub/Scrub	Open Water	Emergent Herbaceous Wetlands	Developed, Open Space	Developed, Low Intensity	Developed, Medium Intensity	Developed, High Intensity	Barren Land	Perennial Ice/Snow	Total
Deciduous Forest	37,636	0.3	0.3	21	26	4	91	55	8	39	26	21	22	8	0.3	0	37,957
Evergreen Forest	0.4	697	2	2	0.2	0.2	6	5	4	3	0.4	0.1	0.2	0	0	0	718
Mixed Forest	1	0.3	1,968	0.9	0.8	0	2	1	0.4	0.6	2	0.6	2	0.5	0	0	1,981
Woody Wetlands	2	0.2	0.2	25,897	23	5	6	4	42	495	22	12	10	8	5	0	26,531
Cultivated Crops	37	4	3	41	193,836	126	54	25	31	291	91	110	170	75	4	0	194,899
Pasture/Hay	4	0.1	0.4	7	105	17,082	19	10	5	38	53	45	41	14	0.4	0	17,422
Grassland/Herbaceous	11	0.3	1	12	34	23	9,403	8	43	25	20	25	30	12	2	0	9,650
Shrub/Scrub	18	0.2	0.8	9	39	13	5	3,097	3	14	7	12	15	11	0	0	3,243
Open Water	9	1	0.9	146	8	3	30	2	4,027	235	0.2	4	6	14	14	0	4,501
Emergent Herbaceous Wetlands	16	1	0.7	820	234	24	23	12	147	3,484	2	3	5	5	8	0	4,786
Developed, Open Space	0	0	0	0	0	0	0	0	0	0	20,020	120	358	61	0	0	20,558
Developed, Low Intensity	0	0	0	0	0	0	0	0	0	0	0	36,002	160	162	0	0	36,323
Developed, Medium Intensity	0	0	0	0	0	0	0	0	0	0	0	0	24,232	22	0.2	0	24,254
Developed, High Intensity	0	0	0	0	0	0	0	0	0	0	0	0	0	11,534	0.3	0	11,535
Barren Land	7	0.7	3	3	0	0	2	0.1	26	3	2	3	6	15	1,516	0	1,587
Perennial Ice/Snow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**37,741**	**705**	**1,981**	**26,959**	**194,306**	**17,279**	**9,642**	**3,219**	**4,337**	**4,627**	**20,245**	**36,356**	**25,058**	**11,942**	**1,549**	**0**	**0**

Table 3B-2 Full NLCD land cover change matrix for 2011 to 2016. All areas are in hectares.

2016: Top 2011: Left	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	Total
Forest Land	66,228	50	179	591	134	5	**67,187**
Cropland	85	193,836	205	322	446	4	**194,899**
Grassland	63	177	29,660	127	286	2	**30,315**
Wetland	995	243	95	7,894	39	22	**9,287**
Settlement	0	0	0	0	92,669	0.5	**92,670**
Other Land	14	0	2	29	26	1,516	**1,587**
Total	**67,386**	**194,306**	**30,141**	**8,963**	**93,601**	**1,549**	**0**

Table 3B-3: Simplified land cover change matrix for 2011 to 2016. All areas are in hectares.

Emission and Removal Factors
A summary of the emission and removal factors used in the calculations is provided in Table 3B-4.

	Emission Factor (t C/ha)	Removal Factor (t C/ha/yr)
Forest Change		
Deforestation		
To Cropland	17.70	
To Grassland	15.76	
To Settlement	30.11	
To Wetland	25.44	
To Other	25.88	
Reforestation (Non-Forest to Forest)		-1.61
Forest Remaining Forest		
Undisturbed		-1.48
Disturbed		
Fire	0	
Insect/Disease	7.95	
Harvest/Other	63.88	
Trees Outside Forest		
Tree canopy loss	93.80	
Canopy maintained/gained		-2.74

Table 3B-4: Emission and removal factors

Harvested Wood Products
Harvested wood products (HWP) temporarily store carbon from the forest ecosystem as the wood goes through a series of production processes and end-uses, with eventual disposal (and emission to the atmosphere). The delay represents a net benefit to the atmosphere. The period of storage varies from long-lived solid wood products that remain in use for long periods of time to products that are quickly disposed of in landfills.

In the web tool, the HWP Calculator tracks carbon in harvested wood through four different "fates," from harvest to timber products to primary wood products to end-use to disposal, applying best estimates for product ratios and half-lives at each stage. Based on user inputs entered about annual harvest volumes in Custom uploaded polygon County, the change in the harvested wood pool over the inventory period 2011 to 2016 is estimated as 0 t CO2e per year.

Caveats
Information presented here represents a snapshot in time of the net GHG balance and many of the factors contributing to that balance. The estimates can help identify where policies may be designed to reduce net GHG emissions. This inventory currently uses a simplifying assumption that a loss of forest or trees results in immediate emissions to the atmosphere (rather than delayed emissions in the case of various use cases from long-term storage to shorter decay timelines if sent to landfills). In general, it is important to consider that these estimates represent a relatively short period of time compared with the long-term consequences of policy decisions and land management actions. For example, a forest converted to settlement represents a permanent loss of removal capacity.

Over the long term, maintaining forests will sustain a higher rate of carbon removal, depending on age-related growth rates and occurrence of disturbances. There are significant uncertainties in the estimates. Although not quantified here, typical greenhouse gas inventories of forests using similar approaches, including the national GHG inventory, report uncertainties in the net GHG balance that can be as high as ±45% (with 95% confidence).
In the results presented here, the most uncertain estimates involve emissions from land-use change which are based on well-documented remote-sensing products, but relatively few field observations from a statistical sampling of county forests. While uncertainties can be high, the estimates can still provide useful information on the relative magnitude and importance of such GHGs; subsequent analyses can also provide information on the directionality of emissions and removals from land management.

Finally, it is recommended that additional analyses be done using models that project impacts of alternatives over coming decades. Such models are available and have been used in other studies at county scale. The GHG inventory presented here is only the first step to providing science-based information to support policy decisions. To more fully explore the potential impacts of alternate policies, projection models can be used to compare long-term results among the alternatives which typically include a "business as usual" (i.e. no change in policy) alternative. This feature may be added into the web tool in the future.